

AND SYLLABLE WEIGHT IN ITALIAN AND GERMAN SECONDARY STRESS

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Abstract

The first part of this study¹ aims at analyzing the directionality of secondary stress and the influence of syllable weight on secondary stress in Italian and German. In order to do this, a nonce-word reading task has been conducted, in which participants read nonce words with three light syllables before main stress (LLLY) and nonce words with a second heavy syllable (LHLY). In the LLLY condition the participants collocated secondary stress mainly on the first syllable in both Italian and German, indicating a directionality from left to right in both languages, while in the LHLY condition the participants collocated secondary stress mainly on the second heavy syllable in Italian and almost equally on the first and on the second syllable in German, indicating a clear influence of syllable weight on secondary stress in Italian but only partial in German.

The second part of this study aims at detecting some possible acoustic correlates of secondary stress in Italian and German. In order to do this, an experiment has been conducted in which participants were asked to read aloud real words having a secondary stress. Duration, intensity, F0, F2 and spectral tilt were measured as possible correlates of secondary stress. The results indicated intensity as a reliable correlate of secondary stress in Italian, while no reliable correlate of secondary stress has been found in German.

1. Secondary stress

Secondary stress refers to a less prominent level of stress which can be found besides main stress in the world's languages. An example of secondary stress can be seen in the first syllable of the English word *localization*² [ˌləʊkəlaɪˈzeɪʃən]. The alternation of a stressed syllable and an unstressed one form a foot, a constituent which represents an intermediary unit between the syllable and the prosodic word. The standard typology of feet (Hayes, 1995) recognizes three main foot types, depending on the position of stress on the foot and on its syllable structure³:

- (1) a. syllabic trochee ('σσ).
- b. moraic trochee ('LL) or (H).
- c. iamb (L'L) or (L'H) or (H).

The organization of secondary stresses into feet determines their directionality. Directionality refers to the way in which a word is parsed into feet depending on the position of secondary stress and can either be from left to right or from right to left, as in the following examples from Pintupi (Hansen & Hansen, 1969) and Warao (Osborn, 1966):

- (2) a. Directionality from left to right (Pintupi):

¹ The present paper is based on my Master's thesis *Directionality and syllable weight in Italian and German secondary stress*, discussed in 2019 at the University of Verona.

² In this paper, a grave accent is used to indicate secondary stress, while an acute accent is used to indicate main stress.

³ σ represents any type of syllable, L represents a light syllable and H a heavy syllable (see also paragraph x).

(σ̣σ)(σ̣σ)σ 'pu.liŋ, ka.la.ṭiʉ
 'We (sat) on the hill.'

b. Directionality from right to left (Warao):

σ(σ̣σ)(σ̣σ) ji, wa.ra. 'na.e
 'He finished it.'

As can be seen from the above examples, in Pintupi the main stress is found on the first syllable, and the first foot with secondary stress is built from the left, leaving a syllable unparsed on the right, thus indicating a directionality from left to right. On the contrary, in Warao the main stress is found on the last syllable and the first foot with secondary stress is built from the right, leaving a syllable unparsed on the left, indicating a directionality from right to left.

The combination of directionality, main stress position and foot type give rise to different stress systems cross-linguistically. According to a survey of 154 languages from various language families (Goedemans, 2010), among the languages in which main stress falls on the left of a word, 84% have a directionality from left to right and 16% have a directionality from right to left, while among those in which main stress falls on the right, 33% have a directionality from left to right and 66% have a directionality from right to left, thus indicating a correlation between main stress position and directionality of secondary stress. With respect to foot type (from a sample of 171 languages), among the languages which have trochaic feet (i.e. stress on the left of the foot), 58% have a directionality from left to right and 41% from right to left, while among the languages which have iambic feet (i.e. stress on the right of the foot), 73% have a directionality from left to right and 26% from right to left, indicating that both types are mainly correlated with a directionality from left to right⁴.

1.1. Secondary stress in Italian

The existence and directionality of secondary stress in Italian cannot be easily established, since, unlike languages such as English where secondary stress is correlated with the absence of vowel reduction, in Italian there are no clear phonological cues which indicate the presence of a secondary stress. Nonetheless, there are some phenomena which have been suggested as evidence of the existence of secondary stress in Italian.

For instance, Camilli (1965) notes that a word like *benevolmente* is sometimes pronounced as [b,ɛnevol'mente] instead of [benevol'mente], which should suggest the presence of a secondary stress on the first syllable, since in Italian the open-mid vowel [ɛ] surfaces only under stress. However, this realization with the open-mid vowel is restricted only to some speakers. Also, Nespor and Vogel (2007) point out how an expression like *onoró Búdda* [he/she honored Buddha], in order to avoid a stress clash between two stresses, is actually pronounced *ónoro Búdda*, where the main stress of *onoró* is retracted on the antepenultimate syllable, i.e. the position which in *onoró* is supposed to bear a secondary stress, instead of going on the penultimate, which is the default position for stress in Italian.

With respect to directionality, Italian is usually thought to have a directionality from left to right, which means that a word like *camaleónte* [chamaleon] would have a secondary stress on the first syllable, as in (*cà.ma*.)*le.ón.te*, instead of on the second syllable, as in *ca.(mà.le.)ón.te*, which would indicate a directionality from right to left. Evidence for this comes for instance from truncation phenomena, as in the following example (Alber, 2009):

(3) cì.ne.ma.tó.gra.fo > cí.ne.ma *ci.né.ma

⁴ However, the existence of languages with iambic feet and a directionality from right to left has been called into question by Alber (2005).

As can be seen, the truncated form *cínema* bears main stress on the antepenultimate syllable, instead of the penultimate, which, as noted before, is the default position for stress in Italian, suggesting that in the truncated form main stress is placed on the syllable which bore a secondary stress in the original word.

Some empirical data with regard to the directionality of secondary stress in Italian come from a small judgment task run by Alber (2009), in which 9 native Italian speakers were asked to judge whether a secondary stress was present on the first or on the second syllable of words like *catamaráno* [catamaran], or whether it could go on either syllable. The results indicated that 70.7% of participants collocated secondary stress on the first syllable, 17.03% on the second and 12.22% on either. In another more extended experiment by Gola (2009), 17 native Italian speakers were asked to read aloud words with the same structure used by Alber and the results indicated that 72.7% of them put stress on the first syllable while 26.4% on the second syllable. All this evidence seems thus to suggest that Italian has a directionality of secondary stress from left to right.

1.2. Secondary stress in German

As is the case in Italian, in German the presence and directionality of secondary stress are also still a matter of debate. However, there are some phenomena which suggest that German has secondary stress and that, as in the case of Italian, it has a directionality from left to right.

Alber (2009) observed that some native German speakers insert a glottal stop before a main stressed syllable in hiatus and that this phenomenon is also extended to secondary stressed syllables, as in [ʔ]Óze[ʔ]ànographíe [oceanography]. However, this phenomenon is restricted only to some speakers.

With respect to directionality, Knaus et al. (2011) ran an experiment using ERPs, in which they had participants listen to compounds made of a first trisyllabic word and a second pentasyllabic word, in both of which main stress could go either on the penultimate or the last syllable, such as *Európa-Enthusiásmus*. The authors then shifted the position of stress of the second word to either the first or the second syllable. The results showed a larger positivity effect when stress of the second word was moved to the second syllable *En.(thù.si).(ás.mus)* than when it was moved to the first syllable (*Èn.thu).si.(ás.mus)*, suggesting that participants perceived the latter, which represents a directionality from left to right, as being more natural. Finally, through a small judgment task, Alber (1997) found that on words with three open syllables before main stress, such as *Philosophíe*, the version with secondary stress on the first syllable was preferred, again suggesting a directionality from left to right.

2. Syllable weight

Weight sensitivity refers to the tendency of a syllable to attract stress, on the basis of the segmental composition of the syllable. A syllable which attracts stress is called a heavy (H) syllable, while one that does not attract stress is considered a light syllable (L). Different types of syllable weight exist among the world's languages. For example, in Latin a syllable is heavy if it is in penultimate position and it is either closed by a consonant, as in *fru.mén.tum* [wheat], or if it is an open syllable with a long vowel, as in *su.bé.gi* [I subjugated]. Some languages might also distinguish between the types of consonants which form a heavy syllable, such as Lithuanian, in which only sonorants are heavy (Zec, 1995). Another type of syllable weight is represented by super-heavy syllables, found for example in Dutch (Köhnlein, 2018), i.e.

syllables with a rhyme structure such as VVC or VCC⁵, which may thus contribute to form a ternary scale of weight. With respect to the syllable onset, although it is generally assumed that it does not contribute to syllable weight, some languages have been reported in which onsets seem to attract stress, such as Pirahã, where voiceless onsets are heavier than voiced ones (Everett & Everett, 1984), or English, in which more complex onsets have been found to attract stress in a gradient way, although less strongly than rhymes (Ryan, 2014). Both main and secondary stress can be weight-sensitive and according to a cross-linguistic survey (Goedemans, 2010; sample = 97 languages) it seems that in 40% of languages both stresses are sensitive to syllable weight, in 33% only main stress, in 18% only secondary stress and in 8% both stresses are weight-sensitive but in different ways.

2.1. Syllable weight in Italian

Italian main stress seems to be at least partially weight-sensitive. Looking at the distribution of stress in Italian it is possible to see that stress can fall on any of the last three syllables of a word (and also, in specific cases, such as in verbs, on the fourth from last), as in (4) (Krämer, 2009):

- (4)
- | | | |
|----|-------------------|----------------|
| a. | vir. 'tu | 'virtue' |
| b. | pa. 'rɔ:.la | 'word' |
| c. | pen. 'ta.go.no | 'pentagon' |
| d. | im. 'ma.dʒi.na.no | 'they imagine' |

Stress position in Italian cannot be predicted by an algorithm, and it is said to be lexically marked, with default stress on the penultimate syllable, which is the one that receives stress in most cases (70-80%), followed by antepenultimate stress (20%) and then by final stress (2%) (Borelli, 2002, cited in Krämer, 2009). Final stress in Italian is always graphically marked by an accent, as in *virtù* [virtue].

With respect to syllable weight a closed syllable in penultimate position always attracts stress⁶, as in *ricórdo* [memory], however this is not always the case when a closed syllable is in antepenultimate position, as in *balcóne* [balcony]. Final syllables also do not need to be sensitive to syllable weight, as can be seen from Italian acronyms with a final closed syllable which usually does not receive stress, such as *ÁNAS* (Krämer, 2009).

In order to investigate the sensitivity to syllable weight in Italian, Krämer (2009) conducted a reading task with 12 native Italian speakers, who were asked to read nonce words of different lengths and with either open or closed syllables. The following results show the percentage of times in which stress was put on the penultimate syllable:

- (5)
- | | |
|----|-------------------------|
| a. | LLLL = 91.7% |
| b. | LLL = 55.1% |
| c. | LHL = 100% |
| d. | HHL = 100% |
| e. | HLL = 71% |
| f. | X ⁷ L = 100% |

⁵ V is used to represent a vowel (VV represents either a long vowel or a diphthong) and C is used to represent a consonant.

⁶ Very few exceptions to this rule are attested, such as *pólizza* [(insurance) policy] (Krämer, 2009).

⁷ X is used to represent a syllable which can be either L or H.

As can be seen, (5c-d) confirm the rule according to which a heavy penult attracts stress; on the contrary it seems from (5e) that an antepenultimate does not attract stress or that it does so only moderately. Finally, it must be noted that in Italian weight sensitivity has also been observed for the onset of 2nd conjugation verbs, i.e. verbs ending in *-ere* (Davis et al., 1987). More specifically, it has been seen that if a 2nd conjugation verb has a closed syllable or a sonorant onset in antepenultimate position then stress goes on that syllable. This observation has also been confirmed by Davis et al. in a nonce-word experiment, in which this kind of antepenultimate attracted stress 90% of times.

With respect to the influence of syllable weight on secondary stress in Italian, to my knowledge no empirical evidence has been provided so far. The nonce-word experiment presented in chapter 4 will be dedicated to shedding some light on this issue.

2.2. Syllable weight in German

As with Italian, German also has no algorithm to determine the position of main stress nor it is possible to say clearly to what extent German is sensitive to syllable weight. Main stress in German is restricted to the last three syllables of a word and even if German seems to be at least partially weight-sensitive there is still no agreement on what counts as heavy. According to Féry (2000) bimoraic syllables attract stress, i.e. syllables having a long vowel or diphthong or having a short vowel plus a consonant. In addition, German also possesses super-heavy syllables which contain three moras, made of a long vowel plus a consonant or a short vowel plus two consonants. According to Giegerich (1985), CVC syllables count as heavy only when they are in word-medial position, while in final position only CVVC syllables count as heavy. Alternatively, only super-heavy syllables of the VVC and VCC type should count as heavy (Alber, 2020).

A first extensive experiment with regard to syllabic weight and main stress in German was conducted by Janßen (2003), using a nonce-word reading task. She found that main stress is collocated most frequently on the penultimate syllable (48.7%), followed by the antepenultimate (25.7%) and the last syllable (25.6%). With regard to syllable weight, the strongest correlation was found with a closed penult syllable (63%) and with a final super-heavy syllable (49.9%), pointing to an interdependence between syllabic weight and stress in German.

A similar experiment has been conducted by Domahs et al. (2014) on three Germanic languages (German, English and Dutch), using nonce words with different types of syllables: CV, CVC and CVCC. With regard to German, they found that stress in general tends to fall mainly on the penultimate, followed by equally frequent stress on the antepenultimate and on the final syllable. Nonetheless, they found that if the final syllable is heavy the probability of stress on that syllable increases and probability of stress on the penultimate syllable also increases (although it remains below 60%). They also found that if the final syllable is superheavy the probability of stress on that syllable is even higher than when it is heavy. If the final syllable is light stress goes on the penultimate.

With regard to the influence of syllabic weight on secondary stress in German, some data comes from a judgment task conducted by Alber (1997), the same as that mentioned in chapter 1.2, in which native German speakers were asked to judge the position of secondary stress in words with only light syllables before main stress, such as *Phi.lo.so.phie* and in words with a second heavy syllable (a diphthong in this example), such as *Ka.lei.do.skóp*. In the condition with only light syllables, secondary stress was judged mainly on the first syllable; however, in the condition with a second heavy syllable secondary stress was judged as possible either on the first or on the second syllable, suggesting at least a partial weight sensitivity of secondary stress in German.

3. Experiment on directionality and syllable weight

3.1. Methodology

In order to test the directionality of secondary stress and the influence of syllable weight on secondary stress in Italian and German, 22 native Italian speakers and 7 native German speakers⁸ were asked to read a series of nonce words with different syllabic structures. Among the Italian speakers (13 females, 9 males, age range: 14-64), 16 were from Verona, and almost all the others came from Northern Italy⁹. Among the German speakers (all females, age range: 57-72 plus one 32-year-old), 6 were from Germany, of which 2 from Hamburg, 2 from the state of North Rhine-Westphalia, (1 from Bochum, 1 has not specified the city), 1 from Ulm (Baden-Württemberg) and 1 from Nuremberg (Bavaria). 1 informant came from Salzburg, Austria. All the German informants had been living in Verona for 10 to 50 years and had a high command of Italian.

The reading task used for this experiment was developed in two versions, one for the Italian informants and one for the German-speaking informants, keeping the same structure but changing the actual items according to the language. The task consisted of reading a list of sentences which all had the same initial structure and at the end a different word, according to the following pattern, where X represents the target word:

- (6) a. Ha detto di nuovo X ‘He/she has said X again.’
b. Sie hat schon wieder X gesagt ‘She has said X again.’

The sentences were chosen so that they would not end with a stress before the target word and so that the target word would be in a metrically strong position, since it bears the nuclear stress of the sentence. In order to analyze both the directionality of secondary stress and the influence of syllable weight, two conditions were developed, each comprising 10 nonce words. In the first condition (7a) the nonce words were constructed having three light syllables before main stress, i.e. only open syllables (CV). In the second condition (7b), the nonce words had the same structure of the first condition but had a second heavy syllable, i.e. a syllable closed by a consonant (CVC). Main stress was elicited using real Italian and German suffixes which are always stressed¹⁰.

- (7) a. only light syllables: LLLY(σ)¹¹ e.g. IT *togedimento* DE *Marapalismus*
b. second heavy syllable: LHL Y(σ) e.g. IT *sibizzità* DE *telenkosieren*

In both conditions a secondary stress could be placed either on the first or on the second syllable, but not on the third since it would create a stress clash, which is usually avoided in these languages. In order to avoid a possible influence of vowel sonority, the vowels of the first two syllables had the same level of sonority, according to the scale, from more sonorous to less sonorous, a > e, o > i, u (Kenstowicz, 1996). In the condition with a second heavy syllable, different types of consonants have been used in the coda, in order to see whether this factor

⁸ The low number of participants in the German part was due to the difficulty in finding native German speakers in Verona, where the experiment was conducted.

⁹ Namely 1 from Trento, 1 from Bologna, 1 from Treviso, 1 from Bergamo and 1 from Ferrara. 1 informant came from Rome (central Italy).

¹⁰ The used suffixes are *mento*, *-tà* and *-zione* for Italian, which are all nominal suffixes, and *-ismus* and *-ieren* for German, a nominal and a verbal suffix respectively.

¹¹ Y is used to indicate any syllable bearing main stress.

might play a role in attracting stress¹². The consonant /s/ has been avoided as a coda in both languages, since it could be syllabified both as coda or as part of the following onset. In general, all nonce words have been constructed respecting the phonotactics of each language, paying attention not to construct nonce words which may be reminiscent of real words, or which might contain parts of real words or real prefixes, which may be linked to specific stress patterns. In order to distract the participants from the target words and in order to prevent repetitive stress patterns, 15 nonce word fillers were added, in which main stress was elicited on the first, second or third syllable using different types of suffixes.

During the task the informants were asked to read every sentence of the list, once silently and then twice aloud, and the position of secondary stress was judged by me by ear. Since secondary stress is not very prominent perceptually, in case I had a doubt on the position of secondary stress, a second person naïve to the aim of the experiment was also asked to judge the position of secondary stress.

The first condition was aimed at analyzing the directionality of secondary stress. In both languages, if participants read the words with a secondary stress on the first syllable this would indicate a directionality of secondary stress from left to right as in *(tòge)di.ménto*, as expected from the literature; on the contrary if they put secondary stress on the second syllable, this would indicate a directionality of secondary stress from right to left, as in *to.(gè.di).ménto*.

The second condition was aimed at analyzing the influence of syllable weight. Assuming for both Italian and German a directionality from left to right, if participants in the second condition still put secondary stress on the first syllable this would indicate no sensitivity to syllable weight; however, if the participants put secondary stress on the second heavy syllable, as in *Varàlkorísmus*, this would indicate an influence of syllable weight, since they would place secondary stress in contrast with the default position on the first syllable, which is the position determined by the left-to-right directionality. Since both languages seem to show some sensitivity to syllable weight for main stress, the expectations were that the participants would put secondary stress mainly on the second heavy syllable; however, the results might be less consistent for German in which, as shown in chapter 2.2, secondary stress may not be entirely sensitive to syllable weight.

3.2. Results

In this chapter the results of the experiments are presented. Only those realizations in which the position of secondary stress was deemed to be perceivable were included in the results. Furthermore, some realizations had to be excluded because they had been pronounced with uncertainty, too slowly or in a syllabified way, so that no clear prominence was perceivable between the first and the second syllable. In other cases the phonemes of the word were changed, dropped, added or swapped, sometimes they were geminated where they should not have been or, vice versa, gemination was not realized when expected. As a consequence, of the total 880 realizations of the Italian part (20 words pronounced twice by 22 speakers), only 793 have been used, while of the total 280 realizations of the German part (20 words pronounced twice by 7 speakers), only 234 have been used. The numbers of mispronounced realizations which were discarded are reported in brackets.

Table 1. Results for the condition ‘all light syllables’ (Italian)

word	total realizations	stress on the first syllable	stress on the second syllable
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¹² The following consonant classes have been used: liquids ([r], [l]), nasals ([m], [n]), fricatives ([f], [s]), stops ([t], [k]) and affricates ([ts], [tʃ]).

batanità	44	8	18.18%	36	81.81%
macaletà	41 (3)	18	43.90%	23	56.09%
lerevazione	35 (9)	29	82.85%	6	17.14%
melotità	41 (3)	39	95.12%	2	4.87%
somoramento	41 (3)	38	92.68%	3	7.31%
togedimento	39 (5)	18	46.15%	21	53.84%
siliretà	38 (6)	25	65.78%	13	34.21%
vunicamento	41 (3)	40	97.56%	1	2.43%
cunupazione	41 (3)	39	95.12%	2	4.87%
ribulazione	40 (4)	30	75%	10	25%
TOTAL	401 (39)	284	70.82%	117	29.17%

Table 2. Results for the condition ‘second heavy syllable’ (Italian)

word	total realizations	stress on the first syllable		stress on the second syllable	
patarcità	41 (3)	0	0%	41	100%
vacalcità	38 (6)	1	2.63%	37	97.36%
lorembamento	38 (6)	4	10.52%	34	89.47%
celondità	40 (4)	0	0%	40	100%
buruffazione	36 (8)	8	22.22%	28	77.77%
gitussizione	37 (7)	12	32.43%	25	67.56%
furiccimento	41 (3)	4	9.75%	37	90.24%
sibizzità	40 (4)	3	7.5%	37	92.5%
devettazione	41 (3)	2	4.87%	39	95.12%
voloccamiento	40 (4)	4	10%	36	90%
TOTAL	392 (48)	38	9.69%	354	90.30%

Table 3. Results for the condition ‘all light syllables’ (German)

word	total realizations	stress on the first syllable		stress on the second syllable	
rataminieren	14	11	78.57%	3	21.42%
Marapalismus	12 (2)	12	100%	0	0%
veretasieren	13 (1)	12	92.30%	1	7.69%
televisieren	12 (2)	12	100%	0	0%
Mofopuzismus	12 (2)	10	83.33%	2	16.66%
Robenarismus	13 (1)	13	100%	0	0%
firipolieren	14	14	100%	0	0%
Gubiranismus	12 (2)	12	100%	0	0%
Julurezieren	11 (3)	11	100%	0	0%
Nirudilismus	10 (4)	10	100%	0	0%
TOTAL	123 (17)	117	95.12%	6	4.87%

Table 4. Results for the condition ‘second heavy syllable’ (German)

word	total realizations	stress on the first syllable		stress on the second syllable	
patarzenieren	8 (6)	2	25%	6	75%

Varalkorismus	12 (2)	3	25%	9	75%
Kosemlarismus	10 (4)	6	60%	4	40%
Telenkosieren	14	9	64.28%	5	35.71%
Zurufkoschieren	12 (2)	6	50%	6	50%
Philuskalismus	12 (2)	6	50%	6	50%
Buritschlanismus	10 (4)	4	40%	6	60%
Bivizkolieren	10 (4)	1	10%	9	90%
Perotpibieren	12 (2)	8	66.66%	4	33.33%
Ropoktalismus	11 (3)	5	45.45%	6	54.54%
TOTAL	111 (29)	50	45.04%	61	54.95%

3.3. Discussion of results

I will start by discussing first the results concerning the Italian part, followed by those concerning the German part. As it is possible to see from Table 1, the majority of speakers (70.82%) placed secondary stress on the first syllable, while only a minority (29.17%) put it on the second syllable. These results seem to be in accordance with the results obtained in previous experiments (in which, however, real words were used) on the directionality of secondary stress in Italian (Gola, 2009; Alber, 2009) which reported about 70% of secondary stress on the first syllable.

Looking at the single items, some words can be found in which secondary stress was put mostly on the second syllable, namely *batanità*, *macaletà* and *togedimento*. A possible explanation for these results could be a neighborhood-effect, i.e. the words were perceived as similar to real words in which secondary stress falls on the second syllable because of stress preservation, such as *procèdiménto* [procedure] (from *procédere* [to proceed]) similar to *togedimento* or *banalITÀ* (from *banále* [banal]) similar to *batanità* and *macaletà*. Overall these results point to a clear directionality of secondary stress from left to right in Italian.

With respect to diatopic variation, no significant difference in percentages of stress on the first syllable was found between participants from Verona (68.27%) and all the others (70.82%). With respect to age differences, 14-37 years (14 informants) put secondary stress on the first syllable in 68.92% of cases, while 51-64 years (8 informants) did so in 74% of cases, showing a slight preference for older speakers to put stress on the first syllable more often than younger speakers.

Turning now to the condition with a second heavy syllable, Table 2 shows very clear results, with only 9.69% of realizations with secondary stress on the first syllable and 90.30% of realizations on the second syllable. These results clearly point to a considerable influence of syllabic weight on secondary stress. Looking at the individual words, it is possible to see that all words received stress mostly on the second syllable, with *patarcità* and *celondità* being stressed on the second syllable in all cases. With regard to the coda consonants, no particular differences emerged among liquids, nasals, affricates and stops. However, a minor tendency to attract stress on the second heavy syllable appears instead in rhymes closed by a fricative, as in *buruffazione* (77.77%) and *gitussizione* (67.56%), which, however, also turned out to be the words which were mispronounced the majority of times (8 and 7 times respectively).

With regard to the diatopic variation, the total percentage of collocations of secondary stress on the second syllable by only the informants coming from Verona amounts to 91.54%, against a total percentage of 90.30%, thus without showing any significant difference. With regard to age, similarly to the condition with all light syllables, there seems to be a slightly major preference among the younger speakers for a collocation of secondary stress on the second syllable (93.52%) than among the older speakers (84.72%).

Turning now to the results of the German part of the experiment, as can be seen from Table 3, in the condition with all light syllables, in 95.12% of realizations made by the German-speaking informants secondary stress was placed on the first syllable, thus pointing to a clear directionality of secondary stress from left to right, in accordance with the studies which have been done so far on the directionality of secondary stress (Alber, 1997; Knaus et al., 2011).

With regard to the condition with the second heavy syllable, a more ambiguous picture emerges from the results of Table 4. Secondary stress was placed on the first syllable in 45.04% of cases, while it was placed on the second syllable in 54.95%, thus without pointing to a clear influence of syllabic weight on secondary stress. The results of a t-test show that the difference between the two is not significant ($p = 0.272$). With respect to differences for single items, the two words *patarzenieren* and *Varalkorismus*, both having the most sonorous type of vowel (/a/) and a second syllable coda made of a liquid, received secondary stress on the second syllable in 75% of cases, maybe showing the influence of one of these two factors. On the other hand, the two other words which showed the majority of realizations with stress on the second syllable were *Buritschlanismus* (60%) and *Bivizkolieren* (90%), in both of which the second syllable was closed by an affricate, /tʃ/ and /ts/ respectively.

In general, in spite of the two similar percentages in the results, the slight majority of realizations with stress on the second heavy syllable may still be interpreted as a partial influence of syllable weight on secondary stress, since otherwise we would have expected a percentage similar to that of the condition with all light syllables, or in any case a much smaller percentage of realizations with stress on the second syllable. Furthermore, such a conclusion would be in accordance with the study conducted by Alber (1997), which also pointed towards an only partial influence of weight on secondary stress. Due to the low number of speakers, it is not possible to establish differences related to diatopic variation or age.

In sum, the results of this experiment suggest a clear directionality of secondary stress for Italian from left to right, in accordance with the previous experiments that have been done on this topic, and a strong influence of syllabic weight on secondary stress. With regard to age, a slightly higher tendency to place secondary stress on the second syllable in both conditions can be observed for younger speakers. With regard to German, the results of this experiment suggest a very clear directionality of secondary stress from left to right, in accordance with the previous experiments on the topic. In the second condition, the data from the reading task suggests a variable weight sensitivity of secondary stress in German, also in accordance with current research on the topic. Although the results of the experiment showed some unexpected data, these results seem to be in line with previous experimental research and the typological data, confirming for both Italian and German a directionality of secondary stress from left to right and pointing to a correlation between the variability of weight sensitivity of main stress and the variability of weight sensitivity of secondary stress in both languages, in accordance with the tendency among languages to show a correlation between the weight sensitivity of main and secondary stress.

4. Acoustic correlates of secondary stress

In the world's languages, many different acoustic correlates of main or secondary stress have been found. The most commonly studied are usually duration, fundamental frequency (F0), intensity and spectral characteristics, which include formant values and spectral tilt (Gordon & Roettger, 2017). The role of each of these parameters in signaling stress varies according to language and Gordon and Roettger, on the basis of their survey of 21 studies, note that in most cases the acoustic parameters that signal main and secondary stress are not the same, except in one language of their sample (Dutch).

With regard to the acoustic parameters of stress in Italian, Eriksson et al. (2016) measured F0 level¹³, F0 variation, duration and spectral emphasis¹⁴ in both main and secondary stress. The authors found F0 level to be a correlate of main stress, being significantly lower in main stressed vowels than in secondary stressed or unstressed vowels; however, this is interpreted as an influence of the overall accent of the carrier sentence. With respect to F0 variation, considerably less variability was found in secondary stressed syllables than in the other syllables. The duration of main stressed vowels (mean 116 ms) was found to differ considerably from that of secondary stressed (61 ms) and unstressed vowels (64 ms). As in the case of vowel duration, for spectral emphasis the differences between main stressed (5.5 dB), secondary stressed (5.1 dB) and unstressed vowels (4.3 dB) have also been found to be statistically significant. Overall the authors conclude that, for both main and secondary stress, the most reliable acoustic parameter is duration, followed by spectral emphasis and finally by F0 variation.

With regard to German, from experiments with minimal pairs like *modérn* [modern] and *móderm* [to rot], it appears that the most significant correlates of stress are duration, followed by F0 and finally by intensity (Dogil & Williams, 1999). In another experiment (Aronov & Schweitzer, 2016), duration was confirmed as a reliable correlate of main stress, while no significant effect of pitch was found. With respect to secondary stress, Zerbian (2002, cited in Kleber and Klippahn, 2006) analyzed vowel and syllable duration, F0 and intensity and did not find any of these parameters to be reliable correlates of secondary stress. Kleber and Klippahn (2006) analysed duration, intensity and formants F1 and F2 in relation to the syllable preceding the main stressed syllable, as in *Mediál* [medial] and in relation to the syllable two positions before the main stressed syllable, as in *Medizíner* [physician]. However, in this study too, no parameters were found to be reliable correlates of secondary stress in German.

5. Experiment on the acoustic correlates of secondary stress

5.1. Methodology

In order to find out the acoustic correlates of secondary stress in Italian and German, a reading task has been administered to 18 native Italian speakers and 7 native German speakers (the same ones who took part in the experiment with the nonce words, minus 4 Italian speakers). The informants had to read aloud two real words, which had the same structure as the nonce words in the first experiment, i.e. one word with all light syllables before main stress (LLLY), and one with a second heavy syllable (LHLY). The following target words were used:

Table 5. Target words used in the experiments on the acoustic correlates of secondary stress.

	all light syllable	second heavy syllable
Italian	camaleónte ‘chameleon’	magazziniére ‘warehouse worker’
German	Kapazität ‘ability’	Adaptatíon ‘adaptation’

All words had the vowel /a/ in the first two syllables, which are the syllables that could receive secondary stress. Furthermore, all words were chosen avoiding the presence of stress

¹³ Defined as the F0 median in the vowel.

¹⁴ Spectral emphasis is calculated as $SPL_{full} - SPL_0$. The two SPLs are defined as following: “SPL of the full spectrum in a given segment and SPL0 is the SPL of the low-pass filtered segment using a cutoff frequency of 1.5 * F0_{mean} at 18 dB/octave” (Eriksson et al. 2016: 1060). Spectral emphasis is measured in dB and it represents a parameter similar to intensity.

preservation, as for instance in the Italian word *capacità* [ability], from *capace* [capable]. Each word was inserted into the same carrier sentence of the nonce-word experiment and participants were asked to read each sentence aloud twice. The total number of analysed vowels, excluding mispronounced items, amounts to 144 for Italian and 48 for German, for a total of 192 vowels.

Before analyzing the acoustic parameters, I listened to the single realizations of the words in order to determine the position of secondary stress. In both *camaleonte* and *Kapazität*, secondary stress was always perceived to fall on the first syllable, while in both *magazziniere* and *Adaptation*, secondary stress was always perceived to fall on the second syllable. The acoustic parameters which were measured are: duration (s), mean intensity (dB), mean F0 (Hz), mean F2 (Hz)¹⁵ and spectral tilt¹⁶ (dB/Hz). All the analysed vowels were extracted manually by me and the acoustic parameters were then calculated using Praat.

The expectations for this experiment were thus to find significantly higher levels of these parameters on the vowel which is deemed to bear a secondary stress, i.e. the first vowel in *camaleonte* and *Kapazität* and the second vowel in *magazziniere* and *Adaptation*. For example, a significantly greater duration on the first syllable of *camaleonte* would point to the presence of a secondary stress on the first syllable, as opposed to an unstressed second syllable, suggesting duration as an acoustic correlate of secondary stress. In order to establish whether the difference between the same parameter in the first and in the second syllable was statistically significant, a t-test was performed on the results.

5.2. Results

Table 6. Results of the acoustic measurements for *camaleonte* and *magazziniere*.

	<i>camaleonte</i>			<i>magazziniere</i>		
	1 st syllable	2 nd syllable	p-values	1 st syllable	2 nd syllable	p-values
Duration	0.05307	0.07465	< .001	0.06827	0.07810	0.009
Intensity	82.39	81.40	0.026	81.94	83.07	0.007
F0	149.6	144.9	0.601	147.1	147.7	0.949
F2	1329	1352	0.537	1303	1721	< .001
Spec. Tilt	-0.007445	-0.007387	0.903	-0.007120	-0.006590	0.273

Table 7. Results of the acoustic measurements for *Kapazität* and *Adaptation*.

	<i>Kapazität</i>			<i>Adaptation</i>		
	1 st syllable	2 nd syllable	p-values	1 st syllable	2 nd syllable	p-values
Duration	0.05094	0.05913	0.055	0.05827	0.07207	0.098 ^a
Intensity	80.96	80.51	0.687	79.12	80.66	0.331
F0	182.3	175.5	0.591	149.9	158.7	0.709
F2	1560	1670	0.032 ^a	1615	1624	0.803
Spec. Tilt	-0.009075	-0.008561	0.433	-0.007626	-0.007085	0.574

5.3. Discussion of results

¹⁵ F2, the second formant, refers to the backness of a vowel, where a higher F2 indicates a front vowel and a lower F2 indicates a back vowel.

¹⁶ Spectral Tilt is defined in Praat's manual as a Ltas object, i.e. "the logarithmic power spectral density as a function of frequency, expressed in dB/Hz relative to $2 \cdot 10^{-5}$ Pa." (Boersma & Weenink 2010b).

With regard to duration, the second vowel is on average longer than the first one in all four target words, irrespective of the condition. Looking at the p-values, it can be seen that the differences in duration for *camaleonte* and *magazziniere* are significant ($p < 0.001$ and $p = 0.009$ respectively), while those for *Kapazität* and *Adaptation* are very close to 0.05 (0.055 and 0.098). These results contrast with the expectations of greater duration on the first vowel of *camaleonte* and *Kapazität*, which were deemed to have secondary stress on the first syllable, and at the same time greater duration on the second vowel of *magazziniere* and *Adaptation*, which were deemed to have secondary stress on the second syllable. Therefore, these results do not suggest a correlation between duration and secondary stress; rather, they suggest a significant correlation between duration and position, with the second vowel consistently longer than the first. In light of these results, the duration of the third vowel of all the four items was also measured and the overall duration was found to gradually increase towards main stress (1st vowel = 0.053, 2nd = 0.067, 3rd = 0.068). This gradual increase in duration also turned out to be present in the measurements reported in other studies both for Italian (Eriksson et al., 2016; Marotta, 1985) and for German (Dogil and Williams, 1999; Kleber and Klippahn, 2006).

Turning back to the analysis of the acoustic parameters, with regard to intensity, as expected, the results show that the first vowel of *camaleonte* and *Kapazität* has an average greater intensity than the second vowel and that the second vowel of *magazziniere* and *Adaptation* has a greater intensity than the first vowel. However, the p-values point to a statistically significant difference in the case of *camaleonte* and *magazziniere* (0.026 and 0.007), but not in the case of *Kapazität* and *Adaptation*. These results thus suggest that intensity can be considered an acoustic correlate of secondary stress in Italian but not in German.

With regard to F0, as in the case of intensity, the results show that the first vowel of *camaleonte* and *Kapazität* has an average greater F0 than the second vowel and that the second vowel of *magazziniere* and *Adaptation* has a greater F0 than the first vowel. Nonetheless, contrarily to intensity, in the case of F0 the p-values point to a non-significance of the difference between the two vowels in both languages, suggesting that F0 cannot be considered a reliable correlate of secondary stress either in Italian or in German.

With regard to F2, the results indicate that this value is always greater in the second syllable, irrespective of the condition. However, the only significant cases are *magazziniere* ($p < 0.001$) and *Kapazität* ($p = 0.032$). Since F2 refers to the backness of a vowel, where a higher F2 indicates a front vowel and a lower F2 indicates a back vowel, a higher F2 in the case of /a/ would mean a more peripheral and less central realization of the vowel, i.e. a more clearly articulated sound. Since more peripheral articulation is deemed to be a possible acoustic correlate of stress, the expectations were to find a higher F2 in the vowels bearing secondary stress. We cannot exclude, as has been the case for duration, that higher F2 may also be correlated with position instead of secondary stress, although the evidence from the p-values is not so strong as in the case of duration.

With regard to spectral tilt, the results show that it is greater in the first vowel of all four words, but no statistical significance suggesting a correlation with position is found in any condition.

6. Conclusions

The aim of the first part of this work was, on the one hand, to establish the existence and the directionality of secondary stress in Italian and German and, on the other hand, to see whether the directionality of secondary stress in these languages is influenced by syllable weight. With regard to the first question, in both Italian and German the results of the experiment with nonce words confirm the existence of secondary stress and they show a clear directionality from left to right, in accordance with the literature and the experimental evidence

gathered so far on this topic. With regard to the second question, in the case of Italian, the results show a clear influence of syllable weight on secondary stress, suggesting that Italian secondary stress is weight sensitive. In the case of German, the results do not show an influence of syllabic weight on secondary stress as clearly as in the case of Italian. Nonetheless, it is still possible to conclude that secondary stress in German is variably sensitive to syllabic weight, in accordance with the literature on this topic.

The second part of this work was aimed at individuating some acoustic correlates of secondary stress. In the case of Italian, intensity has been found to be the only reliable acoustic correlate of secondary stress, only partially in accordance with the literature on the topic, while duration, which was considered to be a predictor of secondary stress in the literature, has been found to correlate with position instead of stress. F2 has also been found to moderately correlate with position. In the case of German, no reliable acoustic correlate of secondary stress has been found, in accordance with the literature on the topic. Similarly to the case of Italian, duration and, more moderately, F2 have been found to correlate with position instead of stress. Further research, possibly conducted with different methodologies and on a greater amount of data, is needed in order to identify more clearly some reliable acoustic correlates of secondary stress in Italian and German.

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