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CONSONANT CLUSTERS IN ONLINE L2 TEACHING: A MULTILINGUAL APPROACH

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L1-L2*map* and CALST (Computer-Assisted Listening and Speaking Tutor) are two complementary platforms for second language pronunciation teaching developed at the Norwegian University of Science and Technology (NTNU) in Trondheim. L1-L2*map* is a multilingual database that allows comparison of the phoneme inventories of a large number of languages. CALST is a Norwegian computer-assisted pronunciation training system (CAPT), which uses the result from the contrastive analysis in L1-L2*map* to select different pronunciation exercises depending on the native language of the user. The online version of L1-L2*map* and CALST contains segmental information and exercises for practicing the perception and production of individual sounds and sound contrasts. But for speakers of many languages, consonant clusters in a foreign language are hard to perceive and pronounce, even if the speakers have no difficulty with the individual consonants. The present article presents the expansion of the multilingual platforms with a contrastive analysis of consonant clusters and exercises to train their pronunciation. The article also discusses some of the methodological challenges in incorporating consonant clusters in L1-L2*map* and CALST.

INTRODUCTION

In second language courses, it is common to encounter learners with very different language backgrounds, especially when the language course takes place in the country where the target language is spoken. For instance, learners with varying native languages usually participate together in the same Norwegian courses taught at Norwegian universities. We can find, for example, Vietnamese, Spanish, Italian, German, Polish, Thai, French, Russian and Mandarin Chinese speakers attending the same Norwegian course. In such a teaching context, it is often difficult to train students in the pronunciation of a second language (L2): the difficulties learners experience generally vary depending on their native language (L1). Furthermore, teachers do not normally have an in-depth knowledge of the phonetics of all the course participants' native languages and, therefore, they do not always know beforehand which are the typical pronunciation challenges for each speaker. Moreover, there is usually not enough time in class to give corrective feedback to individual language learners (Koreman *et al.* 2011). As a possible solution L1-L2*map* and CALST were developed, two online tools for L2 pronunciation training, which take into consideration the sound properties of the user's L1 and its differences with the L2.

THE ONLINE PLATFORM: CONSONANTS AND VOWELS

Languages often show extensive overlap in the sounds they use. But a target language often contains consonants and vowels which are not part of the native language phoneme inventory. These sounds may present problems to learners.

L1-L2*map*: Multilingual Segmental Information

L1-L2*map* (http://calst.no/L1-L2map) is a multilingual database that allows comparison of the phoneme inventories of any two languages (a potential L1 and a potential L2) from a set of around 500 languages. Most of the segmental data available in L1-L2*map* have been extracted from UPSID (Maddieson 1984) and LAPSyD (Maddieson *et al.* 2011), two databases where the phoneme inventories and some basic phonological information about several hundred languages can be consulted. In addition to this, phonemic information of additional languages which are of interest because of their linguistic properties or because they are spoken by large groups of immigrants in Norway has been incorporated in L1-L2*map*. This comparative database is implemented as a wiki, so that language experts can at any time include the phoneme inventory of a new language and/or correct the existing data. The main difference between L1-L2*map* and UPSID/LAPSyD is that only the former allows direct comparison of the phoneme inventories of two languages.

In L1-L2*map* this segmental information is presented in very basic phonetic charts, which are based on the International Phonetic Alphabet charts. A simple color-coding is used to display the sound similarities and differences between two languages. As shown in the following figure, the phonemes that are present in both the L1 and the L2 are indicated in green; the phonemes that only occur in the learner's L1 are coded in blue, and, finally, those that exclusively occur in the L2 are signaled in red (Figure 1).

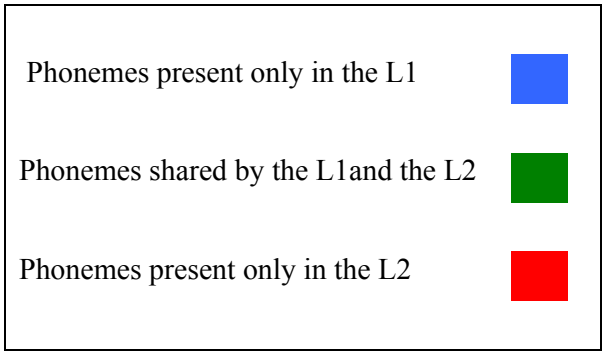

Figure 1. Color coding in L1-L2*map*

The phonemes in red are generally important from the L2 teaching perspective, because speakers tend to experience greater problems in distinguishing and producing unfamiliar sounds (i.e., sounds which are absent in their native languages, cf. Lado 1957). Flege (1995) and others have demonstrated that not all unfamiliar sounds in L2 are difficult to learn. Particularly, sounds which do not have a similar counterpart in L1 often do not present great difficulties. We nevertheless believe that learners must be given the opportunity to familiarize themselves with all sounds which do not occur in the learner's native language, and have therefore also included

unfamiliar sounds which are not necessarily difficult to distinguish from other sounds in the target language. (For more arguments in support of using the contrastive analyses hypothesis in the elaboration of pronunciation teaching materials, see Husby *et al.* 2011; Avery & Eilrich 1992.)

To better illustrate how the comparison of phoneme inventories is carried out and displayed in our database, the chart in Figure 2 below presents the results of a contrastive analysis in L1-L2*map* comparing the phonemic inventory of Mandarin Chinese (L1) with Northern Peninsular Spanish (L2). From this chart, the teacher of Spanish can infer for instance that Mandarin Chinese learners of Spanish will probably experience difficulties with the perception and realization of the fricatives [θ ʝ x], but not with [f s]. Similarly, Mandarin speakers can be expected to have difficulty with the phonemes /b d g/, also indicated in red in the chart. And in fact, difficulties with the realization of voiced stops by Mandarin speakers have been attested in the literature on Spanish L2 acquisition (e.g. Blecua & Esteve 2014 and references therein): Mandarin speakers tend to realize voiceless stops, which are closest to the target phonemes in their L1 (e.g. *estu[t]io* instead of estu[ð̞]jo 'I study') (for a more detailed discussion on how the multilingual comparison of segmental information is carried out at L1-L2*map*, see Koreman 2013).

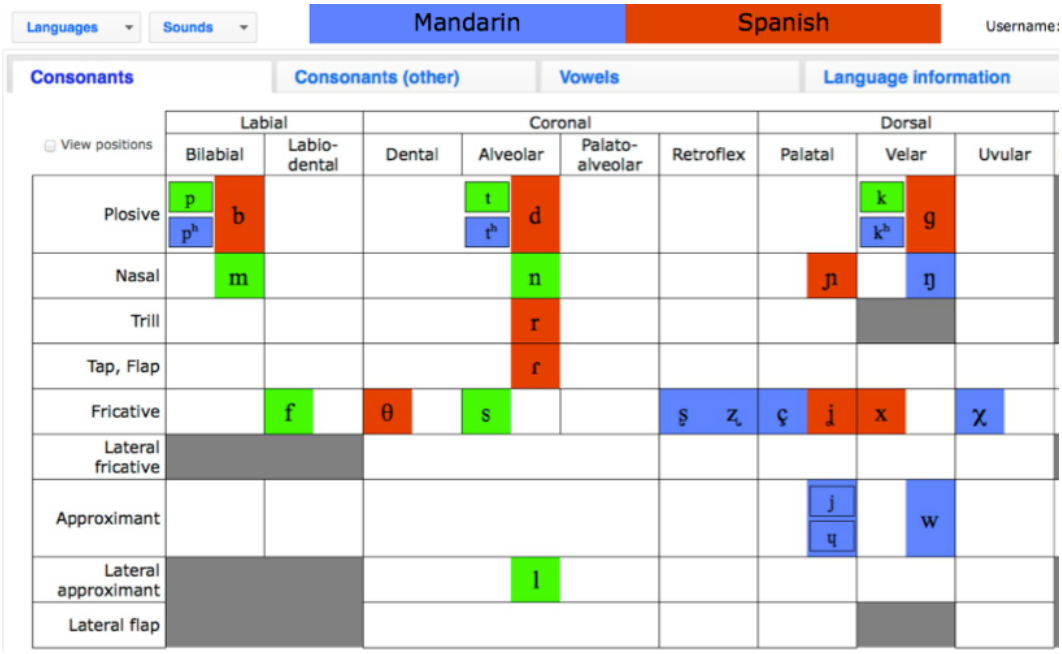

Figure 2. Lay-out of the result of a contrastive analysis comparing the phonemic inventory of Mandarin (L1) with Northern Peninsular Spanish (L2)

The phonemic level displayed in L1-L2*map* can be argued to capture insufficient pronunciation detail, since it does not reflect allophonic variation. For example, the chart above shows that Mandarin learners of Spanish are likely to have difficulty with the realization of the phonemes /b d g/, but it does not reflect the allophonic variation in the realization of these phonemes, which in

Spanish may surface as stops [b d g] or fricatives [β ð ɣ]/approximants [β̞ ð̞ ɣ̞] depending on the context. However, this is not a *big* problem from the teaching perspective: once the phonemes of a language are correctly identified, allophonic variants can be indirectly taught in exercises which contain words instantiating all possible allophones of a phoneme. For an accent-free pronunciation of the target language, allophonic variation must be given explicit attention, but at the level of communicative effectiveness, which is the main goal of our online platforms, this can be ignored.

Given the number of languages documented in our database, L1-L2*map* is a useful resource for language teachers who want to familiarize themselves with the phonemic inventory of the languages of their students. More importantly, by automatically establishing unfamiliar contrasts for different learners, the multilingual database becomes useful in yet another respect: its information can be automatically extracted and linked up to a computer-assisted pronunciation training system (CAPT). CALST, the *Computer-Assisted Listening and Speaking Tutor*, is such a system and uses the result from the contrastive analysis carried out in L1-L2*map* to offer different pronunciation exercises to the learners depending on their native languages. In particular, the phonemes of the L2 that are marked in red (unfamiliar to the user) will be linked to different types of sound contrasts exercises. Learners are directly presented with exercises and do not see the information in L1-L2*map,* which is intended for phonetically trained developers and language teachers.

CALST: Training New Sound Contrasts

CALST allows students to practice their pronunciation, listening and spelling skills. CALST is based on VILLE (Wik 2011), a Swedish CAPT system, and it is freely available online (http://calst.no). Learners can use it for free, not only during class hours, but whenever they have time to work on their Norwegian pronunciation skills. Importantly, CALST benefits from the contrastive analysis carried out in L1-L2*map*. The first time the learner logs in CALST, she must indicate her native and target language. Once this information is registered, the program automatically carries out a contrastive analysis and links the sounds in red in L1-L2*map* (i.e. the possibly problematic sounds) to specific exercises in CALST in which the sound is contrasted with other sounds with which it is likely to be confused. In this way, each learner gets to practice the unfamiliar sound contrasts in the L2 depending on her specific L1. At present, the listening and pronunciation exercises have been developed and recorded only for Norwegian. Because there is no accepted pronunciation standard in Norwegian, exercises have been developed for four main Norwegian dialects, with one male and one female role model for each dialect.

Figure 3 presents a screen view of one type of listening exercise (Listen & Click) in CALST. This exercise will be offered, for example, to a Spanish speaker (L1) who is learning Norwegian (L2). Recall from Figure 2 in the previous section that Spanish contains the underlying phoneme for the bilabial stop /b/ and, hence, we expect that Spanish speakers would not generally experience problems with the production/perception of such phoneme. However, Spanish phonemic inventory does not contain the labiodental fricative /v/. To train Spanish learners of Norwegian on the contrast /v/ *vs.* /b/, they are exposed to different minimal pairs where both sounds contrast in similar positions (word-initially or word-finally). The perception exercise illustrated in the screen view in Figure 3 is a so-called AXB exercise. In AXB exercises, the learner first hears the word on the left, with /v/, then the word on the right, with /b/, and after

that, she will hear one of the two words again and has to decide which of the two first words it corresponds to. Through this type of phonetic training with different minimal pairs, the learner can improve her ability in distinguishing these sounds (see Koreman et al. 2013 for a detailed explanation on other listening, pronunciation and spelling exercises at CALST).

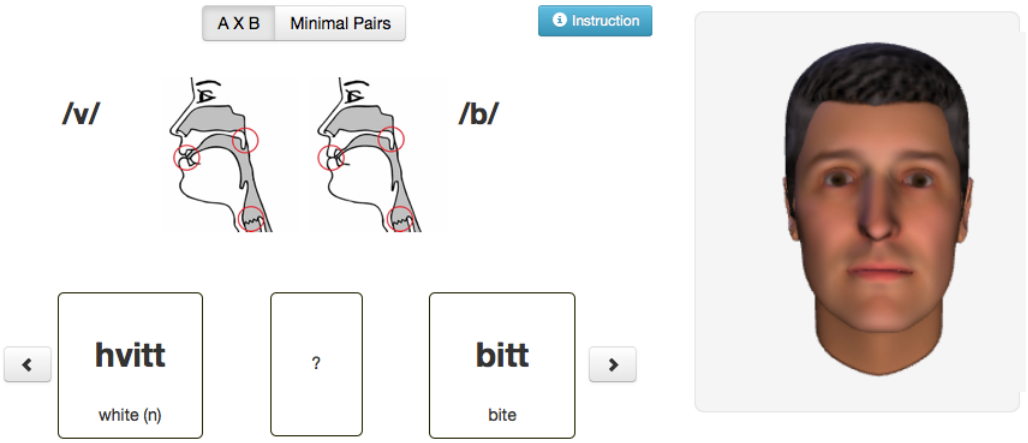

Figure 3. Screen view of a listening exercise contrasting a minimal pair beginning with /v/ *vs.* /b/

In addition to the exercises for new sound contrast, all users of CALST, independently of their mother tongue, have access to a list of general vocabulary exercises. In these exercises, learners can start to familiarize themselves with the sounds of the target dialect they want to acquire. These exercises allow practicing listening, pronunciation and spelling skills with a vocabulary consisting of around a thousand words and basic expressions.

Even if CALST currently contains only pronunciation exercises for several Norwegian dialects, it is important to highlight that it can easily be extended with other target languages (e.g. English, Spanish, French, etc.). Since the platform is modular, the extension of CALST is simple once exercise material is developed for other languages. CALST users who want to learn another L2 automatically take advantage of the multilingual contrastive analysis without any changes to L1-L2*map*.

CURRENT EXPANSIONS: CONSONANT CLUSTERS

It is not sufficient for L2 learners to practice the production/identification of individual sounds in contrast with similar sounds. The ability to combine consonants into clusters and/or to produce them in unfamiliar positions —different from the positions in which that same segment occurs in the L1— is a skill that needs to be practiced to ensure the intelligibility of L2 speakers.

Consider, for example, a Vietnamese learner (L1) of Norwegian (L2). Vietnamese and Norwegian both contain the phoneme /f/ in their inventory. However, /f/ displays a different distribution in the two languages: in English, the sound corresponding to the phoneme /f/ can occur in the onset and coda of a syllable (e.g. ***[f]****eel*, *lea****[f]***); by contrast, in Vietnamese, this sound can only occur in an onset position (e.g. ***[f]****ó* 'deal'). Since /f/ never occurs in the coda in Vietnamese, Norwegian words with [f] in the coda can be difficult to pronounce for a

Vietnamese speaker. Very often, instead of realizing a coda [f], speakers substitute it with an unreleased labial voiceless stop [p̄], especially at a beginner level (e.g. N. *sto**[p̄]*** instead of *sto**[f]***, meaning '*stop'* and *'fabric'* respectively). As in the example, the substitution of the labiodental fricative [f] by an unreleased stop [p̄] in the coda can cause misunderstandings, particularly when both words exist in the target language, as it is the case for our example words. In sum, learners need to acquire not only the sounds of the L2, but also their particular distribution of each segment in the target language.

Another example of the importance of learning more than just individual L2 segments is attested in the interlanguage of speakers whose native languages allow only very simple (or relatively simple) syllable structures, while the L2 they want to master contains more complex syllables. These speakers often experience difficulties with the pronunciation of complex onsets and complex codas in the L2. For example, Spanish speakers (L1) are able to pronounce /s/ and /k/ when they occur in a simple onset position in English (L2) (e.g. ***[s]****ea,* ***[k]****ey*). Even the cluster itself is not a problem, as demonstrated by the Spanish word [e**s.k**a.so] 'little, scarce' (with the dot indicating a syllable boundary). But when these segments form a complex onset as in ***[sk]****ype*, Spanish learners of English tend to repair this complex onset, absent in their native language, by inserting a vowel before the two consonants. Instead of producing the monosyllable *skype* they often utter something closer to [**e**s.kajp] or [**ə**s.kajp], with two syllables. In a similar way, Thai speakers, whose native language bans such complex onsets, often avoid them by inserting a reduced vowel after the /s/, e.g. [sᵊ.kaj] (Kenstowicz & Suchato 2006). This example shows in addition that, due to a native co-occurrence restriction in Thai, the final /p/ may be deleted after a glide in the interlanguage of these speakers (even though /p/ can occur syllable-finally in the language).

To summarize, native language restrictions seem to affect the production and perception of specific syllable types and consonant clusters in the L2 (Broselow & Kang 2013: 540). To enable training beyond single sounds, we decided to expand L1-L2*map* and CALST with multilingual information on possible consonant clusters and positional restrictions of segments. At the moment, our database contains this information for ten languages. In the remainder of this section we explain how this complex information can be now visualized in L1-L2*map*, we discuss the methodological problems we had to face when incorporating multilingual data on consonant clusters and explain how this information is used to develop new exercises in CALST.

L1-L2*map:* Consonant Clusters

L1-L2*map* offers a comparison of consonant clusters allowed in a pre-peak position (cf. onset) and a post-peak position (cf. coda) separately. Figure 4 below illustrates the comparison of consonant clusters as it appears in L1-L2*map*. In particular, this figure displays the comparison of possible pre-peak consonant sequences of two segments (C_1C_2-) in Norwegian (L1) and English (L2); that is, it lists and compares the possible consonant clusters of two segments that can occur before a sonority syllable peak in the two languages. The color coding we employ here is the same as in the segmental comparisons: (i) blue is used to mark complex C_1C_2- clusters allowed only in the native language of the learner (here: Norwegian), (ii) red indicates C_1C_2- clusters permitted only in the L2 (i.e. English) and (iii) green is used to signal C_1C_2- clusters which are common to both languages. The consonants listed vertically correspond to the first

consonant in the cluster (C_1); the consonants in the horizontal dimension indicate the consonants that can follow the first consonant (C_2).

The first row in Figure 4 shows that Norwegian and English both allow the clusters [pj-, pl-] before a vowel (green); it also shows that Norwegian in addition allows the cluster [pɾ-] (blue), while English permits the cluster [pɹ-], which does not occur in Norwegian (red). Ideally, this sequence and others highlighted in red (i.e. unfamiliar sequences for a particular learner, in this case a Norwegian learner of English) will be linked to specific production and perception exercises in CALST to support the learners in the acquisition of these new pre-peak consonant clusters. Once the English version of CALST is developed, a Norwegian learner of English, will, for instance, get exercises which would allow her to practice: (i) the clusters [pɹ-] as well as any other clusters that have the sound [ɹ-] as a second element in the cluster and (ii) *some* clusters containing the glides [j, w] in a second position (e.g. [kj-] and [kw-]). From the comparison in Figure 3, we can conclude that Norwegian and English are not generally very different with respect to possible C_1C_2-, but making this automatic comparison allows Norwegian students of English to focus on those clusters which will probably be more difficult for them, rather than offering them training on all possible clusters.

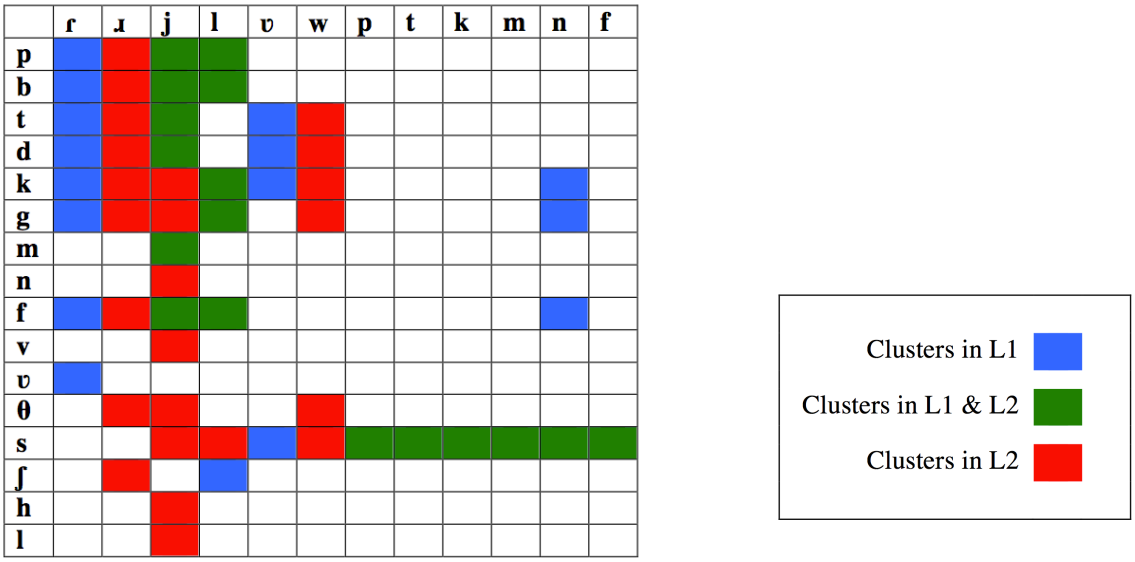

Figure 4. Screen view of the result of a contrastive analysis comparing pre-peak consonant clusters of two segments (CC-) in Norwegian (L1) with English (L2)

*Introducing Multilingual Phonotactic Data in L1-L2*map

This section offers some methodological considerations in the implementation of a contrastive analysis of consonant clusters. Since UPSID and LAPSyD do not offer complete lists of possible consonant clusters for each language, and we are not aware of other linguistic databases where this information can be easily consulted, we started recompiling specific syllabic information

from grammatical descriptions for the following ten languages: Norwegian, Spanish, English, Mandarin Chinese, Farsi, Vietnamese, Thai, Polish, Tagalog and Japanese. These languages were selected for both practical and typological reasons. On the one hand, we were interested in having data for languages representative of various language families with very different syllabic restrictions. On the other hand, we selected native languages which are quite frequent in Norwegian courses, so that the language information can already be of help for learners and teachers of Norwegian. We hope that L1-L2*map* will be expanded with additional data in the future in collaboration with other languages experts.

We first coded the segments and combination of segments that can occur *before* the syllable sonority peak in the above-mentioned languages (this is generally a vowel, but it can also be a consonant in languages which allow syllabic consonants) in the above-mentioned languages. Secondly, we coded the information related to specific segments and combinations of segments that can occur *after* the syllable sonority peak. We defined pre-peak and post-peak material (instead of onset and coda) to avoid analytical problems related to the particular association of prevocalic and postvocalic glides, which in some languages are analyzed as being part of the nucleus, but in others as being part of the onset for rising diphthongs or of the coda for falling diphthongs (see Smith 2007 for discussion). For teaching purposes, it is crucial to know whether both the L1 and the L2 admit, for example, a sequence like [Liquid+Glide] before the syllable peak. If linguists analyze the glide in L1 as being part of the onset, but in the L2 as part of the nucleus (together with the syllable peak), we are assuming that this is not relevant for teaching the pronunciation of the L2. The relevant fact is that the two languages are *equal* with respect to the presence of the sequence [Liquid+Glide]. When a speaker gets to practice the realization of complex sequences in the L2 in CALST, she will not get exercises focused on the sequence [Liquid+Glide]. Only speakers with an L1 that lacks the [Liquid+Glide] sequence at the beginning of a syllable would get such exercises.

By providing only the possible pre-peak and post-peak sequences of languages, we do miss some important linguistic generalizations since, very often, there are restrictions that hold over the whole rhyme (i.e. the nucleus and the coda) or over the onset and the nucleus. For instance, in Urban East Norwegian the vowels [e, ɛ] are in general blocked in front of the consonants /r/ and /ɽ/ and also before the glides /j/ and /ʋ/ (Kristoffersen 2000:14). However, annotating all the possible syllables of a language –rather than just the possible pre-/post-peak sequences– would substantially increase the complexity of each language description, making the comparison between languages very difficult and redundant. Furthermore, we believe the L2 learner will indirectly learn this phonological, structural information when she is exposed to specific data and real examples in CALST. What is important for learners at the beginner level is to familiarize herself with the perception and production of unusual consonants clusters.

CALST: Developing Consonant Clusters Exercises

As explained previously, CALST currently contains exercises which allow learners to familiarized themselves with the pronunciation of general vocabulary, as well as with the discrimination and production of new sound contrasts not present in their native languages. Moreover, building on the information on consonant clusters, which has been implemented in L1-L2*map*, we are now expanding CALST has now been expanded to include pronunciation and listening exercises which allow learners to practice their production and perception of consonant

clusters too. We have now created the Norwegian material for exercises to correct five common repair strategies for consonant clusters: a) simplification (reduction of the cluster, e.g., [st-] > [s-], [t-] as in ***t****op* or ***s****op* instead of ***st****op*), b) substitution (of one of the consonants, e.g., [br-] instead of [bl-]), c) metathesis (esp. in [st-] and [-ts] clusters, e.g. ***ts****op* instead of ***st****op*), d) prosthesis (vowel insertion *before* a cluster, e.g., ***e****stop* instead of ***st****op*) and e) epenthesis (vowel insertion *in* the cluster, e.g. *s****e****top* instead of ***st****op*). This material has been recorded and implemented in exercises in CALST.

A possible listening exercise (Listen & Click) for the Norwegian version of CALST is a minimal pair exercise. This exercise is similar to the sound contrast exercise displayed in Figure 3, except that the learner now only hears a single word. The learner is visually presented with two word alternatives, one of which contains an unfamiliar cluster (signaled in red in L1-L2*map*), while the other has undergone one of the repair strategies attested in L2 interlanguage (see above). For instance, imagine we want to train a particular user in the acquisition of the cluster [st-], which is banned in many non-Germanic languages. The learner will see on the computer screen the Norwegian words <sta> - <ta> (E. “stubborn”, “take”) or <sta> - <sa> (E. “stubborn”, “said”), while one of the words is pronounced by the virtual tutor. The learner has to choose the word she is hearing by clicking on the corresponding button on the computer screen.

Vowel insertion cannot be corrected in listening exercises such as the exercise described above, because there are very few relevant minimal pairs in Norwegian (e.g. ***br****o* [ˈbruː] ‘bridge’ vs. *b****e****ro* [bəˈruː] ‘to rest, to wait’). Pronunciation exercises will, however, offer an opportunity to learn to avoid these repair strategies. In pronunciation exercises (Listen & Speak), learners can train the pronunciation of words with unfamiliar onsets or codas. After listening to the artificial tutor’s pronunciation of a word with the complex onset [st-], for instance, the user records herself and then plays the realization of the word pronounced by the artificial tutor again, followed by the recording of her own voice. By comparing these, she can self-evaluate her pronunciation. In future, we aim to incorporate automatic speech recognition techniques in CALST, so that the artificial tutor will be able to detect pronunciation errors. Automatic speech recognition will not only help to detect vowel epenthesis repairs (e.g [est] or [set] instead of [st-]), but also the use of other repair strategies by the learner.

Finally, spelling exercises (Listen & Write) further strengthen the learner’s association of the perceived clusters with their orthographic representation. For reasons of space, we refer the reader to the CALST platform for examples of Listen & Write exercises, under “Vocabulary”.

FUTURE EXPANSIONS AND CONCLUSIONS

L1-L2*map* and CALST arose to train L2 learners in the acquisition of unfamiliar segments and new sound contrasts. We have explained in this paper how both platforms have been expanded to also incorporate information about consonant sequences. Still, the acquisition of an L2 sound system requires more than learning the new segments and their phonotactic restrictions in the L2. Learners must also acquire a new prosodic system, including (i) the position and phonetic cues of stress (in cases where the L2 has stress), (ii) the tonal patterns (in languages with lexical tones, but also in pitch-accent languages) and (iii) the intonational patterns of the language (Broselow & Kang 2013).

In the future, we hope to extend L1-L2*map* and CALST with information about the position of stress, making use of the StressType database (http://st2.ullet.net/), which contains information about stress in a large number of languages. Since there is no universal system which enables a contrastive analysis of lexical tones and intonational patterns, this will be implemented for Norwegian in CALST without reference to a contrastive analysis. Additionally, we will develop exercises to train the perception and production of Norwegian pitch accent and Norwegian intonation.

Finally, as we indicated in the introduction of this article, we hope to develop CALST with exercises for other languages, so that leaners of other L2s can also benefit from this multilingual approach to language teaching.

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