Processing Swedish Word Accents

-evidence from response and reaction times

Pelle Söderström

Lund University

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Supervisors:

Merle Horne

Mikael Roll

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Rydw i'n hoffi coffi!

Abstract

The effects of Central Swedish word accents on morphological and semantic processing were investigated. It was found that Accent 2-inducing suffixes preceded by an Accent 1 tone were more difficult to process compared to Accent 1-inducing suffixes preceded by Accent 2. This effect was relatively task-independent, i.e. found both when participants judged the tense or number of the word and when they simply listened to the word and pushed a button at word offset. The effect was absent when de-lexicalised stimuli that lacked lexical information were presented. This suggests that there is a stronger association in the mental lexicon between suffixes and Accent 2 compared to Accent 1. Also, correct Accent 2 words took longer to process compared to correct Accent 1 words. It was suggested that this is due to the extra lexical information that is activated upon hearing the Accent 2 tone. When e.g. a suffix is heard, the competing lexical candidates need to be de-activated. In addition, correlation analyses showed that shorter auditory stimuli elicit longer response and reaction times. This will have important implications for improving future response/reaction time experiments.

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1. Introduction

The aim of the present response time study was to investigate the effects of word accents on the morphological and semantic processing of words in Central Swedish. Particularly, the effect of stem tone/suffix match and mismatch on word accent processing was tested by using response and reaction times under different test conditions. Previous studies have provided insightful results, but more work is necessary in order to draw better conclusions about the relationship between word accents and morphological processing. In particular, previous studies have indicated that word accents are used predictively in online speech processing (Roll, Horne & Lindgren 2010; Söderström, Roll & Horne (in press)). For example, results indicate that the high tone of Central Swedish Accent 2 on a word stem is used to cue and predict the meaning of a specific upcoming suffix. These previous studies also suggest that word accents are associated with certain suffixes rather than with whole words in the mental lexicon. This has been supported by the finding that when a supposed "Accent 2-inducing" suffix is preceded by a mismatched Accent 1 tone, parsing breaks down, something which does not seem to happen in the opposite case, i.e. when an Accent 2 is mismatched with an Accent 1-inducing suffix. This suggests that there is a stronger association between Accent 2 and its suffixes as compared to Accent 1. However, further work is necessary in order to be able to generalise results. For example, previous studies have focused either on verb or noun processing. In the present study, both verbs and nouns were used, along with "task" and "no-task" conditions, in order to investigate the effect of linguistic task on word accent processing.

It has been suggested that the response time results obtained in Söderström, Roll & Horne (in press) could be explained by the duration of the stimuli, e.g. that longer stimuli simply elicited longer response times. It was not clear to what degree duration and acoustic stimulus differences influenced the results or whether they could be explained by a lexical association between the stem tone and suffix. For this reason, a methodological section of the present study focuses on the effects of stimulus duration on response and reaction times, to see if participants could have used only stimulus duration as a cue. Also, de-lexicalised stimuli were created, keeping the F0 contour intact whilst removing all lexical information. This allowed for a comparison between lexical and non-lexical stimuli, where the lexical stimuli were assumed to contain more higher-level linguistic information compared to the non-lexical stimuli.

Before moving on to details of the present experiment, several aspects of the Central Swedish word accents will be discussed, including previous studies on the subject, in order to provide a foundation for the discussion and interpretation of the data. In addition, methodological issues regarding response and reaction times will be presented. This will in turn be followed by the hypotheses being tested, along with details regarding the experimental design and results.

2. Background

2.1. An overview of Swedish word accents

Word accents are used in most – but not all – varieties of Swedish and Norwegian to prosodically differentiate between, for example, word meanings. It has been suggested that the word accent distinction arose from a Proto Nordic resolution of lexical stress clash in disyllabic words and that the de-stressing of secondary stress removed intensity and duration distinctions, leaving in place a tonal contour which "separates pitch information from other stress information" and created a separate phonological tonal tier where the tonal information became lexical (Riad 1998:5).

There are two word accent patterns in Swedish, *Accent 1* and *Accent* 2. Word accents are used in most Swedish dialects, with exceptions in the northern part of the country and Finland Swedish. Instead of using the word accent distinction, speakers of northern dialects and Finland Swedish rather generalise the Accent 1 pattern onto words. For the purposes of the present study, the focus will lie on the Central Swedish word accent patterns, namely *2a* in Gårding's typology (Gårding 1974). These are present mainly in an area spreading north and east from the capital Stockholm. There are two principal parts in the analysis of the word accent patterns: the timing of the tonal gesture and the realisation of focus. The tonal realisation of the word accents can be described as follows: Accent 1 consists of a gesture which rises to a high tone in the pretonic syllable and then falls to a *low* (L) tone in the stressed syllable. The pretonic syllable is the one immediately preceding the stressed syllable. If there is no pretonic syllable, only the L* tone is realised. In Accent 2, the gesture rises to a *high* (H) tone in the beginning of the stressed vowel and then falls through the syllable. Both tonal gestures are normally analysed as either HL* (Accent 1) or H*L (Accent 2), where the asterisk signals which tone (L or H) is associated with the stressed vowel. Sentence-level focus adds a tonal rise after the stressed syllable. Since we are interested mainly in the critical effects of the word accent association with the stressed vowel, the words in the present study were pronounced without sentence focus, i.e. omitting the final tonal rise. In the present study, single unfocused words beginning with a stressed syllable were used as test stimuli. See Fig. 1 for an averaged F0 curve over the course of a stressed syllable from the material in the present study. There were no pretonic syllables in which the rise to a high tone in Accent 1 could be realised. This is acceptable, because the tonal gesture in Accent 1 is more context-dependent compared to Accent 2 (Engstrand 1995): the pretonic syllable and its associated tonal rise to a high tone can be omitted in Accent 1 while the high tone falling through the stressed syllable in Accent 2 is a stable feature of the accent pattern and thus context-independent. Following this, the analysis can be simplified from a perceptual point of view: the stressed vowel in Accent 1 is associated with a "low" (L*) tone while Accent 2 is associated with a high tone followed by a fall. This is supported by the finding by House (1990) that in areas of rapid spectral change (such as consonant clusters), sensitivity to pitch movement decreases. Since the H in Accent 2 is realised in an area of relative spectral stability (i.e. a vowel), it is more easily perceived as a high tone. As is visible in the diagram in Fig. 1, the tonal difference between the two accent patterns at vowel onset is on average 7.7 semitones (*re* 100 Hz). This quite considerable pitch difference contributes to the perception of a high vs. low tone.

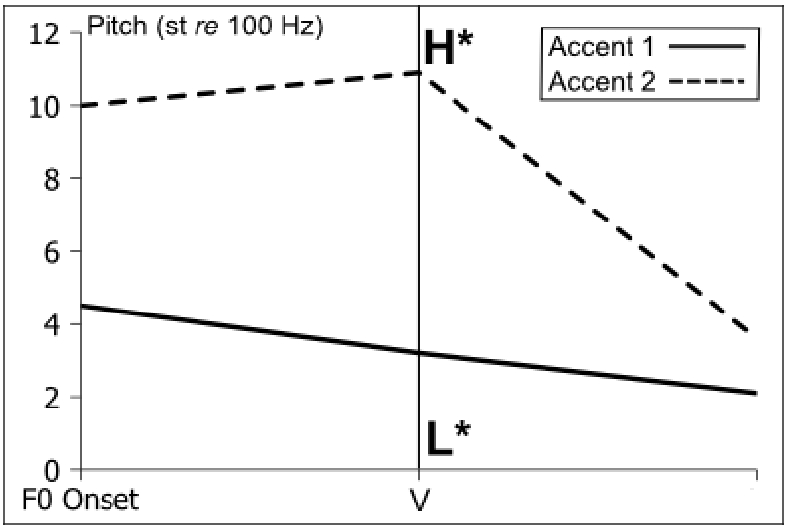

Figure 1. Visualisation of the average F0 differences between Accent 1 and Accent 2 in the stressed syllable from F0 onset to the end of the word accent fall. The vertical line (V) signals the onset of the stressed vowel. The data is taken from average F0 measurements of utterances from the two speakers in the present study.

In Söderström et al. (in press), unfocused test stimuli were created by placing narrow focus on a pronoun which preceded the test word (e.g. *HAN röker$_1$*, 'HE smokes' and *HAN rökte$_2$*, 'HE smoked', where capital letters signal narrow focus and the subscript number indicates which word accent is associated with the stem). In other studies (e.g. Roll, Horne & Lindgren 2010), unfocused test words were also placed in a defocused position in a larger syntactic unit, leading to the natural defocusing of the test words.

2.2. Lexical function of the word accents

At this point, it is important to note the differences between the tonal gestures of the Scandinavian word accents and those used in tone languages such as Chinese and Thai. In the latter languages, the tones are associated with whole words in the lexicon (cf. Wang 1973) while in the former they are more dependent on the morphological properties of the words. In Swedish, the word accents are associated with certain suffixes rather than with whole lexical items (Riad 2009). Thus, the accent difference between the words in the minimal pair *strid*$_1$*-er* ('struggles' VERB PRES, cf. *att strida* 'to struggle') and *strid*$_2$*-er* ('struggles', NOUN PLUR INDEF, cf. *en strid* 'a struggle') is clearly dependent on the present tense verb suffix *–er* which assigns Accent 1 to the stem and the plural noun suffix *–er* which assigns Accent 2[1]. In contrast, the Chinese syllable *ma* could mean 'mother', 'horse', 'hemp' or 'to scold', depending on which tone is associated with it (Brown-Schmidt & Canseco-Gonzalez 2004). Following this, it is clear that the lexical tone used in Chinese conveys more purely lexical semantic information as compared to the Swedish word accents, which are rather strongly associated with grammatical meaning.

2.3. Morphophonology of the Swedish word accents

There are about 350 distinctive word accent pairs in Swedish (Elert 1972), i.e. pairs which are only distinguished by the word accent associated with the word. A common example is the pair *anden*$_1$ – *anden*$_2$ ('the duck' NOUN SING DEF, from *and* 'duck' – 'the spirit' NOUN SING DEF, from *ande* 'spirit'). Often, the words do not even belong to the same word class, such as *buren*$_1$ ('the cage' NOUN SING DEF, from *bur* 'cage') and *buren*$_2$ ('carried' PERF PASS PART, from *att bära* 'to carry'). However, one of the most important actively productive functions of the word accents is (morphological) *connectivity* (see e.g. Bruce 1998): word accents are determined by the morphological and phonological structure of the words, i.e. which constituents are connected. It also means that this function gives listeners clues as to whether another constituent/syllable is coming up. Thus, hearing an Accent 2 tone on a stem is most likely a signal that another syllable associated in one way or another to the stem will follow. As has already been mentioned above, the word accent pattern associated with a word is often dependent on which suffixes it is associated with (recall the verb-noun pair *strider*$_1$ – *strider*$_2$). Also, compound words in Central Swedish receive Accent 2. Thus, when e.g. the two monosyllabic nouns *båt*$_1$ ('boat') and *hus*$_1$ ('house') are combined into the compound noun *båthus*$_2$ ('boat-house'), the compound receives Accent 2.

Unanalysed loanwords from e.g. English into Swedish receive Accent 1, such as *smoking*$_1$ ('smoking' NOUN) and *hockey*$_1$ ('hockey' NOUN, but compare the Accent 2 compound *ishockey*$_2$ 'ice hockey'). Swedes speaking foreign languages also generalise Accent 1 onto words (Bruce 1998). In contrast, when words are incorporated into the lexicon and analysed according to the

[1] Note, however, that Accent 1 might be assigned by post-lexical rules; this will be discussed further below.

phonological and morphological rules of Swedish, English words like *mobbing*$_1$ and *stalking*$_1$ which already contain the English suffix *-ing* have after some time been analysed as consisting of the stem followed by the productive Swedish suffix *–ning*. Since this suffix induces Accent 2 onto stems in Swedish, these loanwords are consequently associated with Accent 2: *mobb*$_2$*-ning* and *stalk*$_2$*-ning*. A more common example is borrowed nouns which receive their word accent pattern depending on productive singular and plural suffixes, such as *chatt* 'chat' or 'chat room', which becomes *chatt*$_1$*-en* ('the chat' or 'the chat room' NOUN SING DEF) and *chatt*$_2$ *-ar* ('chats' or 'chat rooms' NOUN PLUR INDEF).

The question of the lexical specification of one or both word accents has been widely discussed, i.e. whether words or inflectional/derivational affixes (such as suffixes) are specified in the mental lexicon for either Accent 1 or 2 or whether tone association rules are applied post-lexically. It has often been suggested that Accent 2 is the only accent pattern associated with morphemes in the mental lexicon, and that Accent 1 is a post-lexical, "default" accent. For example, Riad (2003) claimed that Accent 1 is "pure intonation", while Accent 2 is lexical tone plus intonation, meaning that in the absence of lexical specification, Accent 1 would prevail. Gussenhoven & Bruce (1999) also viewed Accent 1 as the default accent. Supporting the opposite view, Lahiri, Wetterlin & Jönsson-Steiner (2005) have proposed that Accent 2 in fact is the post-lexical accent. Experimental evidence for lexical specification will be discussed in section 3, and the related question of accent pattern markedness will be investigated in 2.4.

It is especially the connective function of Accent 2 and the association between word accent and morphology that has led to the suggestion that word accents could be used predictively in online speech processing, i.e. used to predict that a particular suffix is coming up. It has also been suggested that there is a difference between Accent 1 and 2 in this regard. As will be seen below, evidence from previous response time experiments show that this in fact could be the case, even though more research is needed in order to obtain more conclusive evidence.

2.4. Word accents and markedness

The concept of *markedness*, i.e. the idea that things such as certain linguistic phenomena can be viewed as either *marked* or *unmarked* has attracted much attention, especially in the 20th century structuralist tradition. Discussing phonetic obstructions (e.g. stops) in phonological systems, the Prague school linguist Nikolay Trubetzkoy suggested that the unmarked member of an opposition is the one that deviates the least from normal breathing (Trubetzkoy 1969), while something that deviates more would be marked. This question has also been raised with regard to the Swedish and Norwegian word accent distinction, since the word accent realisations differ both phonetically and phonologically.

It has often been suggested that Accent 1 is the unmarked (default) member of the opposition, while Accent 2 is marked (Rischel 1963, Riad 1998, Riad 2009). Phonetically, Accent 2 involves a higher tone as compared to Accent 1 and subsequently a higher frequency of vocal fold vibration (Roll, Söderström & Horne 2011a). Accent 2 can thus be seen as the *phonetically* marked member of the pair. Also, the unmarked, "default" status of Accent 1 is also supported by the fact that "in areas where the accent distinction is lost, Accent 1 is typically generalised" (Riad 1998:2). However, Accent 2 can also be seen as marked from other perspectives. For example, Accent 2 seems to be marked with regard to cognitive complexity. As has already been mentioned, this accent pattern is productively used in compound forms in Central Swedish. The high tone itself could then be used during online speech processing to predict upcoming linguistic information. While hearing a high tone would theoretically activate a larger number of associated lexical items, parts of compounds, suffixes etc., the low tone of Accent 1 would only be associated with a smaller, less productive class of words. For example, hearing the syllable *rök*$_1$ ('smoke') would only activate e.g. the noun *rök* ('smoke'), the imperative form *rök!*$_1$ and the present tense verb *röker*$_1$. The syllable *rök*$_2$, on the other hand, would signal that apart from e.g. the past tense verb *rökte*$_2$, any compound noun or verb starting with this syllable could be coming up: nouns such as *rökpaus*$_2$ ('smoke break' NOUN) and *rökförbud*$_2$ ('smoking ban' NOUN) or verbs such as *rökdyker*$_2$ (lit. 'dives in smoke (e.g. a fireman)' VERB PRES). This could mean that the Accent 2 tone leads to an increased cognitive complexity as compared to Accent 1, and could thus be said to be marked in this respect (Roll, Söderström & Horne 2011a; Roll, Söderström & Horne 2011b).

2.5. Previous studies on word accent processing

Roll (2009) and Roll, Horne & Lindgren (2010) tested the effects of stem tone mismatch on sentence processing and comprehension, using EEG/ERP (electroencephalography/event-related potentials). Similarly to the present study, stems with either a low (Accent 1) or high (Accent 2) tone were combined with either matching or mismatching suffixes (e.g. matching *mink*$_1$*-en* 'the mink'/*mink*$_2$*-ar* 'minks' or mismatching **mink*$_1$*-ar*/**mink*$_2$*-en*). Only nouns in non-focal positions, i.e. without the final focal rise, were investigated, embedded in larger sentences. Along with the matching/mismatching accent condition, declensionally mismatching suffixes were also used, such as **mink*$_1$*-or*. Participants were asked to judge sentence acceptability ("OK"/"Wrong") of the auditorily presented stimuli while the EEG was recorded. It was found that the plural suffix *–ar* elicited a P600 effect when preceded by a stem with a mismatching low

Accent 1 tone, suggesting that reanalysis occurred because of the illicit word form (tone/suffix combination). No such effect was found for the singular suffix *–en* preceded by an Accent 2 tone. This suggests that there is a stronger connection between the Accent 2 tone and its associated suffixes than between suffixes and Accent 1. Also, a pre-attentive P200 effect was discovered for Accent 2, possibly reflecting attention being diverted to important upcoming linguistic information. This effect was not found for Accent 1. Taken together, these data suggest that the Accent 2 tone is used online to predict upcoming information, such as inflectional suffixes. Furthermore, no enhanced N400 effect was found for tone/suffix mismatch, indicating that there was no problem with lexical retrieval and that the tones do seem to be associated with suffixes in the mental lexicon rather than with whole word forms (as is the case in e.g. Chinese).

Using a different experimental paradigm than that of Roll (2009) and Roll, Horne & Lindgren (2010) and measuring response times rather than EEG, Söderström, Roll & Horne (in press) further investigated the effects of stem tone mismatch on suffix processing. Only verbs were used as test words. These occurred in short utterances beginning with a pronoun in narrow focus followed by a defocused verb in either the present or past tense, e.g. *HAN* $rö_1$*-ker,* 'HE smokes' or *HAN* $rö_2$*-kte,* 'HE smoked'. Capital letters signal narrow focus. Half of the stimuli featured a stem tone/suffix mismatch. Participants were asked to judge whether the verb was in the present ("Now") or past tense ("Then") (i.e. pressing one button for "Now" and another for "Then"). As expected from the results obtained in Roll et al.'s (2010) experiment, the longest response times were found for utterances where an Accent 1 tone preceded the past tense suffix *–te*, suggesting that these utterances were the most difficult to process and that the tones are used to predict upcoming information. It also suggests that processing difficulties arise when the tone is absent and does not activate its suffix. In addition to this result, it was found that response times were longer for utterances with past tense suffixes compared with those with present tense suffixes. It has been suggested that there is a stronger tone/suffix association for Accent 2 and its related suffixes. Also, it is possible that hearing an Accent 2-inducing suffix activates a neural representation of the tone. This was taken to mean that past tense suffixes, which are assumed to induce Accent 2 onto preceding stems, increased processing load, due to the added lexical specification and/or activation of more lexical material. However, future studies need to investigate this further, to see whether the suffixes actually activate the associated stem tone in some way. The present study also used noun suffixes which differ less in their segmental form as compared to verb suffixes. This allowed for testing whether the previous result was influenced by the different segmental features of the different suffixes. However, since verbs and nouns are processed differently in the brain (e.g. Pulvermüller, Lutzenberger & Preissl 1999), the comparison between word classes may not be so straightforward. Also, Swedish noun suffix morphology is possibly more complex than verb morphology from a semantics point of view: noun declension in Swedish critically involves number, gender and definiteness (cf. *båten* 'the boat' number: SING, gender: COMMON, definiteness: DEF, *båtar* 'boats' PLUR COMMON INDEF) while verb inflection critically involves tense and lacks information about gender and number (cf. *täcker* 'covers' PRES, *täckte* 'covered' PAST).

Increased response times and processing load for Accent 2 words were also found in a study by Felder, Jönsson-Steiner, Eulitz & Lahiri (2009). After hearing the initial syllable of a word, such as *ham*$_1$- or *ham*$_2$-, participants judged whether the upcoming word was (the focal version of) *hambo*$_1$ 'Hambo' (a traditional Swedish dance) or *hampa*$_2$ 'hemp' and response times were measured. It was found that response times for Accent 1 words were shorter (886 ms) than for Accent 2 words (992 ms). This suggests an increased processing load for Accent 2, possibly related to the activation of certain suffixes and other lexical material (e.g. compound forms take Accent 2, such as *rökpaus*$_2$ 'smoke break'). However, since focal versions of the words were used, it is possible that this contributed to the results and that participants responded quickly to the Accent 1 stems because of the focal rise associated with the stressed vowel in that accent pattern. Also, it is not immediately clear what this would mean in the context of morphologically conditioned word accents, since the task was to identify a non-affixed word, i.e. a word without a clearly distinguishable stem and suffix.

Ambrazaitis (2009) found increased response times for words (present tense verbs) where an Accent 2 suffix (present tense ending *–ar*, i.e. *lovar* 'promises') had been associated with a mismatching focal Accent 1 stem. However, the opposite did not hold: a mismatched Accent 2 stem with an Accent 1 suffix (present tense ending *–er*, i.e. *lever* 'lives') did not increase response times (ibid.), showing the same effect as the absent P600 for this condition in Roll et al. (2010). This lends further support to the suggestion that Accent 2 is lexically specified and that Accent 1 is the default accent, and also that Accent 2 might be considered to be *marked*, in comparison to Accent 1.

3. Methodology

In this section, various aspects of the methods used in the present study will be treated. Since both response times and reaction times are used, a brief discussion of the difference between these two measurements will first be made. The term *response time*, as opposed to *reaction time*, is taken to mean the time that elapses between a stimulus and a *response* (such as "yes"/"no" or "present"/"past") rather than a simple reaction (such as pressing a button upon simply hearing or seeing a stimulus). The former is sometimes called *choice reaction time*, reflecting the fact that the participant is forced to make a choice e.g. regarding the quality of the stimulus. As will be discussed below, response times are interesting because of the mental processes that can be inferred from them. A simple reaction time could possibly only reflect a motor response to a simple visual or auditory stimulus.

Since both response time and reaction time measurements were made in the present study, it is important to define and operationalise these two concepts carefully. *Response* times were measured in the condition involving a linguistic task where participants judged the tense or number of the word (LexTask, for "lexical" and "task"), i.e. they were response times because they involved a binary choice between two grammatical categories and a more complex task. Response times were measured from the *stem final plosive*, i.e. the disambiguation point where participants received the "final clue" as to which word they actually heard (e.g. *bå-ten*$_1$ (Acc1Match) and mismatching **bå-tar*$_1$ (Acc1Mis) are tonally (and segmentally) identical up until suffix onset, see Figure 2 below). It is worth noting that the disambiguation point at the beginning of the stem-final consonant will be referred to as the "suffix onset" below, even though the suffixes were *–en* and *–ar* in these cases. This is due to the fact that the test stimuli were created by concatenating stems and endings, clipped in the closure phase of the final stop.

Reaction times were measured in the two conditions LexNoTask (for "lexical" and "no-task") and DelexNoTask (for "de-lexicalised" and "no-task"). They differ slightly from the traditional definition of reaction times. The normal reaction time task would be to *react* to a stimulus (such as a flash of light) and execute a motor response as soon as possible. In the present experiment, participants were asked to push a button when the *word had ended*. Reaction times were thus measured from word offset. "No-task" is taken to mean that there was no complex choice between grammatical categories involved and that they were non-linguistic, i.e. they did not require participants to analyse the stimuli at a higher linguistic level. However, since lexical information was still present in the LexNoTask condition, it is possible that this information was used to predict when the word was going to finish. Naturally, this was not possible in the condition DelexNoTask, since segmental information had been removed. This will be discussed in more detail in Method.

3.1. Methodological aspects of response times and reaction times

Taking inspiration from work on propagation of electricity in animal sensory nerves, Franciscus Donders (1868/1969) conducted experiments that found that "the time that elapses between the stimulus and the response includes a particular mental process" (ibid. p. 417). One of Donders' most important ideas was that subtracting the average response time to a task from another would isolate a difference that is particular to that task. He also found that simple reaction times were always faster than the more complex choice reaction (or response) times. For example, if one task requires participants to simply push a button in reaction to a visual stimulus (e.g. a flash of light) and another task requires the participants to decide whether the light was blue or red, subtracting the response time of the former task (which should be shorter) from the latter (which should be longer) would reflect actual processing time differences between the two tasks. To give a grossly simplified practical example, if the response time on average was 200 ms in the "simple" condition and 250 ms in the "complex" choice condition and if all other task variables were equal, it is probably the case that the extra 50 ms in the complex task reflected crucial task-dependent differences, i.e. the participant choosing between the red and blue buttons before making a choice. The remainder of the response time then reflects similar processes, such as preparatory and motor processes necessary for simply pushing a button or any other mental processes that are task-independent, but "only if the mean durations of the stimulus detection and motor execution stages are invariant across these two tasks" (Miller & Low 2001:266). However, Miller and Low (2001) found that the timing of processes related to motor planning and execution do not differ widely, "even when the perceptual and cognitive requirements of the task are varied" (ibid. p. 279). Thus, when response and reaction times to e.g. words with matching and mismatching tones are compared, motor response times are the same and the differences that remain should be due to the processing of the word accent patterns or suffixes.

Basic research conducted on reaction times in the 19th and early 20th century is still of use today when designing experiments and stimuli. For example, James Cattell (1886) found that the intensity of a visual stimulus (e.g. a flash of light) influenced reaction times, which were shorter for stimuli with higher intensity. Also, in an unpublished experiment with 21 participants performed concurrently with the main word accent experiment in Söderström, Roll & Horne (in press), participants responded 20 ms faster to "high" (~523 Hz) tones as compared to "low" (~262 Hz) tones. In that experiment, participants received training and were asked to press a button to choose whether they heard the "low" or the "high" tone. The tones were separated by one octave. It could be expected that the high tone would involve more cognitive processing. However, a t-test showed that the response time difference was not statistically significant (t=1.39, df=1287, p=0.16). It would therefore be interesting to repeat this experiment using simple reaction times, where participants simply push a button upon hearing the stimulus.

George Wells (1913) found that longer auditory (and also visual) stimuli elicited shorter reaction times. If this effect were found for linguistic stimuli, such as words, it would clarify the question raised in response to Söderström, Roll & Horne (in press), namely whether longer response times simply were an effect of longer stimuli. For this reason, the present study included correlation analyses to look closer at the relationship between stimulus duration and response/reaction time.

4. The present experiment

The present experiment was designed in order to improve on the previous studies in two important ways: using both verbs and nouns, and using three different "task" and "no-task" conditions. This allows for a more fine-grained analysis of the response and reaction time data. In previous studies, it was not possible to definitely rule out acoustic and durational explanations for the results. For this reason, de-lexicalised stimuli were also created. Subtracting the response and reaction times to the de-lexicalised stimuli from the "lexical" stimuli should reveal differences that can only be explained by the linguistic processing of the lexical stimuli, such as processing of stem tone/suffix associations etc. Furthermore, correlation analyses were carried out on stimulus duration and response/reaction time data in order to test the assumption that earlier results could be explained simply by differences in stimulus duration. Also, syllable structure and word frequency were closely matched, ruling out suggestions that differences could be due to these factors.

4.1. Hypotheses

Based on previous studies on the subject, the hypothesis was that word accents are used during online speech processing to predict and divert attention to upcoming, grammatically relevant information, such as suffixes. In particular, this has been true for Accent 2, but not for Accent 1, especially with the P200 effect (related to attention to linguistically relevant information) previously found for Accent 2 but not Accent 1. A connection between Accent 2 and certain suffixes has also been posited, and it is possible that the high tone itself is activated upon hearing a related suffix, even if the suffix is preceded by a mismatched, low tone. This means that an accent/suffix mismatch should slow down processing, which should manifest as slower response times. Again, since no P600 effect (related to morpho-syntactic restructuring) was found for Accent 2 stems combined with mismatching suffixes in a previous study (Roll, Horne & Lindgren 2010), it is possible that this condition would not elicit longer response times (larger P600 latencies have been associated with increases in response time (Kotchoubey, Wascher & Verleger 1997)). However, the previous response time study (Söderström, Roll & Horne (in press)) was not able to conclusively rule out Accent 1 as being used predictively as well. Despite this and due to the evidence for the marked status of Accent 2, the hypothesis is still that Accent 2 suffixes preceded by a mismatching Accent 1 tone (condition Acc1Mis) will take the longest time to process, due to the fact that the suffix is not properly activated. There should also be a lower accuracy for this condition. Also, if this effect is found, it could suggest that Accent 2 is used predictively more than Accent 1, because of the Accent 2 suffix being more dependent on its preceding tone.

The LexTask condition involves virtually the same task that was used in Söderström, Roll & Horne (in press). Using the subtraction method suggested by Donders, differences between the two "lexical" conditions LexTask and LexNoTask and the "de-lexicalised" condition DelexNoTask could indicate that results cannot simply depend on segmental differences between the stimuli, but that higher-level linguistic morphophonological processing will have taken place. Also, if the Accent 1 tone is found to negatively influence the processing of the Accent 2 suffix both for verbs and nouns, syllable structure discrepancies between suffixes cannot be used to explain the differences, since singular and plural suffixes are structurally identical (VC, e.g. -*en*/VC, -*ar*), while present and past suffixes are not (VC, e.g. –*er*/CV, e.g. –*te*).

The hypothesis regarding the correlation analyses was that, following Wells (1913), shorter stimuli should elicit longer reaction and response times. This was expected to vary depending on the lexical status of the stimuli: stimulus duration should play a greater role when lexical information is removed, as in the condition DelexNoTask, since participants have nothing else to rely on for predicting when the sound will end. If this is true, this condition should show the strongest negative correlation between stimulus duration and reaction time, reflecting the results obtained by Wells (1913).

5. Method

5.1. Experimental design

There were four basic word accent conditions in the experiment: matching Accent 1, mismatching Accent 1, mismatching Accent 2 and matching Accent 2, or two factors: ACCENT and TENSE/NUMBER. Both nouns and verbs were used. See Table 1 for an overview of the different accent conditions. Conditions Acc1Match (Accent 1 on the stem and Accent 1-inducing suffix) and Acc2Match (Accent 2 on the stem and Accent 2-inducing suffix) were thus the correct and matching conditions, while Acc1Mis (Accent 1 on stem and Accent 2-inducing suffix) and Acc2Mis (Accent 2 on stem and Accent 1-inducing suffix) were incorrect and mismatching.

	ACCENT	
TENSE/NUMBER	1	2
Present/Singular	Acc1Match	Acc2Mis
Past/Plural	Acc1Mis	Acc2Match

Table 1. This table illustrates the differences between the different word accent conditions, distributed between the two factors ACCENT and TENSE/NUMBER.

Three task-related conditions were used in the experiment. In one condition, participants were to judge whether the word was in the present or the past tense or in singular or plural ("task", henceforth called "LexTask"). In another condition, the participants pushed a button when the word in question had finished ("no-task", henceforth called "LexNoTask"). In a third condition (henceforth called "DelexNoTask"), participants heard de-lexicalised hum sounds based on the word stimuli. These hum sounds were created in Praat (Boersma & Weenink 2011). Again, participants simply pushed a button when the sound had finished. In this way, the latter two conditions measured reaction times rather than response times. Calling these conditions "no-task" is meant to reflect the fact that they are not as dependent on accessing higher-level linguistic information compared to the condition LexTask, where participants are forced to make a choice regarding the tense or number of the stimulus. See Table 2 for an overview of the different task conditions.

Condition	Stimulus	Task
LexTask	Word	Judge tense/number
LexNoTask	Word	Push button at word offset
DelexNoTask	Hum sound	Push button at sound offset

Table 2. Summary of the differences between the different task conditions.

5.2. Production of stimuli

120 words were recorded in an anechoic chamber by two male Central Swedish speakers in the Humanities Laboratory, Lund University. Both speakers were trained linguists and had recorded material for prosodic studies before. A metronome set to 77 bpm was played through headphones to the person recording so as to ensure that there were no rhythm- or tempo-related differences between the two speakers. This tempo was decided upon after trying different articulation rates, and enabled the speakers to sound relaxed, but not unnaturally slow. 60 words from each speaker were used. All words were closely matched for frequency (using the Parole corpus, http://spraakbanken.gu.se/parole/) and syllable structure. There were thus no significant

differences in frequency between e.g. present and past tense verbs or singular and plural nouns. The verbs consisted of an initial syllable with a short vowel followed by a monosyllabic suffix, which meant that there were no phonological differences in stem vowel quantity or quality between the present and past tense (e.g. *täck*$_1$*-er* 'covers' and *täck*$_2$*-te* 'covered'). The nouns either had a long or a short vowel in the initial syllable, but again there were no changes in vowel quantity between singular and plural nouns (e.g. *lek*$_1$*-en* 'the game' and *lek*$_2$*-ar* 'games'). Most, but not all, words included a plosive stop before the suffix vowel for ease of digitally cutting and splicing. This allows for easy cutting during the closure phase of the stop. See Appendix for a list of the words used in the present experiment. All words were pronounced with an unfocused word accent contour, i.e. with no focal rise on the final syllable (the suffix). Furthermore, there was no final fall in the suffix, giving the impression of a "list intonation" of sorts. The mean pitch level was roughly the same for the end of the word accent fall (the L in Fig. 1 above) and the suffix.

After recording, words were divided into a stem and suffix part. In all, 240 utterances were created. Stems were cut immediately after stem-vowel offset, and the rest of the word was used as a suffix (i.e. plosive closure phase plus suffix). As has already been mentioned, however, the phrase "suffix onset" is taken to mean the syllable onset (e.g. *–ken* in *leken*$_1$, even though the suffix is *-en*). Suffix onset was used as the LexTask disambiguation point, meaning that it was the first point where participants knew which word they actually heard (e.g. *leken*$_1$ or *lekar*$_2$). Fig. 2 shows waveforms, F0 curves and disambiguation points for the four word accent conditions. Matching and mismatching stems and suffixes were then cross-spliced using Praat. This proved a more effective cutting/splicing method than the one used by Söderström, Roll & Horne (in press), where closure phases had to be shortened or lengthened. All words were judged as sounding natural by three Central Swedish speakers. After word stimuli had been produced, Praat was again used to create de-lexicalised hum variants for the DelexNoTask condition, based on cross-spliced matching and mismatched words.

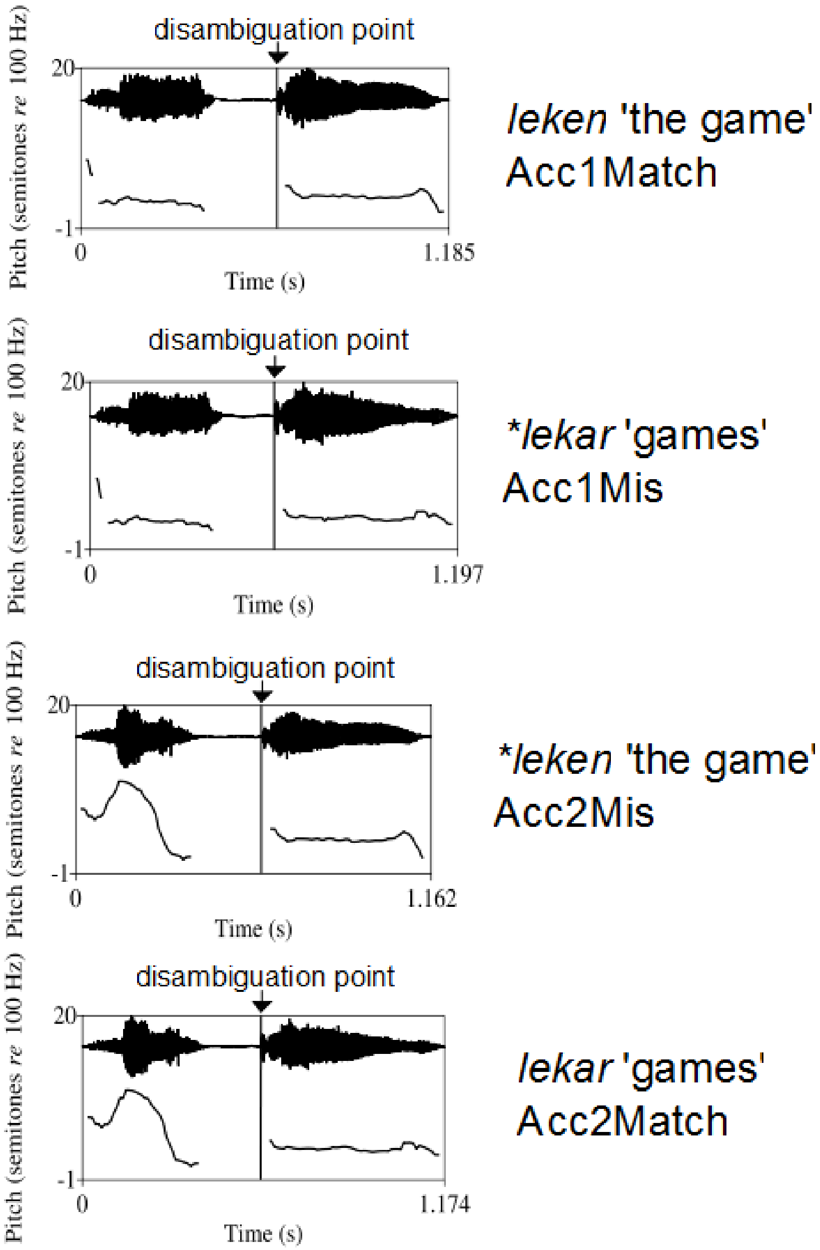

Figure 2. Waveforms and F0 curves of the four word accent conditions for the noun *lek* 'game'. Note the disambiguation point, which was the stem-final plosive -*k*- in this case.

5.3. Procedure

There were 8 participants in the present study, 4 male (mean age 25.0 years, *sd*=5.2) and 4 female (mean age 22.3 years, *sd*=4.7). All participants were right-handed, and none reported any health issues, neurological or otherwise. All spoke a Central Swedish dialect. Handedness was assessed using the Edinburgh Handedness Inventory (Oldfield 1971). The experiment took place in the Humanities Laboratory at Lund University. Participants were seated in front of a computer screen and used both hands for responding to stimuli using a response box (left index finger for left button and right index finger for right button). EEG was recorded for later analysis. An EGI Geodesic 128-channel EEG electrode cap was placed on the participant's head, and response and reaction times and other behavioural data (such as accuracy) were logged using E-Prime. Before the experiment started, participants signed a written consent form. Each session started with a practice block where participants were acquainted with the different tasks used in the experiment. The actual experiment consisted of 12 blocks, each approximately 7 minutes long, with breaks between each block. The blocks included either of the conditions LexTask, LexNoTask or DelexNoTask and either nouns or verbs. The participants were asked to relax in order to avoid unnecessary artifacts, such as facial muscle movements, in the EEG recording. The order of blocks was randomised, but the order and timing of stimuli within blocks was optimised and randomised using OptSeq2 (http://www.freesurfer.net/optseq/), as is often done for event-related fMRI experiments. This introduces so-called "null events", which are silent pauses included randomly across the sequence of stimuli in event-related fMRI experiments. It is also useful in response time experiments, since it introduces random pauses which in turn make it more difficult for the participant to predict when the next stimulus is coming up. Different sequences were used and balanced across participants. Participants were asked to look at a fixation cross on the screen during the tasks, again in order to reduce eye movement artifacts in the EEG. In the condition where participants were to judge the tense or the number of the word (LexTask), they were asked to press either the left or right button on the response box, using their left or right hand, respectively, depending on the answer. In one task, for example, pressing the left button could mean "present tense" and the right button could mean "past tense". This order was counterbalanced across blocks, so as to avoid associations between a certain button and a response. During the "no-tasks" (LexNoTask and DelexNoTask), where participants were asked to simply press a button as soon as the stimulus had finished, they were asked to press right and left buttons alternately in response to the stimuli. Each session lasted approximately 3½ hours, including EEG electrode cap application.

5.4. Predictions

The prediction was that at least some results should replicate those obtained in previous studies, especially in the LexTask condition. For example, the correct Accent 1 condition (Acc1Match) was expected to elicit the shortest response times. The correct Accent 2 condition (Acc2Match) was predicted to differ from the former if this condition is more difficult to process, either depending on the high tone or suffix or both (the correct Accent 2 condition was responded to more slowly than the Accent 1 condition in Söderström, Roll & Horne (in press)). Also, in line with previous studies, an Accent 2 suffix preceded by a mismatched Accent 1 tone (Acc1Mis) was expected to be more difficult to process than the Accent 2 mismatch condition (Acc2Mis). This should be evident when looking at response times, but also accuracy, which should be lower for conditions that are more difficult to process. It was predicted that there would possibly be a difference when nouns and verbs are compared separately, but it was difficult to predict exactly what that difference would look like.

6. Results

See Table 3 for an overview of the response/reaction times to the different tasks and conditions. Note that in Table 3, verbs and nouns have been analysed together. Table 4 and Table 5 show the separate results for nouns and verbs, respectively. Also recall that reaction times in the LexNoTask and DelexNoTask tasks were measured from word offset, i.e. when the word ended, while response times in LexTask were measured from the disambiguation point (onset of stem-final plosive).

	Acc1Match	Acc1Mis	Acc2Mis	Acc2Match
LexTask	661 ms	744 ms	698 ms	744 ms
LexNoTask	206 ms	225 ms	241 ms	268 ms
DelexNoTask	232 ms	204 ms	228 ms	245 ms

Table 3. Mean response and reaction times to nouns and verbs together.

	Acc1Match	Acc1Mis	Acc2Mis	Acc2Match
LexTask	684 ms	730 ms	729 ms	753 ms
LexNoTask	252 ms	237 ms	296 ms	329 ms
DelexNoTask	251 ms	244 ms	243 ms	255 ms

Table 4. Mean response and reaction times to nouns only.

	Acc1Match	Acc1Mis	Acc2Mis	Acc2Match
LexTask	637 ms	757 ms	667 ms	735 ms
LexNoTask	160 ms	214 ms	185 ms	209 ms
DelexNoTask	214 ms	167 ms	225 ms	235 ms

Table 5. Mean response and reaction times to verbs only.

Several one-way analyses of variance were carried out on the data. Results for the LexTask condition will be reported first. Response time measured from the disambiguation point was the dependent variable in all LexTask analyses. For nouns, there were significant effects for ACCENT (F=4.329, p=0.038) and NUMBER (F=4.565, p=0.033). There was no significant interaction between these two factors (F=0.441, p=0.507). For verbs, there was a significant effect for

TENSE (F=25.197, p<0.01) but no significant effect for ACCENT (F=0.044, p=0.835). Accent 1 and 2 were then analysed separately. For nouns and Accent 1, there was an effect for NUMBER (F=4.531, p=0.034, η_p^2 effect size=0.009). This effect was not found for Accent 2 nouns (F=0.955, p=0.329, η_p^2 effect size=0.002). For verbs and Accent 1, there was a significant effect for TENSE (F=20.955, p<0.01, η_p^2 effect size=0.042). This effect was also found for Accent 2 verbs, where it was smaller (F=6.454, p<0.01, η_p^2 effect size=0.013).

The term *effect size* is expressed as η_p^2 or ”partial eta-squared”. It is a measure of the proportion of variance in the dependent variable (response/reaction time) explained by the independent variable (e.g. ACCENT or TENSE/NUMBER), similarly to the R^2 coefficient used in multiple regression analyses. It is often reported when there are effects for multiple factors in an experiment in order to illustrate the actual effect size difference between the factors.

Further separate analyses were carried out for the LexNoTask condition, with reaction time measured from word offset as the dependent variable. For nouns, there was a significant effect for ACCENT (F=9.882, p<0.01) but no effect for NUMBER (F=0.171, p=0.680). When the accent patterns were analysed separately, there was no effect for NUMBER (F=0.294, p=0.588) for Accent 1 and also no effect for NUMBER (F=0.998, p=0.318) for Accent 2. For verbs, there was no significant effect for ACCENT (F=0.283, p=0.595) but a significant effect for TENSE (F=4.161, p=0.042). For Accent 1 there was a significant effect for TENSE (F=3.941, p=0.048, effect size=0.008). No such effect was found for Accent 2 (F=0.792, p=0.374).

Table 6 shows mean response accuracy for each condition in LexTask. An analysis of variance and *post hoc* Tukey HSD revealed a significant difference between the two mismatch conditions Acc1Mis and Acc2Mis (p=0.03). When accuracy for Acc1Mis was compared to the two other conditions Acc1Match and Acc2Match, the difference approached, but did not reach, significance (p=0.083 and p=0.084, respectively).

Acc1Match	Acc1Mis	Acc2Mis	Acc2Match
99.6%	98.3%	99.8%	99.6%

Table 6. Mean response accuracy for each condition in LexTask.

Correlation analyses were then carried out on the data. For all three conditions, there were negative correlations between stimulus duration and reaction/response time. Again, response times in the LexTask condition were measured from suffix onset, normally the onset of the first plosive after the stressed vowel, since this was the disambiguation point where participants would find out which word they actually heard (e.g. present/past tense or singular/plural). Reaction times in the two other conditions (LexNoTask and DelexNoTask) were measured from word offset. See Table 7 for an overview of the conditions and statistical details from the Pearson correlation tests, where *r* is the Pearson product-moment correlation coefficient (larger number equals larger correlation) and *df* stands for "degrees of freedom". "Stimulus duration" thus means duration up until the point where response or reaction time was measured, meaning until *plosive onset* for LexTask and *word offset* for LexNoTask and DelexNoTask.

Condition	*r*	*df*	*p*
LexTask	-0.23	1908	<0.01
LexNoTask	-0.21	1862	<0.01
DelexNoTask	-0.29	1913	<0.01

Table 7. Correlations between stem duration and response/reaction time.

However, there was a *positive* correlation between response/reaction time and suffix duration, as is shown in Table 8, meaning that response time increased with suffix duration, but only for LexTask. In the other conditions, no significant correlation was found.

Condition	*r*	*df*	*p*
LexTask	0.26	1908	<0.01
LexNoTask	0.03	1862	0.14
DelexNoTask	0.04	1913	0.09

Table 8. Correlations between suffix duration and response/reaction time.

7. Discussion

7.1. Response/reaction time data

As can be seen in the results section above, the mismatch condition Acc1Mis took longer to process than Acc2Mis in the LexTask condition, as was predicted. This is particularly evident for verbs. The fact that this did not happen in the LexNoTask and DelexNoTask conditions suggests that this task-related difference is due to language-related processing, i.e. analysing suffix form-meaning relationships. Response accuracy for condition Acc1Mis was also the lowest compared to other conditions, again suggesting a processing difficulty. A comparison between e.g. DelexNoTask and LexTask for verbs shows that while Acc1Mis was processed slowly in the LexTask condition, it was processed the *fastest* in the DelexNoTask condition, where participants were to press a button when the sound had ended. At the same time, this condition took the *longest* to process in the LexNoTask condition for verbs, possibly indicating that participants used the word accent and were slowed down by the tone/suffix mismatch even when the task was simply to press a button at stimulus offset. This suggests that there are many considerations that need to be kept in mind when dealing with response times to auditory stimuli, and that not only acoustic and phonetic variables play in, but also more higher-level – e.g. morphophonological – patterns. Also, using Donders' subtraction method discussed above, subtracting the Acc1Mis response time in DelexTask from the one in LexNoTask and LexTask shows that there is a large task- (and stimulus) related difference.

The fact that response times to verbs showed an effect for TENSE but not ACCENT suggests that the accent patterns (Accent 1 for present tense suffixes and Accent 2 for past tense) did not play any role when tense was judged. However, when the two accent patterns were analysed separately, results for both nouns and verbs indicated that Accent 1 affects the processing of the mismatched suffix more than does Accent 2 (cf. the difference in effect sizes), lending further support to the hypothesis that Accent 2 is more closely associated with its suffixes in the mental lexicon. When the correct accent is absent, processing slows down. Since this effect was present both in nouns and verbs, it seems clear that the results were not influenced by segmental differences between suffixes. This finding could suggest that Accent 2 is used more predictively than Accent 1. It is possible that the suffix itself activates an abstract (neural) representation of the tone, which again leads to slower processing. The difference between nouns and verbs could be explained by the fact that nouns involve more semantic information, as was discussed above. It is possible that this has an effect on response time data. A related explanation could be that since verb morphology is normally more regular than noun morphology in Swedish, a stronger accent/suffix association is created for verbs compared to nouns.

It is interesting to note that mismatch even played a role in the LexNoTask condition for verbs. Specifically, Accent 1 was found to influence the processing negatively in the mismatch condition Acc1Mis, while Accent 2 had no effect. This suggests that this Accent 1 effect – which was also found for the LexTask condition – is not task-dependent, i.e. that even during a task where there is no direct semantic judgement and when a suffix normally associated with Accent 2 is preceded by Accent 1, word processing breaks down. This does not happen for stem tone/suffix mismatch and Accent 2 (Acc2Mis) in LexNoTask. It is possible that the lexical semantics of the word were still involved in the "no-task" LexNoTask condition, i.e. even though word duration could play a greater role in this condition (due to the fact that reaction times were measured from word offset), participants could still use information derived from the word accent pattern to predict which suffix was coming up and consequently when to push the button. Naturally, this was not possible during the DelexNoTask condition, where there was no segmental content.

The "correct" condition Acc2Match was processed slowly for LexTask, LexNoTask and DelexNoTask. This condition took longer to process as compared to Acc1Match in Söderström, Roll & Horne (in press) as well, but in that study, both mismatch conditions took longer to process than Acc2Match. A couple of different explanations can be given. To begin with, word frequency cannot explain the difference, since frequency did not differ between the different word forms. However, if Accent 2 is assumed to activate more lexical forms as compared to Accent 1, this could possibly lead to a generally slowed down processing, because of lexical "candidates" which have to be de-activated upon hearing the suffix. It is also possible that since words were presented in isolation (i.e. with no preceding tone-bearing syllable), the high tone of Accent 2 could stand out acoustically and might lead to slower processing and a higher cognitive load. Another more theoretically driven explanation could be that in that condition, two marked structures are present: the high tone of Accent 2 and morphologically marked structures (plural for nouns and past tense for verbs). However, this would not explain why Acc2Match also took longer to process in e.g. the DelexNoTask condition, where all lexical information was removed. The results do support the assumption that Accent 1 is the unmarked pattern, since it was processed the quickest in the LexTask condition and was also associated with very high mean accuracy. Another explanation for the slow processing of Acc2Match comes from the correlation data discussed above. Stem durations were shorter (663 ms (past) and 643 ms (plural)) and suffix durations were longer (649 ms (past) and 666 ms (plural)) for past tense and plural words compared with present tense verbs (755 ms (stem)/622 ms (suffix)) and singular nouns (639 ms (stem)/629 ms (suffix)). It is possible that this – if the effect of short stems being processed more slowly and long suffixes being processed more quickly is somehow additive – led to the longer general response time to the Acc2Match condition since it consisted of a test word with a "short" stem and a "long" suffix. However, if participants only relied on the duration of the stimuli when responding, results should have turned out differently from what was actually obtained in the experiment. For example, Acc1Mis should then have been responded to the fastest for verbs since it has the longest duration. This condition was processed slowly both for LexTask and LexNoTask, but was processed the *fastest* for DelexNoTask verbs. This means that factors other than duration have to be taken into account when analysing response and reaction time data. This is particularly clear when the DelexNoTask condition is compared to the other conditions: reaction times for Acc1Mis were relatively short for both verbs and nouns, meaning that when only the F0 contour was available to the participants, they responded to this condition relatively fast.

7.2. Correlation data

The correlation analyses provided interesting information. Recall that in the LexTask condition, participants pressed a button to judge whether the word was in the past or present tense (verbs) or in singular or plural (nouns), while in the other two conditions participants simply pushed a button when the word or de-lexicalised hum sound had finished. The first condition, then, was more complex than the others since it involved a choice between grammatical categories. As could be seen in the data presented above, the negative correlation was the strongest for the least complex condition (DelexNoTask). This is expected, since in the LexNoTask condition, which included lexical information, participants probably still used prosodic and other clues in order to plan their response ahead of time, just as they did in the LexTask condition, leading to a faster reaction time. This was not possible in the DelexNoTask condition, since the segmental, morphological and lexical information had been removed. For this reason, stimulus duration probably played a larger role in DelexNoTask compared to the other conditions, as was reflected by the stronger correlation.

Mean accuracy (when judging tense or number) across subjects for the LexTask condition was 99.3%, meaning that faster responses did not lead to poorer accuracy. In general, these correlation data suggest that response times decreased as stimulus duration increased, in accordance with Wells (1913). In other words: when stimuli were longer, participants responded quicker. This has implications for the interpretation of the response time data in e.g. Söderström, Roll & Horne (in press), since it means that the results could not have been explained simply by differences in stimulus duration.

8. Conclusions and directions for further research

A few tendencies can be seen in the data. For example, one result that was also obtained by Ambrazaitis (2009), Roll (2009), Roll, Horne & Lindgren (2010) and Söderström, Roll & Horne (in press) was that when verb suffixes which are normally associated with Accent 2 were preceded by a mismatched Accent 1, processing slowed down. This effect was not as apparent for the opposite case, where an Accent 2 tone preceded an Accent 1-induced suffix. This possibly suggests a stronger stem/suffix association for Accent 2, meaning that this accent pattern is more sensitive to tone/suffix mismatch, i.e. that there is a stronger association between Accent 2 and its suffixes as compared to Accent 1. It was interesting to note that this effect was present in both the LexTask and the LexNoTask conditions, suggesting that the effect was relatively task-independent. Seeing as there is a difference between Accent 1 and 2 in this respect, future studies should aim to investigate the supposed stronger neural association between Accent 2 and its suffixes in more detail.

It does not seem possible to say that e.g. Accent 2 facilitated identification of the following suffix. If anything, this should have been reflected in a shorter response time, but response times were relatively long for the "correct" condition Acc2Match. Reasons for this were discussed above.

Correlation analyses showed that longer stimulus duration up until the disambiguation point led to shorter response times. In the previous experiment (Söderström, Roll & Horne (in press)), stem duration was identical for same-accent conditions, e.g. Accent 2 matching and mismatching, allowing for easy comparison of response times. However, the correlation results obtained in the present study showed that there was a negative correlation between time of suffix onset and response time and that longer stem durations led to shorter response times (in line with the results obtained by Wells (1913)). This finding could be valuable for experimenters designing auditory stimuli for response or reaction time studies.

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Appendix

List of the 120 words used in the study in alphabetical order.

VERBS	NOUNS
blänker	bockar
blänkte	bocken
byggde	bultar
bygger	bulten
bände	buntar
bänder	bunten
hände	båtar
händer	båten
kläcker	bäckar
kläckte	bäcken
knycker	bänkar
knyckte	bänken
knäcker	fiskar
knäckte	fisken
krymper	flockar
krympte	flocken
kysser	fläckar
kysste	fläcken
lyfte	hattar
lyfter	hatten
miste	hinkar
mister	hinken
märker	hästar
märkte	hästen
rycker	klackar
ryckte	klacken
skvätte	klickar
skvätter	klicken
släcker	kockar
släckte	kocken
släpper	koppar
släppte	koppen
spräcker	korkar
spräckte	korken
sprätte	krockar
sprätter	krocken
stjälper	kåkar
stjälpte	kåken
stänker	lekar
stänkte	leken
stärker	låtar
stärkte	låten

sände	lökar
sänder	löken
tiggde	mackar
tigger	macken
trycker	minkar
tryckte	minken
tycker	ostar
tyckte	osten
täcker	prickar
täckte	pricken
tände	sparkar
tänder	sparken
tänker	säckar
tänkte	säcken
värker	tolkar
värkte	tolken
värper	tuppar
värpte	tuppen