Universitat Autònoma
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The Interlanguage Phonology of Spanish-Catalan Learners of English: A Factorial Exploration of /e/ Prothesis in L2 English Initial Onset sC Clusters

MA in Advanced English Studies: Multilingualism and Acquisition of

English

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Abstract: Prothesis (also prosthesis) is a phonological term that involves the addition of a vowel to an onset cluster. In this regard, English initial sC clusters present unusual sonority patterns that make native Spanish (NS) speakers add an /e/ before onset clusters as in /'stjuːdənt/ > [es.tjuːdənt]. This phenomenon occurs in learners' interlanguage (IL). Research has extensively assessed which factors around sC trigger more prothesis. However, which coda consonant preceding the sC cluster affects prothesis remains unexplored. Similarly, previous research on this issue has generally made use of reading tasks. The aim of this study is to assess Spanish-Catalan bilingual speakers' production of sC clusters and explore what aspects contribute to /e/ prothesis. Eleven 1st year English Studies undergraduates which are considered upper-intermediate learners of English read some sentences and words and described a few pictures using only words and then sentences. Two NE speakers were recruited for control; 1.056 tokens were collected. Results show a surprisingly low total amount of prothesis (14%). In fact, two participants accounted for 80% of the prothesis, revealing dramatic within-subjects variability. There wasa tendency for prothesis in /s/ + oral stop onsets, in postconsonantal environments and in non-reading tasks. More prothesis was also found when the preceding coda consonant was an /s/ instead of an oral stop. This study is in alignment with previous research and advances the field by exploring preceding consonant and bringing innovative methodological designs. It also has implications for pedagogy. Future studies could test non-English Studies participants, control for L2 experience more carefully and provide acoustic measurements of the prothesized vowel.

Keywords: Prothesis, L1 Spanish-Catalan, L2 English, sC clusters, Elicitation tasks, Preceding Sound.

1. Introduction

Languages differ in the type of sound combinations they allow and their consequent phonotactic restrictions. For example, words in English may begin with an /s/ followed by another consonant while this type of cluster is not possible in initial onset position in Spanish. Native Spanish (NS) learners of English need to learn that in English /e/ initial sC sequences are possible without a supporting vowel. However, the influence of L1 phonotactic structures is strong, causing negative transfer and, therefore, prothesis. It is also very subtle, meaning learners barely notice it. For this reason, this specific kind of mispronunciation error easily fossilizes into their interlanguage, as it may be particularly difficult to notice, unless the speaker in question is receiving explicit phonetic instruction.

Many studies have examined prothesis at a perceptual level (Carlson, 2018; Carlson et al., 2016; Cuetos et al., 2011; Daland and Norrmann-Vigil, 2015; Davidson, 2011; Gibson, 2012; Hallé et al., 2008; Leeuw et al., 2021). For example, Leeuw et al. (2021) showed that native Spanish (NS) monolinguals hear an /e/ in initial onset sequences where there is no vowel. Additionally, if they hear a pair of sC sequences such that sequence A contains an initial vowel and sequence B does not, some NS monolinguals and Spanish-English bilinguals are unable to hear a difference, especially if the duration of the vowel in sequence A is shorter than that of sequence B.

The oral production of sC sequences has also been researched extensively (Carlisle, 1991, 1997, Daland and Norrmann-Vigil, 2015; Escartín, 2015; Leeuw et al., 2021; Major, 1994; Major and Kim, 2021; Yavaş, 2011; Yavaş and Barlow, 2006). For instance, Daland and Norrmann-Vigil (2015) reported a higher number of prothesis in obstruent forms such as /sk/. In contrast, Escartín (2011) found more prothesis in /sl/, while Carlisle (1991) reported higher amounts in /st/. It becomes visible that /s/ + oral stop sequences have a special structure. However, more research is necessary in order to draw more conclusive patterns.

In tasks where the sC sequences were preceded by a word, all studies show more prothesis after coda C, but which consonant triggers more prothesis remains unexplored. Anecdotal evidence would seem to suggest that Spanish speakers indent a vowel between coda /s/ and initial onset /s/. However, no empirical evidence exists at the moment.

Elicitation tasks of sC sequences are varied, ranging from more formal to more informal tasks. To my knowledge, no work has administered a non-timed picture description task so far, perhaps because it is challenging to make sure that all pictures will elicit the right stimulus, unless accompanied by visual or written cues, and even so – (see section 4 on Methodology).

Daland and Norrmann-Vigil (2015) assessed /e/ prothesis resulting from sC clusters on Mexican Spanish learners of English who had been living in the US for over 10 years. Their study examined multiple variables: speech style (read, spoken), elicitation context (sentences, words), phonological environment – preceding sound (coda C, coda V), place of articulation of the consonant following /s/ in the sC form (velar, alveolar, labial) and its sonority (obstruent, nasal, liquid). They found more prothesis in velar sC forms (/sk/), and a significant effect of prothesis when the test item was repeated the second time. Similarly, more prothesis was found when the sC sequence was preceded by obstruents. No significant differences were reported for the other variables. The multiplicity of variables in their study of /e/ prothesis is exhaustive and has motivated the current MA research. Therefore, this current study will share similar research questions and methodological approaches. The reader is encouraged to continue reading the next few pages and discover if the results from this study match those from the original study (see section 6).

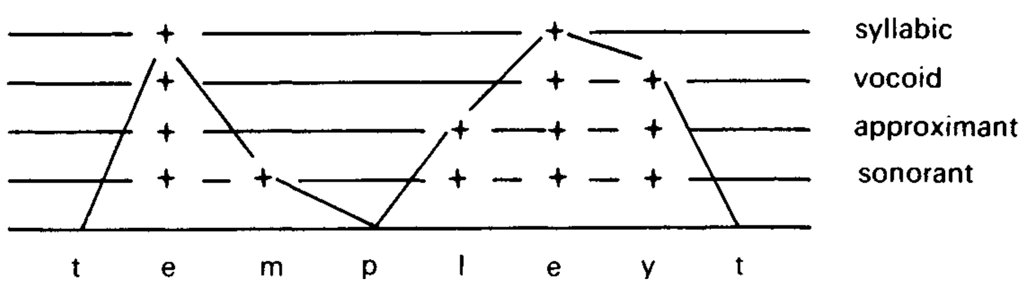
In the following pages, this research will provide a theoretical examination of the phonological idiosyncrasies of sC sequences, thereby involving theories of prosodic sonority, markedness, interlanguage phonology, implicational universals and second language acquisition. In the next section, the research questions addressed in this paper and their ensuing hypotheses will be introduced. After that, a detailed methodology will describe the design of four elicitation tasks and how the stimuli were analysed. Then, the results of the study will be presented. The following section will discuss the findings based on the research questions and hypotheses and relate them to previous findings. A conclusions section will summarise relevant takeaways, acknowledge some limitations from this study and provide future lines of research.

2. Theoretical Background

2.1 A theoretical review of /sC/ clusters

This study is aligned with previous research examining the interlanguage (IL) of sC sequences. Differently from other onset clusters, sC sequences show special parameters and involve the domain of syllables. A syllable is characterized by a rise and fall in sonority, as shown in (1) taken from Clements (1988):

(1) Syllable structure and sonority of the word "template"



Such pattern shows a scalar relationship between syllable structure and sonority (degree of stricture). Syllables tend to abide to the Sonority Sequencing Principle (henceforth, SSP, Clements, 1988), as shown by the quasi-regular periodicity of rise-fall structure in (1).

The SSP is a phonological principle which seems to hold true for all languages in one form or another, governing sequences of sounds. It predicts that sounds rise in sonority towards the margins of the syllable, and drop minimally at the end (Clements, 1988). Therefore (1) "template" exhibits regular sonority patterns. Some word-initial sC clusters also do, those being /sn, sm, sl/. However, some sC onset clusters violate the SSP, since a sound of a sonority level of 2 (fricative /s/) is followed by one of a sonority of 1 (oral stop /p, t, k/), thus showcasing a reversal in sonority.

The sC clusters present other unusual behaviours. Firstly, if two segments are homorganic, that is, share the same place of articulation, they tend not to occur in the same consonant cluster (Yavas and Barlow, 2006), hence the non-occurrence of */tl-, dl-/, to put an example. Yet, /#st, #sn, #sl/ occur. Secondly, onset clusters rarely allow a nasal consonant. Therefore, */pn, tn, ln/ do not occur. Nevertheless, /#sm, #sn/ are allowed. Finally, the authors also report that /s/ is the only phone which can form initial onset clusters made up of three elements, such as /#spr/ as in "spring", further supporting the infrequent nature of /#sC/ clusters.

Such irregular pattern has motivated several authors to treat the /s/ as an appendix or adjunct to the syllable structure (Clements, 1988; Selkirk, 1984; Yavaş, 2011), as shown in Figure 1:

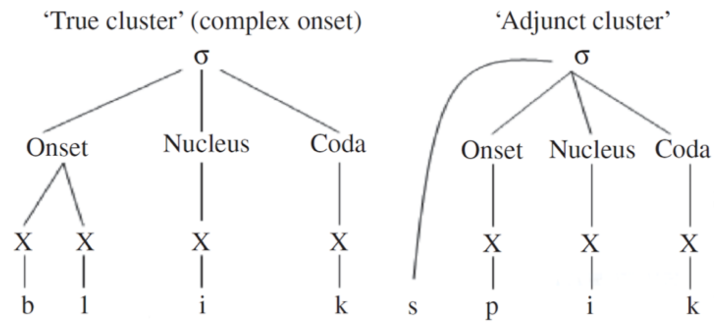


Figure 1. Metrical trees illustrating true and adjunct clusters (Yavaş, 2011: p. 982).

Appended /s/ as an adjunct to the cluster maintains uniformity with the SSP as well as the previous three principles while avoiding complex constituent onset structures (Escartín, 2005). However, there are no further theoretical motivations or empirical bases other than the abovementioned ones.

As has been described above, sC clusters violate universal sonority and syllable structure principles. Consequently, they are more marked (Eckman, 1977) and difficult to acquire than other initial onset clusters. Eckman's (1977) Markedness Differential Hypothesis can help to predict which areas of the language are more difficult to acquire. The author postulated through implicational universals that elements which are less common and usually require the existence of another one, are more marked. In other words, elements that violate SSP as well as other universal principles of phonology are less common, and therefore more marked and difficult to acquire.

The sonority scale predicts an increase in markedness the closer in sonority a sound is from its adjacent one, as illustrated below in (2), adapted from Foley (1972, quoted in Clements, 1988).

(2) Sonority Scale

Least sonorous
1. oral stops
2. fricatives
3. nasals
4. liquids
5. glides
6. vowels
Most sonorous

In other words, the markedness of a cluster increases as its elements (1 to 6) are closer from one another in the sonority scale and reduces the further apart they are. Therefore, /sp/ is more marked than, for example, /sl/.

The MDH also establishes that if its acquisition involves *suppression*, an L2 element will be more easily acquired than if it involved *addition*. Therefore, it could be claimed that the acquisition of English sC onsets will be less problematic to Spanish speakers in this regard, given that they only have to suppress the vowel, that is, delete the /e/ from the /#esC/ sequence.

Similarly, the MDH predicts that if the element from the target language is different from the native language but is less marked, it will not be considered difficult to acquire. For example, in Spanish initial sC onsets have a VCC structure, whereas in English they have a CC one, as the vowel is removed, making them less marked (Clements, 1988). According to the MDH, it should not be difficult for Spanish-Catalan learners of English to acquire the CC sequence because it is less marked than its VCC counterpart. In sum, the MDH predicts that for some principles, the acquisition of the sC clusters might be challenging for Spanish speakers, but not for all of them, as was seen above, revealing that markedness and sonority scale principles work in conjunction to showcase the oddities of sC clusters.

Difficulty of acquisition cannot only be measured through the MDH, since other factors may influence illicit production of target language /sC/ clusters too (Escartín, 2005). To my knowledge, no studies have yet assessed the development of sC clusters in English in terms of markedness theories alone. This claim is substantiated by studies which argue against establishing patterns of difficulty based solely on predictions about markedness (Flege and Bohn, 2021; Gibson, 2012). Along the same lines, Carlisle (1997) notes that the MDH has not been tested in previous studies, because "researchers have examined cases in which both structures, the marked and unmarked, are found within the target language. In other words, the L1 has neither of the structures and the L2 has both" (Carlisle, 1997, p. 328). In his Interlanguage Structural Conformity Hypothesis (ISCH, Eckman 1991, quoted in Carlisle, 1997), Eckman showed that the marked and the unmarked structures can be found in one language.

One additional limitation of Eckman's MDH is that it solely considers ultimate achievement and degree of difficulty, not rate of acquisition. This is revised later by Major and Kim (2002) in their Similarity Rate Differential Hypothesis (SRDH). They propose that second language acquisition (SLA) is gradual and unique to each learner. Additionally, areas of the target language which are dissimilar to those in the native language will be more accessible. They do not discard Eckman's MDH, though. In fact, "markedness acts a mediating factor" for the SMDH (Major and Kim, 2002, p. 167). In other words, the most conclusive difference between both theories is that areas of difficulty are not treated as a static concept. In this regard, the SRDH adds an additional layer of depth by acknowledging different rates of acquisition for different non-native elements.

Similarly, the SRDH draws on the linguistic system that second language learners create as they acquire a second language, called Interlanguage (IL) (Major and Kim, 2002).

The IL can be conceived as a mental inventory where L2 knowledge is stored. According to the authors, similar elements will be more difficult to acquire because they will not incorporate additional aspects into the IL. Therefore, the latter are expected to become non-transferable sequences, deemed as non-learning, and thus acquired later (Major and Kim, 2002). In other words, if we claim that Spanish EFL learners unconsciously regard /#sC/ sequences as being rather similar to /#esC/, then, the former will not be integrated into the learners' IL. Consequently, they will be treated as negative transfer, non-learning sequences. In sum, Spanish speakers will be expected to repeat the same mistake until there is noticing of the minimal differences between Spanish and English phonotactic construction of /sC/.

Rate of acquisition is linked to language experience (LE), which in turn has an effect on the amount of prothesis. According to the Speech Learning Model (SLM, Flege, 1995), experience is understood as the amount of speech input an L2 learner has gained as a consequence of face-to-face conversations. However, experience as a categorical term is somewhat vague, at least in the respect that it fails to consider the quality of experience. For example, two speakers may receive the same amount of exposure, usually defined in terms of Length of Residence (LOR) – if there has been abroad stay, but speaker A makes no prothesis, while speaker B does. The SLM predicts that speaker A make have been exposed to more native input, whereas B to non-native input, with native input leading to native-like output – and thus no prothesis.

Exposure to non-native speech does not determine whether speakers will produce illicit output of /#sC/ clusters, or at least terminally. In that respect, Flege and Bohn (2021) propose the term Full-Time Equivalence (FTE) which is calculated by multiplying the LOR by the proportion of L2 used. Although this formula does not consider the nativeness aspect of input received, it makes a step further from LOR by incorporating the role of L2 usage.

However, LOR will not be analysed in the current study as speakers are Spanish-Catalan upper-intermediate language learners.

In addition to LE, amount of prothesis can be further explained by phonetic categorization. According to the SLM (Flege, 1995; Flege and Bohn, 2021), at first, many new sounds are produced as in the L1, given that no distinctive phonetic category exists for them yet in the learner's IL, affecting much of the pronunciation of the L2 inventory ubiquitously (Flege, 1995; Flege and Bohn, 2021). With progressive exposure speakers become more attuned to nuanced differences between similar L1 and L2 phones, and gradually form distinct phonetic categories for L2 sounds. In fact, this has been substantiated by previous research. Leeuw et al. (2021) showed that sequential Spanish learners of English with certain degree of L2 experience can choose freely between using either the L1 or the L2 phonology depending on the task at hand and the language with which they are asked to complete the experiment.

A final caveat to the SLM is that it operates at the sound level, not in the syllable region. To this respect, the voiceless alveolar fricative /s/ found in sC sequences in both languages is identical. Neither do the following possible consonants present any phonological variation. Therefore, for the sake of fitting into the SLM, [es] could be treated as an allophone of English /s/. In the end, previous studies have observed that Spanish speakers prothesize sC sequences in English even when there is no vowel in the lexical form that could lead to misguidance (see 2.2.1). Thus, Spanish speakers could be regarded as producing [es] in place of /s/, mainly in sC sequences.

2.2 Previous studies on /e/ prothesis

2.2.1 Corpora-based studies

Prothesis has been researched widely. A few corpora-based studies have found records of it in loanword adaption. (Bland 2021; Daland and Norrmann-Vigil, 2015). For example, Fleischhacker (2001, 2005, cited in Daland and Norrmann-Vigil, 2015) analysed cross-linguistic patterns in loanword phonology, and showed that sC sequences can be repaired cross-linguistically in more than one fashion, either through epenthesis or prothesis. She observed that the amount of prothesis increased as the sC sequences fell in sonority. For example, /st/ is reported to prefer prothesis more than /sl/, as shown in (3):

(3) Sonority ranking of preference for prothesis (adapted from Escartín, 2005)

sp, **st**, sk > sf, sv > sn, sm > **sl**

Bland (2021) examined how 35 English /sC/ loanwords were adapted into the speech of Portuguese-American immigrants (Luso-Americans Portuguese, henceforth LAP) based on a corpus of phonetically transcribed historical depictions of varieties of Standard European. The author found that prothesis was manifested through /ɨ/ before /s/ + stops, as in English steamer > LAP [ɨʃ.ˈti.mɐ]. No prothesis was identified for /s/ + sonorant onset clusters, but epenthesis was, as in snow > LAP [sɨ.ˈnɔ]. Thus, he proposed a pattern of preference for either prothesis or epenthesis based on the interaction between principles of syllable cluster formation, as shown in (4) and (5):

(4) Restriction against word-medial insertion

(5) Restriction against codas except /s/

It seems that depending on the prosodic characteristics of the onset cluster, the vowel can be adapted with either prothesis or epenthesis. Bland's (2021) study offers an insight into historical development of prothesis in Portuguese from the mid-20th century, thus making an important contribution in the field of IL phonology.

2.2.2 Perceptual studies

Although the present study only involves production tasks, perceptual studies will be reviewed in order to provide a comprehensive understanding of /e/ prothesis, since perception and production are related in a complex manner (Carlson, 2018; Flege, 1995; Flege and Bohn, 2021; Hallé et al., 2008; Leeuw et al., 2021). However, it needs to be mentioned that a causal relationship between perception and production has not been empirically proven (Leeuw et al., 2021) for English sC clusters produced by native Spanish (NS) speakers.

Several perceptual studies show regular patterns of prothesis of sC clusters (Carlson et al., 2016; Carlson, 2018; Gibson, 2012; Leeuw et al., 2021). Auditorily, initial onset clusters may be perceived as containing an additional onset vowel. In the literature, this is often referred to as perceptual repair, or perceptual distortion. That is, Spanish speakers *repair* the illegal phonotactic cluster /#sC/ that is not found in Spanish through prothesis, or the sC cluster is perceived wrongly due to the influence of L1 phonotactic rules, hence *distorted* in the perceived input.

In Carlson et al. (2016), 83 Spanish-English bilinguals participated in a two-alternative forced choice vowel-detection task of /sC/ non words with an initial vowel either /e/ or /a/. Results show that Spanish-dominant speakers perceived an /e/ 22% of the times when the stimulus presented no initial vowel. Nevertheless, L2 experience in English mitigated the effect. When a vowel with partial duration was heard, both groups (Spanish-dominant, English-dominant) seemed to readily accept the perception of an /e/, but not /a/, with this effect being stronger in Spanish-dominant speakers. As Carlson et al. (2016) note, this is indicative that a perceptual repair effect is influenced by speakers' expectation of Spanish word-structure "rather than by the canonicity of the acoustic signal as a token of /e/ and viceversa for /a/" (p. 946), that is, independently of whether NS are aware that they are prothesizing, and the vowel with which they are doing so is /e/ by default.

Gibson (2012) revealed a similar pattern occurring as early as in childhood. The author conducted a series of discrimination and identification tests on 50 Spanish children aged 10-11 years. They were presented with nonce stimuli which included licit and illicit word-initial onset clusters, and they were asked to provide the number of syllables they heard. Results show that children consistently perceived an additional syllable, revealing strong effects of underlying phonotactic representations found in the L1. However, findings are not supported by statistical data, or at least they are not visible to the reader. Therefore, results may not be tangible. Nevertheless, they were warranted on the basis of generative theories of phonology, and thus have been further elaborated in Gibson (2012) but fall outside the scope of this study.

Carlson (2018) assessed accuracy and reaction times of 32 late Spanish-English bilinguals (mean age 25.5 years *sd* = 6,8) (p. 6), and 14 NS monolingual speakers in an AX discrimination task. The main aim was to assess the perceptual interplay between different vowels (/e/ or /a/ in sC sequences: /#Vspid/) presenting different durations. The researcher was also interested in the effects of language activation. Therefore, one group of bilinguals received instructions in Spanish, and a second one in English. Results show that when the pairs contained the same vowel but differed in duration, monolingual speakers were significantly quicker to respond than bilinguals, but also significantly more inaccurate. Spanish speakers who had received instructions in English were slower than those who had received them in Spanish, but more accurate. Findings reveal "coactivation of the English and Spanish systems in real-time processing, and not merely retuning of perception through long-term exposure to English" (Carlson, 2018, p. 3).

Leeuw et al. (2021) conducted an AX discrimination task to assess categorical and continuous perception of three conditions involving sC clusters and prothesis on native English (NE) speakers and Spanish-English bilinguals. These conditions were:

(6) spi-spu

(7) spi-espi

(8) spi-spi

Specifically, they also measured accuracy and reaction time. To do so, they reduced the duration of the initial /e/ in (7) by several stages, presenting each durational stage in a counterbalanced fashion. In sum, the authors wanted to assess if presence of vowel posed any perceptual illusion (Carlson, 2018), that is, causing speakers to perceive an /e/ in stimuli where it was not present (spi), and the extent to which duration of the vowel affected such perceptual distortion. Results show that Spanish-English bilinguals perceived condition (7) *spi-espi* much less accurately than conditions (6) and (8) (62% of correct responses versus 93-95%, respectively), and RT was also significantly slower. Thus, Leeuw et al.'s (2021) study is closely aligned with similar studies that reveal NS speakers' skewed perception of English sC clusters.

2.2.3 Production studies

Several studies have also shown the IL idiosyncrasies of sC clusters through production tasks (Carlson, 2018; Daland et Norrmann-Vigil, 2015; Escartín, 2005; Leeuw et al., 2021; Major, 1994; Yavaş and Barlow, 2006; Yavaş 2011). For example, Major (1994) assessed developmental and transfer errors of several sC sequences from L1 Portuguese – a language which does not accept /#sC/ sequences – into L2 English. He found that LE ameliorated the amount of prothesis. Incidentally, when prothesis was made, it was not a pure [ɨ] which is typical of Portuguese (Bland, 2021) but a schwa, and thus, was treated as a developmental error – not a transfer one. To my knowledge, no other study has made a separation between developmental and transfer errors, specific to /sC/ clusters. Therefore, Major's (1994) study contributes actively to the exploration of cross-linguistic development of sC clusters, adding a nuanced understanding in the field by introducing a taxonomy of errors.

Yavaş and Barlow (2006) also reported instances of /e/ prothesis from 40 Spanish-English bilingual children in /s/ + oral stops. Prothesis in this case was associated to possible negative transfer from Spanish phonotactics. Drawing on Major's taxonomy (1994), /e/ prothesis would be considered a transfer error, since unlike Portuguese, Spanish prothesizes with /e/. Originally, /sw/ was included as a type of /#sC/ cluster although the researchers discussed that given the significant number of correct productions, /sw/ sequences behave differently than other /#sC/ clusters because they are acquired much faster, reportedly. No other work has considered /sw/ as an /sC/ cluster either, partly due to the faster rate of acquisition of /w/, and because s + w/vocoid is no longer considered an sC cluster (Clements, 1988).

Leeuw et al. (2021) also carried out a production task as part of their study. They administered a timed phonemic verbal fluency task and asked Spanish English (SE) bilinguals (in the L2) and English monolinguals to provide as many words as possible starting with different sC sequences, those being /sp, st, sk, sm, sn, sl/. Participants were given ten seconds for free production for each cluster. Results show that SE bilinguals produced a significantly higher amount of prothesis across all sC sequences. Surprisingly, NE monolinguals also produced some, which has not been found in previous studies, although the percentage was minimal (see 2.3.1 for considerations on the choice of task and its impact on amount of prothesis). The authors also revealed a significant influence between amount of prothesis and lower daily use of English as well as smaller L2 experience (Leeuw et al., 2021).

2.3 Linguistic and extralinguistic factors

Escartín (2005) postulated that prothesis is affected by a combination of linguistic and extralinguistic factors. For example, linguistic factors include speech style (Cebrian, 2001), sC forms, preceding sound (e.g., vowels, consonants and pauses) and markedness principles. Extralinguistic factors encompass LE, daily use of English and task. Speech style and task are not explored in Escartín (2005), although in her study she included a variable of formality. Finally, the author indicates that previous studies have not considered the abovementioned factors, and neither have been supported by phonological theories such as resyllabification or markedness. Several studies, fortunately, provide evidence against this conclusion (Carlisle, 1997, 1998; Eckman and Iverson, 1993; Flege, 2003; Major, 1994). For example, Major's (1994) study successfully incorporated extralinguistic and phonological aspects by examining the effects of task variation on transfer errors. Additionally, his study was embedded within the frameworks of markedness theory.

2.3.1 L2 Experience

Language experience has been assessed by multiple studies. For example, Carlson et al. (2016) showed in an AX discrimination task that participants with more L2 experience correctly perceived a vowelless sC sequence without such vowel. On the other hand, less experienced language learners showed higher distortion in perceptual identification of sC clusters with initial /e/. In other words, the experiment showcased the declining effects of /e/ prothesis thanks to LE.

Carlson (2018) showed that Spanish dominant speakers in a Spanish speaking area, who are late English bilinguals, acquired English at a point where the Spanish phonotactic system had fully developed and, thus, distorted the perception of sC clusters. Findings in Carlson (2018) and Carlson et al. (2016) support the authors' initial hypothesis that perceptual repair effects decrease gradually as knowledge of L2 increases, ultimately yielding support to the learnability process proposed by Major and Kim's (2002) SRDH. Similarly, Leeuw et al. (2021) and Carlson (2018) showed that the amount of produced prothesis was reduced owning to increased magnitudes of L2 exposure and daily English use. However, perception of sC clusters was significantly affected by competition of language (English or Spanish) during task demands regardless of participants' level of L2 proficiency. Perhaps a production task involving coactivation would make an excellent follow-up study. Broselow and Finer (1991, quoted in Eckman and Iverson, 1993) analysed Korean speakers' production of English clusters and suggested that although participants did not show complete mastery over clusters, they were reported to have moved from the "NL [native language] setting". (p. 44-45). Escartín (2005) had examined the development of sC clusters in Spanish EFL beginner, intermediate and advanced learners and adequately showed a progression in the decrease of prothesis as proficiency level increased. Such progression showed that the acquisition of the dissimilar Spanish-to-English /#sC/ structure reflects a continuum, not a categorical point in which prothesis abruptly vanishes. This claim is further supported by the fact that native English monolingual speakers in Leeuw et al. (2021) prothesized sC clusters, although marginally so.

2.3.2 Task formality

Task also seems to influence the rate of prothesis. For example, reading a text is claimed to be more formal than reading a list of words because of the amount of self-monitorization and general concentration a text involves (Cebrian, 2001; Escartín, 2015; Major, 1994). However, Major (1994) showed that participants in those two reading tasks produced more target-like sC clusters reading a text than reading words in isolation. Nevertheless, he acknowledged that the linguistic environment preceding and following the sC cluster may have favoured target-like pronunciation. Along the same lines, Cebrian (2001) showed that minimal pair tasks are highly formal since they require the greatest amounts of self-monitorization and mental workload, that is. In contrast, he showed that spontaneous or planned story tasks incur less pressure on participants. Nevertheless, planned stories are more formal than spontaneous ones.

Leeuw et al. (2021) conducted one perceptual and one production task. The perceptual task consisted of a forced-choice AX discrimination whereas the second one of a phonemic fluency. The perceptual task was shown to be formal than the production one because it made participants more aware of their responses. Additionally, the production task was timed, which according to Cebrian (2001) does not give participants enough time to monitor their speech and complete the task at the same time. Conversely, a non-timed elicitation task could provide participants some leeway for self-monitorisation. In sum, tasks timed to evaluate participant performance are shown to lead to greater attention to speech, which aligns with the discussions raised by Cebrian (2001), although he did not explore prothesis nor sC clusters. Nonetheless, his study was reviewed for the sake of explaining the incipient effects of task variation in empirical studies of second language acquisition (SLA).

2.3.3 Phonological environment and sC place and sonority

Daland and Norrmann-Vigil (2015) assessed rate of prothesis on 4 Mexican NS intermediate learners of English with a LOR in the United States superior to 10 years. They were also interested in the effects of modality, so they conducted two pairs of elicitation tasks: reading and repetition. Furthermore, they assessed the effects of linguistic factors. Therefore, both tasks were further subdivided into reading of sentences and words, and repetition of sentences and words. Additionally, the researchers were interested in the effects of the phonological environment, by which they assessed if there was more prothesis when the sC sequence was preceded by either a vowel (V) or a consonant (C). Finally, they assessed if prothesis was also affected by the type of sC form, including /sp, st, sk, sm, sn, sl/. In this respect, sC forms were further divided depending on the parameters of the second consonant, that is s**C**: place (labial, coronal, dorsal) and sonority (obstruent, nasal, liquid). In total 100 stimuli were elicited, and participants had to repeat their answer twice (100 x 2 = 200 tokens per participant). Results showed a significant effect of spoken as opposed to read style, with double the amount of prothesis on the second repetition. Findings also reached significance for increased rate of prothesis in postconsonantal contexts, although it did not specify which preceding consonant affected the most. Finally, significance was also reached for place, with

[sk] triggering more prothesis. The authors discussed that the occurrence of prothesis became more frequent as the place of articulation receded in the vocal tract, hence the significance of /sk/.

Conversely, in Escartín (2015), /sl/ triggered more prothesis than nasals and stops. However, her study did not diversify for place. It did for manner (stop, nasal, liquid). Post-consonantal environment yielded higher amounts of prothesis as well as opposed to postvocalic and no preceding context. Language experience had a significant effect, with prothesis considerably increasing as LE diminished. Task formality consisting of a grammatical judgement task and a 20-minute interview did not have a meaningful impact on prothesis. In Carlisle (1997), sC clusters were prothesized more significantly after coda consonant. In alignment with previous studies, /s/ + oral stop sequences showed a higher amount of prothesis (Carlisle, 1991, quoted in Carlisle, 1997), likely due to their violation of SSP – and therefore increased markedness.

It needs to be mentioned that multiple variables were assessed in Daland and Norrmann-Vigil (2015), contributing to field of IL phonology by measuring the effects of multiple linguistic factors on presence of prothesis in L2 English initial onset sC cluster. For these reasons, they motivate part of the methodological design choice of this current study, which will further contribute by involving a larger sample of participants (4 in Daland and Norrmann-Vigil (2015), 11 in the present study).

The inherent complexities of such a study undoubtedly highlight potential limitations that must be addressed. Firstly, choosing the right participant level in which prothesis is significantly sensitive to the variables studied. Secondly, conducting a well-designed methodology that can test all these variables as well as controlling for possible confounding ones such as participants' comparable level of English, whether all tasks should include identical stimuli or not, whether the stimuli should differ in length or not and whether both pairs of tasks have comparable levels of formality (as in elicitation contexts) and difficulty. Thirdly, an adequate number of control sentences is required so that participants do not become aware of the targeted stimuli and monitor their own pronunciation accordingly (Cebrian, 2001). Finally, adequate statistical tests need to be able to capture all the variables as well as their interactions. (see section 5 for discussion of the results).

All in all, studies show that prothesis is more active in postconsonantal contexts, with effects being magnified in tasks involving spoken speech rather than read speech and being mediated by time-based restrictions on task completion. Predictions also indicate that /sk/ forms should contain more prothesis on the basis of violation of SSP and additional markedness of sounds further back in the vocal tract. Finally, language experience seems to mitigate the effects of prothesis although studies typically include a modest number of participants.

3. Goal and Research Questions

The goal of this paper is to evaluate the interlanguage phonology of Spanish-Catalan bilinguals who are L2 English learners. Specifically, it will examine a series of linguistic and extralinguistic factors and assess if they have an effect on prothesis, and to what extent they do. Presence of prothesis will be analysed both impressionistically and acoustically. Then, mean rates, standard deviations, and minimal and maximal scores of prothesis by participants and variables will be provided. Follow-up inferential tests will be conducted to assess if the differences between the variables are significant and if they interact with one another. The main research questions guiding this paper are the following:

1. Does the type of elicitation task have an effect on the production of /e/ prothesis by Spanish/Catalan learners of English? In other words, do learners produce more /e/ prothesis in picture-naming description tasks as opposed to reading tasks?
2. Does task elicitation context have an effect on prothesis? That is, do Spanish/Catalan learners of English produce more prothesis when tasks involve sentences as opposed to word lists?
3. Does phonological environment have an effect on quantity of prothesis? Namely, do Spanish/Catalan learners of English produce more prothesis when the /#sC/ cluster is preceded by coda C as opposed to a V?
4. Does the preceding consonant have an effect on rate of prothetic implementation? Specifically, do Spanish/Catalan learners of English generate more prothetic vowel errors when the preceding C is a voiceless fricative /s/ as opposed to a voiceless stop (/p/, /t/, /k/)?
5. Do place of articulation and sonority have an effect on prothesis? To put it differently, do Spanish/Catalan learners of English exhibit more prothetic vowel insertion when the second consonant in the initial sC onset sequence is a stop, particularly a velar voiceless stop, that is, /sk/?

Prothesis is expected to be more common in picture-naming description tasks as opposed to reading tasks, as the former are more informal, allowing participants to focus on the pictures, resulting in less attention to pronunciation. In contrast, reading tasks are more formal, resulting in the opposite effect. Additionally, spelling in reading tasks may contribute to a favourable pronunciation. Similarly, prothesis should occur more frequently when participants are tasked with producing sentences rather than isolated word lists. This is because sentence production requires attention to multiple elements, thereby reducing the ability to effectively monitor pronunciation compared to the relatively simpler task of dealing with individual words. Following that, prothesis is predicted to be more frequent after a consonant than before a vowel or silence. This is because they will have to string three obstruent consonants together, resulting in a C#CC structure which is usually more complex than V#CC or #CC structures. Learners are expected to make more prothesis when the preceding consonant before the sC word is a voiceless fricative /s/ rather than a voiceless stop. This may seem counterintuitive, because /s/ is slightly less obstruent than voiceless stops, but fricatives are more uncommon than plosives. Besides, the fact that the /s/ from the sC sequence is preceded by another /s/ should confuse participants, not knowing how to link them, effectively forcing them to process the sequence as inherently wrong, thereby adding prothesis in order to repair it. Finally, it is predicted that obstruent forms will yield higher amounts of prothesis than sonorant ones (/s/ + /sm, sn, sl/) because the former violate universal syllable sonority principles. Additionally, in alignment with previous studies, /sk/ is hypothesised to prothesise more than the other sC forms (Escartín 2005).

4. Methodology

Four elicitation tasks were conducted. The first two tasks were adapted from Daland and Norrmann-Vigil (2015) and involved reading words and sentences. The other two tasks involved describing pictures using one word or thematic sentences. The experiment was recorded. The researcher wrote in a piece of paper if each stimulus produced by the participants was correct or not: X if it was prothesized, V if not. The recordings were then analyzed and where prothesis was heard, acoustic measurements were carried out with Praat (version 6.4.12, Boersma and Weenink, 2024). Results were computed and analysed using Microsoft Excel and the free online statistics software Jamovi.

4.1 Participants

Eleven Spanish/Catalan first year English Studies undergraduates participated in the study (10 females and 1 male, ranging from 18-23). The male-to-female ratio is not unexpected since the first-year ratio for 2023 for the English Studies bachelor's degree at UAB is 81% women and 19% men (Universitat Autònoma de Barcelona, 2023). Some participants are more dominant in Spanish while others in Catalan, which shows in that they differ in the use of language in daily environments (see Appendix C). No participant has lived abroad. They all report a very high level of motivation to learn English as well as to improve their English pronunciation. Some report having jobs involving English, for example teaching English, and report a higher use of English at work. Others who do not work or have a job where English is the language of communication, report some use of English in daily life. Some report a rare use of English daily, while others a fairly frequent daily use.

No English proficiency test was administered. The only requirements were that students did not have experience abroad, that their self-reported level of English was no higher than C1 and that they had not received explicit phonetic instruction, which is provided later in Phonetics and Phonology I and II (EPP), two key subjects in their second year. Three participants reported receiving specific phonetic instruction though, but they were recruited due to participant limitations and self-reported difficulties with the subject. One of them reported repeating EPP three times, so it was interesting to examine their performance in the study. Two NE speakers, one from Vermont, US and the other from London, UK completed the elicitation task. This was to test the clarity of the tasks and if they also made prothesis and, if they did not, so that their recordings served as a reference for correct production of sC clusters, without prothesis.

4.2 Linguistic questionnaire and recordings

Participants completed an online questionnaire indicating their native languages and the degree of usage in different daily environments. Some participants filled it in digitally the same day of the experiment too. Some recordings took place in a sound attenuated recording studio at a Speech Laboratory at Universitat Autònoma de Barcelona, and the remaining took place in a quiet room with a Zoom H4n Pro Handy Digital Recorder. Technical specifications of the equipment in the sound studio are shown in Table 1 below:

Info	***Technical specifications***
Pre-amp	Module Api 500-Series SSL Six CH Solid Stage Logic.
Sound card	RME Fireface 802
Recording software (DAW)	Reaper
Sound file format	WAV
Bits per sample	24 bits
Sampling frequency	48kHz
Condenser microphone	Audio-technica AT2050
Mode	Cardiode

Table 1: Technical specifications of the recording materials in the sound studio

If participants were recorded in the quiet room, the researcher sat behind them in order to minimize observer's paradox (Labov, 1972). At the end of the experiment, participants received a conference bag and a mug as compensation for their time. Additionally, they were given the option to do a free 1h consultation with the researcher to work on their own L2 English pronunciation errors in the future. The same linguistic questionnaire was sent later asking more questions. Table 2 shows the type of questions and how they were rated where applicable:

Type of information requested	*Type of ratings (if any)*
Personal data	None
Native language and their parents'	None
LOR abroad	Time
Amount of English use in daily environments	Adverbs of frequency
Amount of motivation to learn English	Likert scale
Amount of motivation to learn pronunciation	Likert scale
Self-report of performance	Likert scale

Table 2: Design of the ad hoc post-experiment linguistic form.

Participant responses of both forms can be found in the Appendix. The researcher wanted to assess participants' actual perceptions of how they performed and compare with their actual results, hence the Likert scales. This would open new lines of research in the field as it would implement a qualitative approach to prothesis. Furthermore, no research has applied self-perception ratings on prothesis of sC clusters yet, either. However, due to time limitations a decision was made to leave the examination of the self-assessment ratings for future analysis.

4.3 Variables

This study aimed to assess Spanish-Catalan upper-intermediate learners of English' production of sC sequences under different tasks (reading, picture-naming description) and contexts (sentences, words). At the same time, it assessed prothesis in different preceding environments, those being preceding sound (consonant, vowel, silence) and more specifically preceding consonant (/s/, voiceless stops). Then, place of articulation of the second consonant making up the sC form (velar /sk/, alveolar /st, sn, sl/, bilabial /sp, sm/) and its sonority (obstruents /sp, st, sk/ vs. sonorants /sm, sn, sl/).

4.4 Task design

A total of 96 stimuli were tested across four elicitation tasks which were delivered in a PowerPoint[1] presentation. Table 3 below shows the number of words per condition per task and their order of presentation:

A. Reading tasks	
<u>*1. Sentences*</u>	<u>*2. Words*</u>
4 sp (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 st (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sk (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sm (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sn (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sl (1 s#sC, 1 p,t,k#sC, 2 V#sC)	4 sp 4 st 4 sk 4 sm 4 sn 4 sl
6 x 4 = 24 critical stimuli + 20 fillers	*6 x 4 = 24 critical stimuli + 10 fillers*
B. Picture-naming description tasks	
<u>*3. Words*</u>	<u>*4. Sentences*</u>
4 sp 4 st 4 sk 4 sm 4 sn 4 sl	4 sp (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 st (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sk (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sm (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sn (1 s#sC, 1 p,t,k#sC, 2 V#sC) 4 sl (1 s#sC, 1 p,t,k#sC, 2 V#sC)
6 x 4 = 24 critical stimuli + 10 fillers	*6 x 4 = 24 critical stimuli + 20 fillers*

Table 3: Task design.

As Table 3 shows, the sentence tasks assessed the phonological environments of coda C (/s/ vs. /p, t, k/) and V, whereas the word tasks assessed sC forms in isolation. A decision was made to reduce the number of filler words by half in the word tasks in order to avoid a longer experiment. The same number of critical stimuli per sC form was introduced in each task for comparability. Each task was preceded by a slide showing the instructions. Task 1 included

[1] The presentation can be accessed here

one sentence per slide, task 2 one word per slide, task 3 four pictures per slide and task 4 one picture per slide, as shown in Table 4 below. Participants were asked to read the instructions in order to adjust volume levels and facilitate initial engagement. The SRT (see table 4) was presented first to avoid attention to the target forms (sC) or prevent participants from detecting the objective of the study. In the second half of the experiment, the word picture naming description task (WPNDT) was presented first to get participants used to the dynamics of the task. Figure 2 below Table 4 shows a slide taken from the WPNDT containing four test items:

Task	***Stimuli x slide***
Sentence reading task (SRT)	1
Wordlist reading task (WRT)	1
Word picture-naming description task (WPNDT)	4
Sentence picture-naming description task (SPNDT)	1

Table 4: Name of the task and number of stimuli per slide

Figure 2: Four test items from the WPNDT

Participants were asked to describe each picture using one word, following the numbered order from above. Thus, figure 2 represents the following test items: (1) *Sloth*, (2) *Spoon*, (3) *Rice* and (4) *Fork*. *Spoon*, a critical item, and *fork*, a control one, share the same hypernym: "cutlery". Other control items were co-hyponyms of sC words in order to prime visual lexical association, thus distract participants from the sC form. As it can be seen in Figure 2 above, some pictures such as (1) *sloth* were accompanied by a written hint. This was done in order to increase the chances of eliciting the right /sC/ form. If participants missed the word, the researcher intervened and helped them by asking them to provide a synonym or by providing the word in Catalan or Spanish and asking them to translate it into English. The researcher was aware of the observer's paradox (Labov, 1972) though and tried to offer only limited assistance.

In the SPNDT (task 4), participants had to describe four sets of pictures using specific sentences, for example:

(9) Carrier phrase + colour + object: I can see a yellow *skateboard.*

(10) Carrier phrase + number + object: I can see *eight Spanish flags*.

(11) Read written cues and fill the blank: I see *three sports*.

(12) Carrier phrase + person/animal/object + action (-ing): I can see a *cow sleeping*.

Above, the critical stimulus in each sentence is marked in italics. Figure 3 below represents each sentence visually:

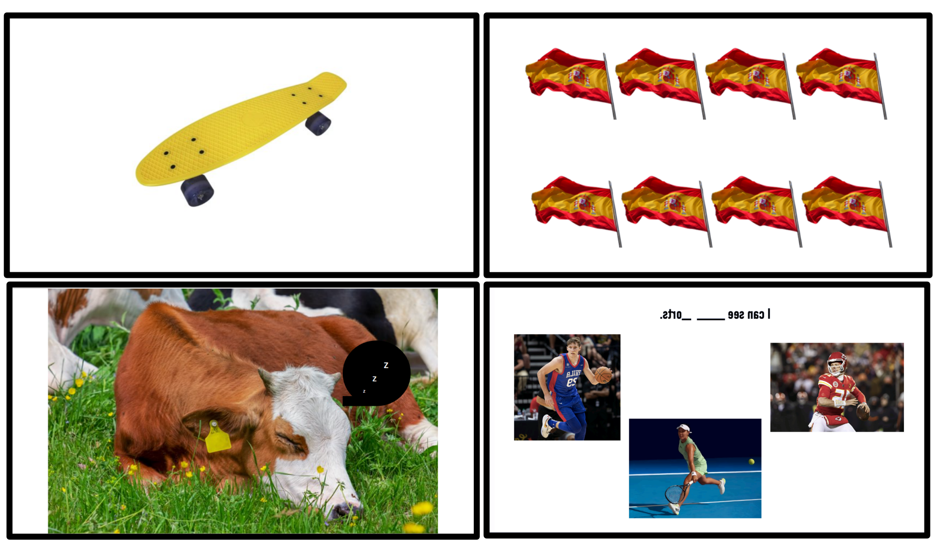


Figure 3: Four slides showing a different type of test item.

4.5 Stimuli

All sC words were adapted to the learners' proficiency level, so that the tasks could test prosodic aspects of phonology, not speaker's ability to face new linguistic items. By this token, it also made sure that all sentences were of similar lengths and complexity. Compound nouns were discarded. No onset clusters containing three elements were included, although they trigger more prothesis than double-element onsets (Carlisle, 1997). Pauses were controlled for. Therefore, in sentence reading/building tasks, the sC words and their preceding word belong to the same syntactic constituent (Ladefoged, 2011). To ensure morphosyntactic concord, preceding words were mostly functional items such as: *to, a, will, some, two*.

The first set with reading tasks presented the same sC words. The second set with picture-naming description tasks presented other sC words, in order to avoid progressive noticing of the test item. The study was piloted twice first with 2 monolingual Spanish speakers, and then with a lower-intermediate English speaker in order to test picture-stimulus correspondence. Only during initial phases of data collection, sometimes the intended words were not guessed, and no prompts were given. These instances were discarded from data analysis.

4.6 Detection of /e/ prosthesis

Data was analyzed using Praat (Boersma and Weenink, 2024), both through auditory perception of the presence of a vowel and visual inspection of the spectrogram and soundwave. Every instance of prothesis was annotated on a TextGrid tier tagged */e / prothesis*, coded for participant, word and context.

Prothesis was measured in several ways. Generally, there was pitch and formant structure, so the left boundary was set at the nearest 0-crossing where periodicity started, and the right boundary was set where the first striation of aperiodic frication began. Sometimes, there was no pitch nor pulse because the vowel had been whispered. Other times the vowel was produced with a creaky voice. For cases where prothesis was detected immediately after postvocalic context, any changes in formant structure were inspected, since there were usually no changes in pitch, but only minimal changes in formant structure. In these cases, the sequence was heard several times, and the boundary was then slightly adjusted. Finally, in alignment with Leeuw et al. (2021), any additional sound before an sC cluster independently of duration was considered prothesis. This was so on the basis that the two NE speakers who completed the elicitation tasks did not produce any initial vowel whatsoever. There were neither accidental initial burst, whisper, pauses or creaky vowels, thereby increasing the reliability of the recordings.

5. Results

5.1 General amount of prothesis

A total of 1054 stimuli were collected, but 24 were discarded because some pictures did not elicit the right sC form for some participants. A key result is that only a total of 140 test items were produced with prothesis (*M* = 14%, *SD* = 17.3), as reported in Table 5 below in the next page:

							Shapiro-Wilk	
	N	**Mean**	**Sum**	**SD**	**Min**	**Max**	**W**	***p***
Total prothesis	11	14%	140	16.3	0	53%	0.776	0.004

Table 5: Total amount of prothesis. The table shows N (number of participants), Mean, Sum, SD, Minimum and Maximum percentage of prothesis across participants, and Normality Shapiro-Wilk W and p value.

Minimal and Maximal scores show dramatic variability between speakers. In fact, a Shapiro-Wilk Normality test revealed that the distribution of scores was not normal ($p < 0.005$). Table 6 below shows the amount of prothesis per participant, with a ranking of the 5 highest scores and lowest scores (*Median* = 4, *Mode* = 4). This means that 3 participants made 4 instances of prothesis out of the 96 stimuli elicited per participant. Table 6 further shows that 72% of the participants produced only 11% of the 96 words with prothesis. Participants 11 and 9 accounted for 82% of the total of prothesis:

	Ranking	**Participant**	**m**
Highest	1	11	.53
	2	9	.37
	3	10	.23
	4	4	.10
	5	2	.11
Lowest	1	7	.0
	2	1	.01
	3	5	.01
	4	3	.04
	5	6	.04

Table 6: Ranking of highest and lowest scores of all participants (% of prothesis produced)

5.1 Task and context

Table 7 below reports individual scores per participant per task (reading vs. pictures). It also shows the group mean per task. Highlighted are the highest scores in both tasks:

Tasks	1	2	3	4	5	6	7	8	9	10	11	Mean
Reading	0,00	0,08	0,02	0,15	0,02	0,06	0,00	0,02	0,23	0,19	0,52	**0,12**
Picture	0,02	0,16	0,07	0,06	0,00	0,02	0,00	0,06	0,51	0,28	0,53	**0,16**

Table 7: Sum of prothesis by participant and task.

As the table refects, the values for prothesis were distributed highly abnormally with participants 9, 10 and 11 accounting for 72% of the total amount of prothesis. Table 8 below also reflects this result with participants 2, 9, 10 and 11 outputting abnormal different scores than the other participants. In this case, the mean rate of prothesis was below 11% for the other participants:

Context	1	2	3	4	5	6	7	8	9	10	11	Mean
Sentences	0,02	0,22	0,04	0,10	0,02	0,06	0,00	0,08	0,58	0,08	0,38	**0,14**
Words	0,00	0,02	0,04	0,11	0,00	0,02	0,00	0,00	0,15	0,38	0,68	**0,13**

Table 8: Sum of prothesis by participant in sentences and words.

Table 9 below reports the scores for reading tasks (RT) and picture naming description tasks (PNDT), which are distributed abnormally according to a Shapiro-Wilk Normality test ($p < 0.05$).

Tasks	**Mean**	**SD**	**Min**	**Max**	***p.***
Reading - Sentences (SRT)	13%	15.7	0.00	46%	0.015
Reading - Words (SRT)	9%	21.4	0.00	67%	< .001
Pictures - Words (WPNDT)	15%	22.7	0.00	70%	0.002
Pictures - Sentences (SPNDT)	15%	22.5	0.00	71%	0.002

Table 9: Mean rate of prothesis per tasks, including Sum, Standard Variation, Minimum and Maximum percentages of prothesis per task per participant and Normality Shapiro-Wilk W and p scores.

As expected, PNDTs show a higher amount of prothesis, although a non-parametric Wilcoxon-Signed Rank test used to evaluate differences between RTs and PNDTs did not reveal any significance, with $p = 0.18$. Table 9 also shows that the amount of prothesis was slightly higher in picture naming description tasks, although the difference in scores was small. Additionally, the *SD* in each task-modality pair was higher than its mean, which indicates that the data was not normally distributed. This was further confirmed by the significance encountered by the Normality Test, which can explain that the disperse values for Min. and Max. That is, the SRT presented a higher mean than reading – words, however, a participant produced a higher maximum in the WRT than in the SRT. The same holds true for the PNDTs, although the magnitude of dissimilar distributions was smaller. In short, the results of the non-parametric test showed no significant effect of task nor context.

A non-parametric Friedman Repeated Measures Anova was conducted to assess the effect of task (reading vs picture naming) and elicitation context (words vs sentences) and their interaction. The test showed that the differences between the different levels were not significant (χ^2 (3) = 4.15, $p = 0.246$). For exploratory purposes, follow-up post-hoc non-parametric Durbin-Conover tests were conducted too. There was no significant difference observed in any level, although the scores between word RDT (WRDT) and sentence RDT (SRDT) almost reached statistical significance ($p = 0.06$), given that the lowest value for prothesis was found in the WRT (shown in Table 9).

Correlation matrixes were conducted to find any pattern as well as dependencies. A non-parametric Spearman's rank test revealed a significant correlation coefficient between WRT and WPNDT (r_S (9) = 0.75, $p < 0.005$), and SRT and SPNDT (r_S (9) = 0.70, $p < 0.001$). This indicates that the scores were related such that as one variable increased, the other also did. That is, participants who produced prothesis in, i.e., WRT also did in WPNDT, or the other way around. The scores were thus related by tendency, not causality. Figure 4 below shows a visual summary of the correlation matrixes reported above:

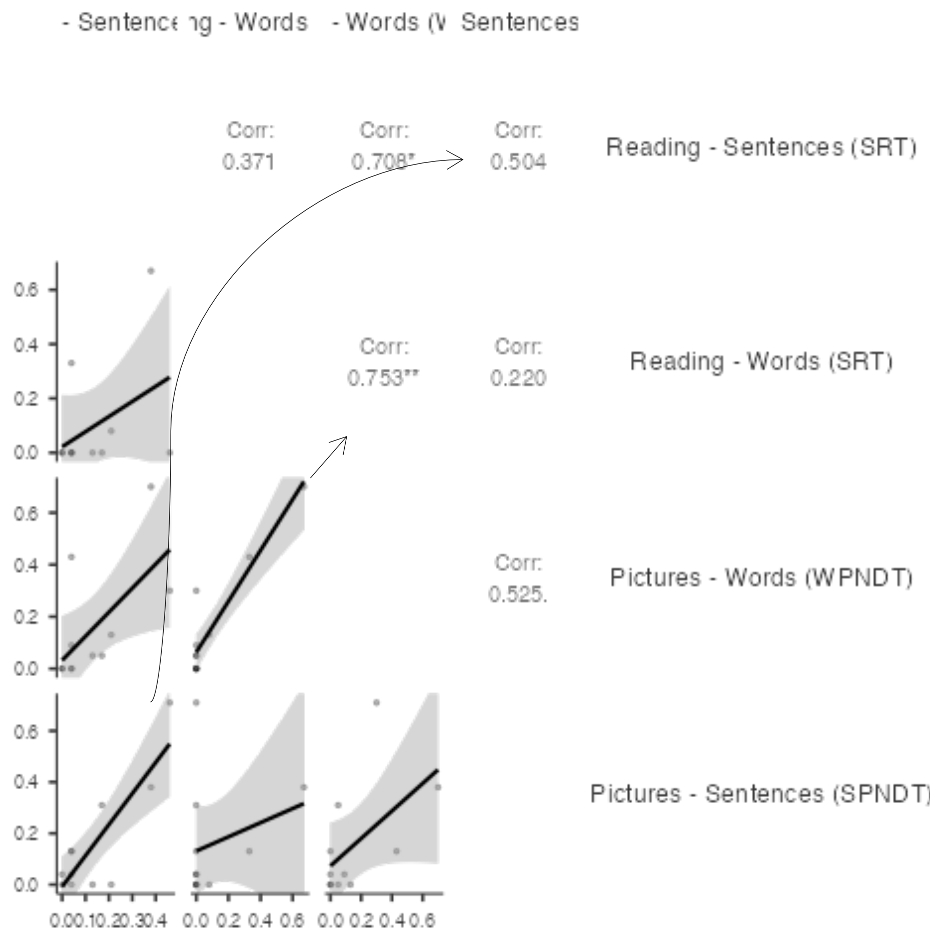


Figure 4: Correlation matrixes of the pairs different-task*same-modality with two arrows signaling from plot to r value.

5.3 Phonological Environment

The next variable assessed was phonological environment, that is, what occurred when the sC test item was followed by a preceding sound, i.e. a consonant "six slingshots", a vowel "blue sky" or silence " ∅ smiles" (underlined are the coda element and the following sC sequence). Table 10 in the next page shows the main dispersion and central tendency values:

	Mean	SD	Minimum	Maximum	Shapiro-Wilk	
					W	p
Preceding sound:	14%	18.2	0.00	58%	0.753	0.002
➢ C_	17%	23.2	0.00	69%	0.758	0.003
➢ V_	11%	13.6	0.00	45%	0.810	0.013
Ø_	13%	21.6	0.00	68%	0.668	< .001

Table 10: Mean values for phonological environment including Mean, Sum, SD, Min, Max, Shapiro-Wilk W and *p* values.

As table 10 reflects, all variables violated the normal distribution, with very similar amounts of prothesis between preceding sound and silence. Two follow-up non-parametric Wilcoxon Rank tests were carried out to test if the difference in prothesis produced was significantly different. The first one showed that the amount of prothesis between preceding sounds and silence was not significant ($W = 29.0^a$, $p > 0.05$ (0.23). The second one showed a marginally significant difference in the amount of prothesis between C_ and V_ ($W = 28.5^a$, $p = 0.07$).

Then, a non-parametric Friedman Repeated Measures test assessed if the scores for prothesis postvocalic and postconsonantal contexts were significantly different between picture and sentence reading tasks (note there was no preceding sound in word tasks, only silence). The test did not show a significant difference between the groups. For further analysis, this data was then subjected to six follow-up non-parametric Durbin-Conover pairwise comparison tests, revealing a significant difference in the number of prothesis in V_ contexts between the tasks ($p < 0.05$). The other pairs were not statistically significant.

Next, the variable preceding consonant (s, voiceless stop) was closely examined. First, an examination of the normality was conducted, see Table 11:

					Shapiro-Wilk	
	Mean	**SD**	**Minimum**	**Maximum**	**W**	**p**
Reading-s	23%	0.309	0.00	83%	0.771	0.004
Picture-s	17%	0.231	0.00	71%	0.781	0.005
Reading-p,t,k	21%	0.334	0.00	100%	0.713	< .001
Picture-p,t,k	10%	0.190	0.00	57%	0.619	< .001

Table 11: Mean rate of prothesis in s_ and p,t,k_ per tasks, including Sum, Standard Variation, Minimum and Maximum percentages of prothesis per task per participant and Normality Shapiro-Wilk W and p scores (there is no preceding consonant in tasks involving wordlists, because the words are read in isolation, thus being followed solely by silence).

Table 11 above describes several findings. First, as expected, Shapiro-Wilk normality tests revealed that the data did not follow a normal distribution. Acknowledging that, the means for prothesis before s or voiceless stop were higher in the reading task as opposed to the picture task, with preceding /s/ producing a few more instances of prothesis. Nevertheless, a participant produced 100% of prothesis after /p_, t_, k_/, but only in the reading task; the picture counterpart yielded the least of both means and maxima of prothesis. At the same time, these tasks, that is, both tasks after preceding voiceless stop (/p, t, k/) had scores whose distribution was slightly less normal than those of preceding /s/. Although marginally so, normality scores of prothesis after p_, t_, k_ can explain both the lowest mean of prothesis and the dispersity of the maximum scores.

Notwithstanding the scores showed by the test, Q-Qs were plotted to have a visual representation of where the abnormality had been found (Appendix C shows the four Q-Q plots). If the quantiles fell approximately along the reference line, it may be deemed adequate to conduct a parametric test afterwards, as sometimes the model assigns low p values because it is sensitive to sample size which, in this case is low; 11. Q-Qs proved the violation of normality, therefore in order to assess if there were significant differences between the means of the four groups, a non-parametric Friedman Repeated Measures Anova was carried out. The test revealed a marginal significance: $\chi^2(3) = 7.01$, $p = 0.071$ ($p > 0.05$). Therefore, post-hoc non-parametric Durbin-Conover tests were conducted. The tests revealed, in line with the findings in Table 9 (p. 33), a marginally significant difference between picture and reading tasks after preceding /p, t, k/ ($p = 0.065$). Additionally, they revealed a significant difference between both tasks after preceding /s/ and the picture task after /p, t, k/ ($p < 0.05$ in each case). However, according to a one-tailed Wilcoxon Signed-Rank test following the hypothesis that there would be more prothesis in /s/ than in /p, t, k/, there was no statistically significant difference in the number of prothesis produced between one preceding sound (/s/) and the other one (/p, t, k/) ($W = 23.0^a$, $p = 0.26$).

Despite no significant effects between the different means, Spearman correlation matrixes were carried out and they revealed a significant correlation for different variables. The central variable was Picture – /p, t, k/, again. Firstly, it showed a significant correlation with its read task counterpart, meaning that participants who prothesized in the sentence picture description task before preceding voiceless stop, also did for read sentences where the sC test item was preceded by voiceless stop ($r^2(9) = 0.81$, $p < 0.001$). Secondly, the variable also correlated with its preceding counterpart, /s/, indicating that if prothesis in pictorial tasks occurred before preceding /p, t, k/, it also tended to appear before preceding /s/ ($r^2(9) = 0.95$, $p < 0.001$).

5.4 Properties of the sC sequences

In this section, the number of prothesis produced was assessed according to the place articulation of the second consonant making up the sC cluster (alveolar /k/, alveolar /t, n, l/ and bilabial /p, m/) as well as its sonority value (obstruents /p, t, k/ and sonorants /m, n, l/). First, Table 12 shows main dispersion and central tendency values of each sC form, and underneath it Figures 5, 6 and 7 a plot with the mean rates for each variable:

					Shapiro-Wilk	
	Mean	**SD**	**Minimum**	**Maximum**	**W**	**p**
sp	11%	0.169	0.00	56%	0.708	< .001
st	12%	0.179	0.00	50%	0.723	< .001
sk	16%	0.228	0.00	63%	0.725	< .001
sm	12%	0.167	0.00	53%	0.771	0.004
sn	17%	0.195	0.00	50%	0.832	0.025
sl	11%	0.160	0.00	44%	0.727	0.001

Table 12: Mean values for sC forms including Mean, Sum, SD, Min, Max, Shapiro-Wilk W and *p* values.

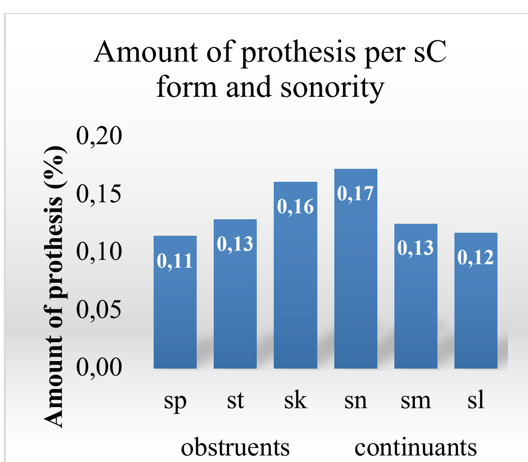


Figure 5: Mean rate of prothesis by sC form

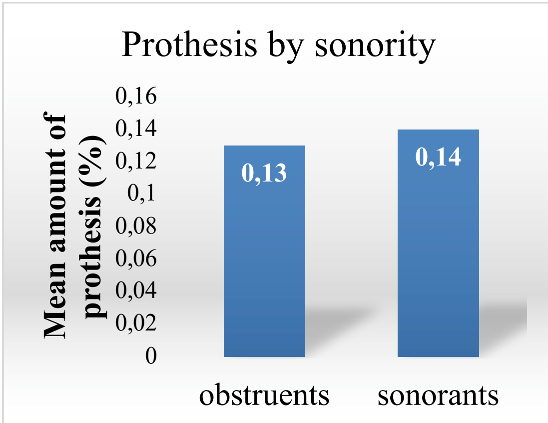


Figure 6: Mean rate of prothesis by sonority

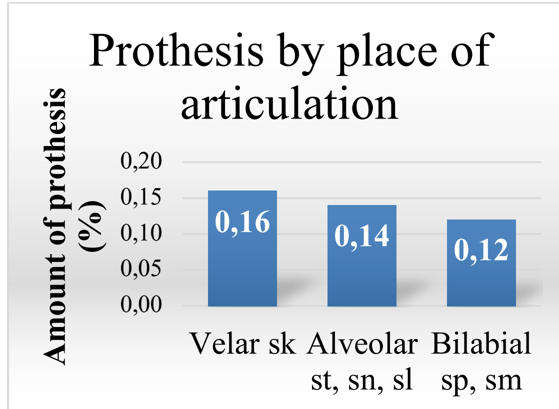


Figure 7: Mean rate of prothesis by place

In Table 12, six normality tests showed that the distribution of prothesis of each sC form in the four tasks was non-normal ($p < 0.001$). Figure 5 complements the previous table and reveals that the scores for prothesis between each sC form are similar, with /sk/ and /sn/ yielding slightly higher number of prothesis. Figure 6 indicates that by sonority division, the production of prothesis did not differ. Figure 7 showed that as the place of articulation receded in the vocal tract, more prothesis was produced, although the margin is very little.

Six follow-up non-parametric Friedman Repeated Measures tests did not find any significant differences between the means of each sC form in each task ($p > 0.5$ in all cases, see Appendix C). Finally, a non-parametric Kruskal-Wallis One-Way Anova did not reveal any significant differences in the amount of prothesis between the means of each sC forms (also see Appendix C). In other words, no sC form yielded more prothesis than the others such that the difference was significant, although there was slightly more prothesis for /sn/ (17%) closely followed by /sk/ (16%), as presented earlier.

The data from Figure 6 was subjected to a one-tailed non-parametric paired Wilcoxon Signed-Rank test following the prediction that there would be more prothesis when the second consonant of the sC forms was an obstruent. The test showed that the differences in prothesis produced between obstruents and sonorants was not significant ($W = 24.5^a$, $p > 0.5$). Finally, a Friedman Repeated Measures Anova was conducted from the data in Figure 7 to assess the level of differences between the different sonority groups. The test was not significant (χ^2 (2) = 1.03, $p > 0.5$). Follow-up pair-wise comparisons using Durbin-Conover tests did not reveal any significant pair either (p > 0.5 in all cases).

6. Discussion of results

The aim of this study was to assess the interlanguage phonology of Spanish-Catalan bilingual intermediate learners of English who are entry students to a bachelor's degree in English Philology at UAB. The purpose was to test their production of sC clusters in English. They completed four production tasks involving reading sentences and words, and then describing some pictures using one word or some thematic sentences. In this section, the main results will be discussed on the basis of the initial research questions and previous research.

The first research question considered whether the kind of task used to elicit the sC forms had an effect on the amount of prothesis produced. The main goal of incorporating pictures was to a elicit a more kind of spontaneous speech[2]. Results are in line with Cebrian's (2001) postulation that non-reading tasks are usually less straightforward, since participants need to concentrate on other elements of the task and do not have the mental space to monitor their own pronunciation as carefully. However, the difference is marginal, and the tests did not reveal significance either. Therefore, the null hypothesis could not be rejected statistically. Nevertheless, it is proposed that different elicitation task could affect the rate of

[2] Participants responded well to the tasks, with some explicit reactions. Some of them were surprised to have forgotten some lexical items such as "sloth, spoons or slipper", overall indicating high levels of engagement.

prothesis, although more studies would need to attest this proposal.

Picture description tasks incorporated an added effect of difficulty: picture-guessing. Participants needed to go through different mental processes in a rapid succession. Firstly, identifying the picture. Secondly, retrieving the correct lexical item from their interlanguage lexicon and, thirdly, processing the correct pronunciation. For this reason, scores in prothesis during this task could also be due to the inherent difficulties of a picture description, challenging the claim that it is a casual task. In other words, for some participants, the task may have not presented a challenge in terms of lexical retrieval, but for some others it may have. This study differs from Leeuw et al. (2021) in the choice of a non-reading elicitation task of sC sequences since the authors carried out a timed phonemic verbal fluency task instead. In hindsight, though, a timed picture naming description task is more challenging than the other task since it not only involves lexical retrieval, but picture-lexicon association, which inevitably is more challenging as it tests participant's L2 knowledge at a deeper level.

The second research question asked if elicitation context influenced the amount of prothesis. As reported by the test of predictability as well as the repeated measures Anova, task formality did not have a significant effect. Therefore, the null hypothesis cannot be rejected. It seems that the means of both prothesis in sentences and in words was slightly higher in the picture description naming task, possibly revealing some task effect, but since the tests were not significant, the results are considered preliminary. Sentence-word symmetries between tasks reflects the inherent differences in formality discussed in Cebrian (2001), who reported less interlanguage errors in reading of isolated words than sentences. Additionally, in Daland and Norrmann-Vigil (2015) and Escartín (2005) participants also showed lower number of prothesis in words. In this regard, the results are consistent with the prediction that sentences would trigger more prothesis than wordlists – although not significantly so.

The third research question was concerned with the effects of phonological environment and predicted that prothesis would be more active in postconsonantal environments. The scores revealed that preceding context did not have an effect on reading tasks, showcasing task effects on participants, although it almost significantly affected prothesis in picture description tasks. A reported higher amount of prothesis when preceded by consonant aligns with the results from Daland and Norrmann-Vigil (2015), who also reported a significant likelihood for sC sequences to read adding prothesis when the former were immediately preceded by a coda consonant. Results also align with phonological theories of acquisition (Flege, 2001; Flege and Bohn, 2021; Major and Kim, 2002) and markedness (Eckmann, 1977; Eckman 1991, quoted in Carlisle, 1997, Clements 1988) discussed in earlier sections, which posited that the acquisition of CCC (c#sC) was more difficulty than VCC (V#sC) since Cs are more marked (Clement, 1988; Ladefoged, 2011). Besides, s#s is prosodically complex since two elements of the same sonority value are conjoined, involving complex syllabic interfaces (Escartín, 2015). In contrast, Vs contain inherent phonological properties which allow them to liaise naturally with a following voiceless obstruent.

The fourth research questions explored preceding consonants more in depth. It examined whether a particular consonant triggered more prothesis than others. Daland and Norrmann-Vigil (2015) included coda consonants in their assessment of prothesis in sC sequences, particularly s#, p#, t#, #k, f#, θ#. However, during data analyses, they only accounted for the different coda consonants as belonging to the postconsonantal group. In this study, coda /s/ was specifically assessed due to anecdotal evidence and assumed difficulties for learners to liaise coda s with onset s. In contrast, /p, t, k/ were included by default as some of the test sentences were replicated (Daland and Norrmann-Vigil, 2015, p. 682 – 683). On the other hand, only /p, t, k/ were kept for comparison with s because they do not differ as much in terms of sonority and they also feature as the second consonant of some sC sequences. Coda /s/ had triggered slightly more prothesis than coda voiceless stop, but since the results are not significant, the null hypothesis could be rejected.

The fifth research question aimed at examining if place and sonority of the sC form had an effect. Previous research has shown that Spanish speakers tend to introduce more prothesis when the biliteral sC sequence violates the Sonority Sequencing Principle. (Bland, 2021; Carlisle, 1991, 1997, Clemens, 1988; Major, 1994, Major and Kim, 2002; Daland and Norrmann-Vigil, 2015; Eckman and Iverson, 1993; Escartín, 2005; Yavaş, 2011; Yavaş and Barlow, 2006). More prothesis was also reported when the second consonant from the sC sequences presents a more backed place of articulation. The results from this study partly align with previous studies. Firstly, /sn/ was the form which presented more prothesis, but it was not expected to surface as often as it did because it does not violate the SSP and therefore is not marked enough for it to be predominantly challenging. Secondly, it aligns with the results from Escartín (2015) and Carlisle (199b) since they found more instances of prothesis production for /st/ and /sl/, respectively, which are alveolar sounds, like /n/. Additionally, predominance of /sn/ could be ascertained because it is a homorganic cluster (Yavaş, 2006) and therefore universally uncommon and marked, thus more difficult to acquired. The /sk/ sequence was second in showing higher amounts of prothesis. Studies in the field indicate the marked nature of /sk/ on the basis of violation of the SSC cluster, minimal distance in the sonority scale and backness properties. At the same time this study aligns with Daland and Norrmann-Vigil (2015) since they also showed an effect of /sk/ and Escartín (2005), who showed an effect of /st/, thereby revealing potential effects for obstruent sC clusters to trigger prothesis insertion. However, since the results were not significant, findings from this study would not be generalizable.

7. Limitations and conclusion

The greatest limitation of this study is that it did not carefully control for language experience explicitly. Participants had been recruited who did not have any experience abroad, and who considered themselves to possess an upper-intermediate to advanced level of English. No formal level of English had been requested either. On the one hand, baseline level of English need not be ascertained since students with at least an upper-intermediate to advanced range of L2 English level join the degree. Additionally, the sample was relatively small, 11.

No pronunciation level test was carried out, which could account for inter-variability. In addition, while it was originally assumed that first-year students would make pronunciation errors at the level of sC clusters, their pronunciation levels were underestimated. That is, this study overestimated the capacity for sC sequences to trigger /e/ prothesis in the specific profile of the participants. This was done under a misapprehension that the profile of participants would provide many instances of sC prothesis since the tasks were being adapted from Daland and Norrmann-Vigil (2015) and they had tested the items on Mexican Spanish adult learners of English who had been living in the US over 10 years (as condition *sine qua non*) – some over 20, who had provided multiple accounts of prothesis.

Nevertheless, the study revealed that sC prothesis was a potential point of conflict for some participants at a big capacity, for others at a medium sized capacity and for others at a small capacity, even null. In other words, it turned to be of no challenge to most of the participants, indicating possible generalizability effects that this methodology may pattern in the same way with a different pool of participants with the same age and level requirements.

That is, it is proposed that similar scores would be obtained without actively controlling for inter-speaker differences in terms of L2 abilities. Therefore, it should be possible to elicit more prothesis by slightly adjusting some methodological variables. In other words, either reducing the level band requested, or increasing the difficulty of the test items, as well as tweaking the tasks such as by applying time restrictions or including a second repetition of each answer. Applying time-restrictions on a casual task ought to make it more challenging and elicit less careful speech, which aligns well with the objectives of this study's PNDTs. Therefore, regarding the first research question, this study's methodology could be revised so that, 1) the pictures are to be elicited under time constraints, 2) a phonemic verbal fluency task is administered instead of or in addition to the PNDTs, and 3) a combination of timed and non-timed picture description tasks and phonemic verbal fluency tasks are administered.

More research is needed that addresses, confirms or rebuts the limitations of this study by 1) testing whether the observed inter-speaker variability is generalizable to more contexts involving pronunciation mistakes of other segments, 2) recruiting a larger sample of participants from the same year, filtering them based on English placement tests and deciding whether to conduct an experiment between two or more groups of proficiency (Escartín, 2015) or choosing a single group adapting the dependent variable and the difficulty to the level of the group and 3) eliciting participants to repeat their answer twice, since Daland and Norrmann-Vigil (2015) showed a dramatic effect of repetition on the amount of prothesis. In terms of methods, additional studies could also choose a qualitative approach and collect sC stimuli based on interviews, conversations, classroom recordings, spontaneous data during actual classroom recordings. In terms of phonological measurements, formant structure of the prothesized vowel could be measured, since studies show that for Spanish-Catalan bilinguals /e/ is the default prothesized vowel (Gibson, 2012; Leeuw et al., 2021) although causality has not been established for perception and production, so the vowel might be different in the latter. In this case the study would need to control for dialectal differences. Considering the inter-variability, the same high-scoring participant(s) from this study could be re-assessed once a year for progressive L2 gains.

In the end, /e/ prothesis did not seem to be a challenge for English Studies first-year participants, albeit with some exceptions. Nevertheless, this research hopes to have implications for pedagogy, allowing teachers to offer a more nuanced instruction of /sC/ clusters on behalf of the findings reported in this study. At the same time, it invites students to reflect on their ideal L2-self and develop an intrinsic motivation towards L2 pronunciation in order to maximize the potential of upcoming courses.

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Appendix A. Questionnaire

QUESTIONNAIRE (Adapted from Gorba, 2016)

How often do you use Spanish at work?

How often do you use Spanish at home?

How often do you use Spanish at uni?

How often do you use Spanish with friends?

How often do you use Catalan at work?

How often do you use Catalan at home?

How often do you use Catalan at uni?

How often do you use Catalan with friends?

QUESTIONNAIRE AFTER THE EXPERIMENT
(adapted from Gorba, 2016)

https://forms.office.com/e/Xd3rQHHQP5

Section 1

1. Name
2. Age
3. Occupation,
4. Place of birth
5. Parents' place of birth
6. Current residence
7. Other places of residence (where you have lived at a couple months. Indicate when and for how long)
8. Have you taken any subject on English phonetics or English pronunciation (including Phonetics and Phonology I and II?)

Section 2

Languages and language use

9. Mother tongue
10. Parents' mother tongue.
11. Indicate with which frequency you use English daily in the following groups:

At home,
With friends
At university
At work
In general

Options: Never, Rarely, Sometimes, Usually, Very often, Always, N/A

12. What is your level of motivation to improve your English?
13. And how motivated would you consider yourself to be to learn or improve specifically your pronunciation in English?

Options: Very Little, Little, Normal, A Fair Amount, A Lot

Section 3

Self-perception

My experiment analyzed an interlinguistic phenomenon between English and Catalan/Spanish known as /e/ prosthesis, under which we introduce an additional vowel element at the beginning of words that start with /s/ + consonant, e.g., "strong" [estrong], "sloth" [esloth], as a consequence of the transfer of phonotactic rules from the native language.

Specifically, it analyzed the frequency of prosthesis under different variables. For example, one of them was to analyze what happened if the preceding word ended in /s/ and the next one began with s + consonant (/sC/), e.g., "six spoons" compared to if it ended in a voiceless plosive (p, t, k), e.g., "eight sloths" or in a vowel "the/a blue sky." Another variable was to analyze the frequency of prosthesis in more formal tasks such as reading sentences vs. isolated words, in comparison to more spontaneous tasks like describing images.

In general, you introduced more prosthesis when reading the sentences and describing thematic images, but there is quite a bit of variability.

Please rate how well you did in each task in relation to whether you think you introduced a lot of prosthesis (1 star) or not much (5 stars).

Task 1: Reading of sentences
Task 2: Reading of isolated words
Task 3: Pictures description (1 word per image)
Task 4: Description of thematic sentences (I can see…)

Section 4

Thank you very much for your participation! :)
My e-mail for any consultation is: [university e-mail]

Appendix B. Participants’ answers to the questionnaire.

	Age	Place of birth	Parents’ place of birth	Native Tongue	Parents Native Tongue	Current residence	Time spent in an English speaking country	Has taken Phonetics and Phonology I or II?	Use Sp at home	Use of Sp with friends	Use of Sp at university	Use of Sp at work	Use Cat at home	Use of Cat with friends	Use of Cat at university	Use of Cat at work	Use En at home	Use of En with friends	Use of En at university	Use of En at work	General use of English
1	19	Mallorca, Espanya	Catalunya, Espanya	Catalan/ Spanish	Catalan	Terrassa	None	Yes	Usually	Never	Often	Often	Usually	Always	Often	Often	Never	Often	Very Often	Always	Very Often
2	18	Tarragona	Tarragona	Spanish	Spanish	Tarragona	None	Yes	N/A	Always	Always	Always	N/A	Rarely	Rarely	Rarely	Rarely	Rarely	Often	Sometimes	Sometimes
3	18	Badalona	Barcelona	Catalan	Catalan	Lloret De Mar	None	No	Often	Never	Often	Usually	Sometimes	Always	Usually	Usually	Never	Rarely	Often	Never	Sometimes
4	18	Barcelona	Barcelona	Spanish	Spanish	Barcelona	None	No	Always	Always	Always	Always	Sometimes	Rarely	Rarely	Rarely	Never	Never	Never	Rarely	Rarely
5	19	Barcelona	Barcelona And Pamplona	Catalan/ Spanish	Spanish	Mollet Del Vallès	None	No	Always	Always	Always	Rarely	Sometimes	Always	Always	Rarely	Never	Rarely	Sometimes	Often	Often
6	18	Sabadell	Sabadell	Catalan/ Spanish	Spanish	Sabadell	None	No	Sometimes	Usually	Rarely	Usually	Sometimes	Usually	Usually	Sometimes	Sometimes	Often	Very Often	Very Often	Very Often
7	18	Sabadell	Sabadell	Catalan/ Spanish	Spanish	Sabadell	None	No	Sometimes	Often	Rarely	Often	Sometimes	Often	Usually	sometimes	Sometimes	Often	Very Often	Very Often	Very Often
8	21	Lleida	Lleida	Spanish	Spanish	Cerdanyola del Vallès	None	Yes	Often	Always	Usually	Usually	Always	Sometimes	Usually	often	Never	Never	Always	Always	Often
9	23	Tortosa, Tarragona	Tortosa,Tarragona	Catalan	Catalan	Barcelona	None	No	Rarely	Never	Sometimes	Rarely	Often	Always	often	often	Never	Rarely	Always	Always	Often
10	18	Barcelona	Mollet del Vallès (Mom), Basque country (Dad)	Catalan/ Spanish	Catalan (mom), Spanish (dad)	Mollet del Vallès	None	Yes	N/A	Often	Rarely	Someties	N/A	Often	Always	often	Never	Rarely	Very Often	N/A	Often
11	19	Granollers	Granollers	Spanish	Spanish	Montornès del Vallès	None	No	Sometimes	Always	Often	Always	Sometimes	Sometimes	rarely	sometiems	Sometimes	Sometimes	Very Often	Rarely	Often
NE	N/A	Worcester, UK		English English	Accent:		Southern English (UK)														
NE	N/A	Burlington, Vermont, USA					Northeastern English (USA)														

*NE indicates Native English speakers

Appendix C. Tables and Figures

	ReadingS-sp	ReadingW-sp	PictureW-sp	PictureS-sp
Mean	0.636	0.545	0.182	0.455
Shapiro-Wilk W	0.754	0.504	0.486	0.600
Shapiro-Wilk p	0.002	< .001	< .001	< .001

Table A. 1. Shapiro-Wilk Normality Test of /sp/ for each task.

	ReadingS-st	ReadingW-st	PictureW-st	PictureS-st
Mean	0.636	0.364	0.636	0.364
Shapiro-Wilk W	0.698	0.474	0.662	0.619
Shapiro-Wilk p	< .001	< .001	< .001	< .001

Table A. 2. Shapiro-Wilk Normality Test of /st/ for each task.

	ReadingS-sk	ReadingW-sk	PictureW-sk	PictureS-sk
Mean	1.00	0.545	0.545	0.455
Shapiro-Wilk W	0.863	0.615	0.486	0.512
Shapiro-Wilk p	0.064	< .001	< .001	< .001

Table A. 3. Shapiro-Wilk Normality Test of /sk/ for each task.

	ReadingW-sn	ReadingS-sn	PictureW-sn	PictureS-sn
Mean	0.364	0.455	1.09	0.818
Shapiro-Wilk W	0.486	0.701	0.700	0.714
Shapiro-Wilk p	< .001	< .001	< .001	< .001

Table A. 4. Shapiro-Wilk Normality Test of /sn/ for each task.

	ReadingS-sm	ReadingW-sm	PictureW-sm	PictureS-sm
Mean	0.364	0.273	0.636	0.545
Shapiro-Wilk W	0.625	0.504	0.698	0.689
Shapiro-Wilk p	< .001	< .001	< .001	< .001

Table A. 5. Shapiro-Wilk Normality Test of /sm/ for each task.

	ReadingS-sl	ReadingW-sl	PictureW-sl	PictureS-sl
Mean	0.182	0.273	0.545	0.818
Shapiro-Wilk W	0.486	0.504	0.615	0.714

	ReadingS-sl	ReadingW-sl	PictureW-sl	PictureS-sl
Shapiro-Wilk p	< .001	< .001	< .001	< .001

Table A. 6. Shapiro-Wilk Normality Test of /sl/ for each task.

	χ^2	df	p
sp	4.00	3	0.261
st	2.00	3	0.572
sk	7.00	3	0.072
sn	5.07	3	0.167
sm	2.87	3	0.413
sl	2.87	3	0.413

Table A. 7. Non-parametric Friedman Repeated Measures Anovas comparing each sC sequence across the four tasks.

Picture-/s/ Picture-voiceless stop Reading - /s/ Reading - voiceless stop

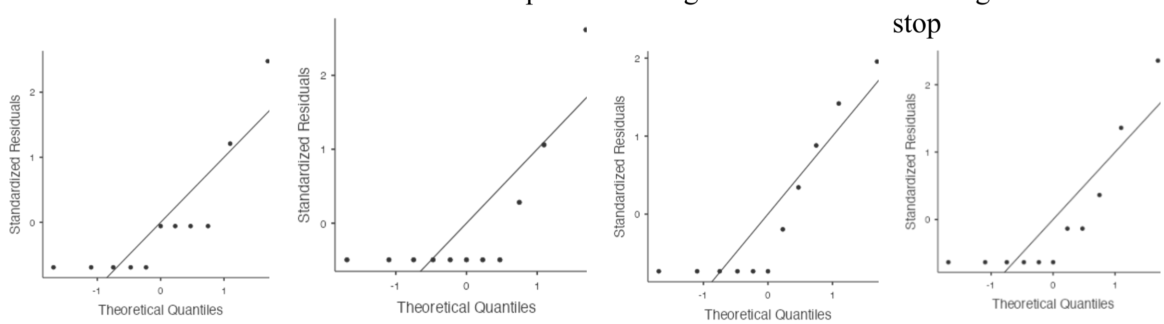

Figure A. 1. Q-Q plots of preceding sound per possible tasks.

Appendix D. Test items

Reading task – SENTENCES (24 critical, 10 fillers)

		C#sC	*V#sC*
	k#sC	He is a weak spokesman.	The thief was asked to speak.
sp	s#sC	He eats soup with nice spoons.	Mario went to spy on him
	t#sC	He went out and bought stamps.	It was an angry stomp
st	s#sC	She is a Swiss student.	I heard she likes to steal..
	k#sC	I'll book screenwriters.	Joe picked at the scab.
sk	s#sC	She traps scapegoats.	Anna donated three scooters.
	p#sC	He wants cheap smokes.	The painters don't want to smear it.
sm	s#sC	He has a marvellous smile	For breakfast, I made two smoothies.
	p#sC	With this pill, he'll stop snoring.	He tried to step on a snail.
sn	s#sC	I bought him some sneakers.	The police shot two snipers.
	k#sC	You have to cook it slowly.	She always plays at the slot machines.
sl	s#sC	I have a new Christmas sleigh.	He bought a fancy slab.
		The sailor broke his compass.	The professor has written many books.
Filler		The couple bought a new mattress.	I don't like my new boss.
sentences		The boy gave her a kiss.	The bottle was full.
		In the city there are many cabs.	The old lady has five cats.
		Susan has three daughters.	The doctor gave her an injection.

Reading task - WORDS (24 critical, 20 fillers)

sp	st	sk	sm	sn	sl
spokesman	stamps	screenwriter	smoke	snoring	slow
spoons	student	scapegoats	smiles	sneaker	sledge
speak	stomp	scab	smear	snare	slot
spy	steal	scooters	smoothies	snipers	slab

	compass	daughters	followed	digital	because
Filler	mattress	tears	oxygenate	locked	bottle
words	kiss	dirty	room	newspaper	cats.
	city	aquarium	one-way	professor	injection.
	.				

Picture description task – WORDS (24 critical, 20 fillers)

<u>sp</u>	<u>st</u>	<u>sk</u>	<u>sm</u>	<u>sn</u>	<u>sl</u>
spanish	stone	skirt	smoke	snake	sloth
spoons	station	skull	smiles	snails	slingshot
space	strong	sky	small	snore	slipper
sports	stop	skate	smith	snowmen	sleep

	rice	dress.	Nose	pineapple	dragon
Filler	fork	bones	lips	leaves	feather
words	rocket	night	big	pillow	reindeer
	mirror	Hotel	salt	olaf	bed

Picture description task – SENTENCES (24 critical, 20 fillers)

		C#sC	*V#sC*
	t#sC	Eight Spanish flags.	Rocket flying to space.
sp	s#sC	Six spoons.	Three sports (soccer, basketball, golf).
	k#sC	Black stone.	Two strong men.
st	s#sC	Astronauts in Space station.	A stop sign.
	k#sC	Pink skirt.	Blue sky.
sk	s#sC	Dinosaur's skull.	Yellow skate.
	t#sC	Cat smelling tuna	Three smoke balls.
sm	s#sC	Six smiles.	Black smith.
	t#sC	Eighth snakes.	Boy snoring
sn	s#sC	Six snails.	Two snowmen
	t#sC	Eight sloths	Throwing a slipper
sl	s#sC	Six slingshots	Cow sleeping.