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THE EFFECTS OF LINGUISTIC AND COGNITIVE FACTORS ON THE L2 PROCESSING OF ORAL INPUT: A SELF-PACED LISTENING EXPERIMENT

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ABSTRACT

Listening comprehension is a real-time process, yet very little is known about the variables affecting real-time second language (L2) listening. The present study aimed at investigating the effects of syntactic complexity and word frequency on L2 listening. Furthermore, the role of the listener's working memory capacity in listening comprehension was investigated. Fifty-three Dutch learners of French were tested using a working memory task and self-paced listening technique. Working memory scores and reaction times were collected as a measure of processing efficiency. Contrast analyses were run on the reaction times per variable. Correlation tests were run between the working memory scores and reaction times. The results showed that syntactic complexity affects L2 listening comprehension. However, no effect of word frequency on L2 listening and no correlation between working memory capacity and L2 listening in any of the conditions was found. We conclude that linguistic factors shown to affect offline L2 listening are not always generalizable to online L2 listening. We also conclude that working memory considered as a cognitive system separate from other cognitive processes involved in language comprehension does not explain individual differences in real-time L2 listening. Further research needs to be done to better understand (real-time) L2 listening comprehension.

Introduction

Listening comprehension in a second language (L2) is a very important factor in successfully participating in today's international society. As L2 listening is a real-time activity, this language competence is a challenging task for L2 learners. The difficulty of L2 listening can be related to the fact that this type of language comprehension concerns a cognitive online (= real-time) task in which semantic, syntactic, neurological and pragmatic processing is involved (Rost, 2011). Besides these factors, knowledge about the communicative context and the world is also taken to be related to L2 listening (Buck, 2001; Vandergrift, 2007). The ability to process and combine all this information in discourse is essential to successfully comprehend L2 oral input (Rost, 2005). Therefore, these processes must run efficiently and quickly. To understand which linguistic components and learner characteristics affect L2 listening comprehension, recent studies focused on a componential approach (e.g., Andringa et al., 2012; Brunfaut & Révész, 2015; Révész & Brunfaut, 2013; Wang & Treffers-Daller, 2017). In such an approach, the relative contributions of linguistic components such as general language proficiency and vocabulary knowledge (Wang & Treffers-Daller, 2017), the linguistic complexity of the task or the speed of oral input (Brunfaut & Révész, 2015) to L2 listening performance are investigated. Besides linguistic components, general cognitive abilities such as working memory

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capacity or word monitoring abilities have also been studied in this particular L2 competence (e.g., Andringa et al., 2012). In comparison to L2 reading, relatively few studies have, however, been dedicated to factors which may affect L2 listening. To date, these studies have only focused on offline L2 listening comprehension (e.g., Kostin, 2004; Nissan et al., 1996; Norris & Ortega, 2009; Ying-hui, 2006). This means that listening comprehension has been investigated by means of tests in which listeners need to hold sentences in memory and interpret them within the communicative context. However, linguistic competence is claimed to have a dual nature in the sense that it comprises the ability to interpret linguistic input in real-time (online) and within the communicative context (offline) (Hopp, 2007; Marinis et al., 2005). In order to account for this dual nature, studies need to also focus on online measures of L2 listening to complement our understanding of this L2 language competence. Research on online L2 listening will complement previous studies in which only offline measures were included and enable us to detect differences in the effects of linguistic and cognitive factors on online vs. offline L2 listening.

To the best of our knowledge, no studies, however, investigated the influence of linguistic factors such as syntactic complexity and word frequency, in online listening comprehension in L2. The aim of the present paper is to provide new insights into the role of these linguistic factors in the processing of oral input in L2.

Regarding cognitive factors such as working memory capacity, no consistent results have been found in previous L2 research on language comprehension. While many theories assume that the available working memory capacity is related to language comprehension (Just & Carpenter, 1992; Kintsch, 1998; Townsend & Bever, 2001), others suggest that working memory capacity should not be viewed as a system separate from other cognitive processes involved in language comprehension (MacDonald & Christiansen, 2002; G. S. Waters & Caplan, 1996). Just and Carpenter (1992) for instance, demonstrated that larger working memory capacity enables interaction between syntactic and pragmatic information, leading to better comprehension. In contrast, MacDonald and Christiansen (2002) did not show any effect of working memory capacity in language comprehension and suggested that working memory equates to experience in text processing. They claimed that working memory should not be considered as an autonomous cognitive system.

In the present study, we will investigate the potential effects of two linguistic factors and working memory capacity on online listening in L2. The selected linguistic factors will be the syntactic complexity of sentences and the frequency of words. Since reading and listening comprehension share similar components (Bae & Bachman, 1998), the rationale behind the selection of these linguistic factors can be sought in the fact that these factors have been shown to affect online reading comprehension in L2 (e.g., Kim & Kim, 2012 for word frequency; Havik et al., 2009 for syntactic complexity). Additionally, Matthews and Cheng (2015) found an effect of word frequency on offline performances in L2 listening. Yanagawa and Green (2008), however, found no correlation between word frequency and L2 listeners' performances. Regarding the syntactic complexity of sentences, most of the studies on (offline) L2 listening do not show an effect of syntactic complexity on this particular language competence (Blau, 1990; Kostin, 2004; Ying-hui, 2006). Based on the dual nature of linguistic competence and the fact that the influence of linguistic factors may be different in online vs. offline language comprehension (Sagarra & Herschensohn, 2010), more research is needed to better understand the real-time component of L2 listening.

Listening Comprehension

As shown by Buck (2001), Rost (2011), and Vandergrift (2007), L2 listening comprehension is a complex task in which real-time processing of linguistic information is involved. The construct of listening comprehension can be defined as in Buck (2001, p. 114):

> the ability to process extended samples of realistic spoken language, automatically and in real-time; to understand the linguistic information that is unequivocally included in the text; and to make whatever inferences are unambiguously implicated by the content of the passage

Good listeners, thus, have the ability to efficiently and automatically process real-time linguistic information and to interpret this information within the context of the discourse. Less proficient listeners (e.g., with less linguistic knowledge and/or limited cognitive abilities) often show more controlled and conscious processing (Segalowitz, 2003). Listening comprehension shares many components with reading comprehension. Receptive linguistic (e.g., syntax and vocabulary) knowledge and world knowledge (e.g., prior knowledge on the topic and text structure) for instance, are the basis of both oral and written types of language comprehension (Bae & Bachman, 1998; Kintsch, 1998).

However, listening is a real-time comprehension process of spoken language. While readers can review written texts and influence the speed of language input, listeners cannot. Listeners also need to hold more information in working memory. Therefore, listening comprehension is considered to be cognitively more demanding than reading comprehension (Vandergrift & Goh, 2012).

Factors Influencing L2 Listening Comprehension

Studies investigating potential factors that affect L2 language comprehension have mainly focused on reading (e.g., Havik et al., 2009; Kim & Kim, 2012; Van Gelderen et al., 2004; Walter, 2004). These studies investigated the role of several linguistic and cognitive factors such as syntactic complexity (Havik et al., 2009) and word frequency (Kim & Kim, 2012) and the L2 learner's working memory capacity (Walter, 2004). Only few studies have run similar analyses on listening comprehension.

Whereas the effect of word frequency on L2 reading comprehension has been consistently demonstrated in previous research (e.g., Kim & Kim, 2012; Sonbul, 2015), the literature on L2 listening comprehension shows mixed results in this respect. Based on the fact that correct word identification is a prerequisite for listening comprehension (Goh, 2000) and that high frequency words are identified faster than low frequency ones in L2 listeners (Muljani et al., 1998), one could expect that oral input which contains low frequency words is comprehended with more difficulty than input with high frequency words. However, no conclusive results have been found in previous studies. Matthews and Cheng (2015) for instance, investigated the relative contribution of word identification to the listening competence of 167 Chinese learners of English. The test items in the word identification task were categorized per word frequency level (i.e., high vs. low frequency words). L2 listening competence was measured by means of the (offline) International English Language Testing System. A multiple regression analysis revealed that 52% of the observed variance in the listening scores could be predicted by the identification of high frequency words. In contrast, the identification of low frequency words revealed to have no predictive power in listening scores. The authors conclude that the successful identification of high frequency words in speech predicts successful L2 listening comprehension. Similar conclusions were drawn by Nissan et al. (1996). In investigating TOEFL dialogs they found that L2 listeners have greater difficulty comprehending input with low frequency words than input with high frequency ones. In contrast to Matthews and Cheng (2015), Nissan et al. (1996), and Yanagawa and Green (2008) argued that word frequency is not correlated to L2 listening comprehension. In their study listening performances in three multiple choice comprehension test formats (i.e., preview both the question and answer option, preview only the question and preview only the answer options) were compared. Besides ten other variables, the test items' word frequency was manipulated in these test formats. In contrast to previous findings, the results revealed for this variable that items containing low frequency words are comprehended better than items with high frequency words. The authors explained this surprising finding by the prediction that the low frequency words taken from the JACET 2000 word list may be more familiar to the listeners than the high frequency words. They conclude that word frequency is not a good predictor for L2 listening difficulty. However, it is important to note that the focus of the Yanagawa and Green (2008)'s study was on the role of question types in L2 listening comprehension tests. Word frequency was taken as one of the covariates included in the study. In a similar vein, Ying-hui (2006) did not show any correlation between word frequency and L2 listening difficulty in listeners' performances. In this study L2 listening task features such as word frequency, were investigated in relation to listening performances in L2. By means of regression analyses it was shown that word frequency did not affect L2 listening performances. Based on the dual nature of linguistic competence, the influence of word frequency in L2 listening may differ between online and offline comprehension (e.g., Sagarra & Herschensohn, 2010). To the best of our knowledge, only one study, however, tackled this issue in real-time listening comprehension. By means of self-paced listening technique Ferreira, Henderson, Anes, Weeks, and McFarlane (1996)investigated the effect of word frequency on listening comprehension in 32 native speakers of American English. The test stimuli were sentences in which the word frequency of one segment was manipulated (high vs. low frequency word). On each segment the reaction time was registered as a measure of processing difficulty. A contrast analysis revealed that high frequency words were processed faster than low frequency ones. Under the assumption that increased processing costs reflect an increased difficulty of comprehension, the authors conclude that the frequency of words is related to the listening difficulty of native speakers. No research on the real-time comprehension of oral input has, however, tackled this issue in the L2 domain.

Regarding the syntactic complexity of sentences, a large body of L2 literature showed that this particular factor does not affect (offline) listening comprehension (e.g., Blau, 1990; Kostin, 2004; Norris & Ortega, 2009; Révész & Brunfaut, 2013; Ying-hui, 2006). These studies demonstrated that there is no significant correlation between L2 listening and a set of subconstructs of structural complexity such as complexity by subordination (Blau, 1990; Révész & Brunfaut, 2013; Ying-hui, 2006), phrasal complexity (Révész & Brunfaut, 2013), discourse complexity (Révész & Brunfaut, 2013) and overall complexity (Kostin, 2004; Révész & Brunfaut, 2013; Ying-hui, 2006). While these experiments focused on offline listening comprehension, the link between structural complexity and the online component of listening has only been investigated in L1 listening comprehension (e.g., Ferreira, Henderson, et al., 1996; G. Waters & Caplan, 2004; Waters et al., 2003). These studies used a self-paced listening technique and showed that structurally complex sentences are comprehended with more difficulty than structurally simple ones in L1 speakers. In this respect, structurally complex sentences have been considered as sentences exhibiting a relatively large syntactic configuration (e.g., sentences with embedded clauses) or sentences in which syntactic movement has taken place (e.g., object relative clauses) for instance. The processing of these structurally complex sentences is cognitively more demanding than structurally simple sentences (G. Waters & Caplan, 2004). In view of the dual nature of linguistic competence, the potential effect of syntactic complexity on online listening comprehension needs to be investigated to complement our understanding of L2 listening.

Besides linguistic factors affecting L2 listening comprehension, cognitive factors have also been shown to influence this language competence. Of particular interest in L2 research is the role of working memory capacity in individual differences in listening comprehension (Bloomfield et al., 2011; Juffs & Harrington, 2011). Working memory deals with a temporary storage and manipulation of input during cognitively demanding tasks such as the processing of linguistic information (Baddeley, 1992). According to Baddeley (1992), working memory can be taken as a multicomponent model in which the central executive component involves the planning and coordination of input received and retrieves prior knowledge stored in long-term memory. Two other subcomponents are the phonological loop and the visuo-spatial sketchpad. The first one involves the retention of phonological information in the oral input, while the second one involves the interpretation of non-verbal information such as gestures. For listening comprehension, the central executive component and the phonological loop are crucial. Since both components are limited in capacity and related to individual cognitive capacities, the link between working memory capacity and language comprehension (reading and listening) has been investigated in a large body of research (see Andringa et al., 2012 for an overview). The way how working memory exactly constrains language comprehension is under debate. As shown in the introduction, Just and Carpenter (1992), and King and Just (1991), on the one hand, claimed that working memory can be considered as a separate system in which different linguistic processes take place simultaneously and consequently, language comprehension is constrained by the amount of working memory capacity available to comprehend oral input. On the other hand, MacDonald and Christiansen (2002), and G. S. Waters and Caplan (1996) argued that a specific cognitive system handles syntactic parsing, but cannot be considered as a system separate from other cognitive systems. From their perspective, language comprehension is not linked to a specific working memory system and correlations found in previous studies (e.g., Just & Carpenter, 1992) are the result of post-parsing processes as reading span tasks only measure controlled processes rather than implicit processes involved in language comprehension.

In research on L2 listening comprehension, very few studies focused on this potential link. The few studies which attempted to find a relation between working memory and L2 listening comprehension showed mixed results. Miyake and Friedman (1998) demonstrated that working memory is correlated to (offline) L2 syntactic listening comprehension in the sense that listeners with a high level of working memory capacity are more sensitive to cues in the oral input than listeners with a lower level of working memory capacity. A similar correlation has been found in Kormos and Sáfár (2008). In contrast to these findings, Andringa et al. (2012) carried out a more fine-grained study on the role of working memory in (offline) L2 listening comprehension. Working memory was measured using four-digit span tasks and one non-word recognition task. While some of the tasks revealed a weak correlation between working memory and listening performances, this cognitive factor could not explain any unique variance in the listening scores. In view of the dual nature of linguistic competence, the role of working memory needs to also be investigated in the online component of listening comprehension. To the best of our knowledge, no studies have, however, been done to tackle this issue in online L2 listening.

Research Questions and Hypotheses

RQ1: Do syntactic complexity and word frequency affect the efficiency of real-time listening comprehension in L2?

RQ2: Can working memory be taken as a factor for individual variation in real-time listening comprehension in L2?

We hypothesized that

(1) if syntactically simple sentences are processed more efficiently than complex ones, participants demonstrate lower reaction times in syntactically simple sentences than syntactically complex ones,
(2) if high-frequency words are processed more efficiently than low-frequency ones, participants demonstrate lower reaction times in high-frequency words than in low-frequency ones,
(3) working memory does not affect the efficiency of real-time listening comprehension in L2.

Method

Participants

The participants in this study were 53 second language learners of French. They were all native speakers of Dutch living in the Netherlands and were not informed on the purpose of the experiment. All participants were enrolled in a French language class for 5 to 8 years. The age range of the test population was between 17 and 31 (M = 19.7, SD = 2.6). All participants were at a B1 or a B2 level of listening proficiency in French, which was tested by means of a listening proficiency test. In the test population women were overrepresented (36 women and 17 men). As an inclusion criterion, participants confirmed that they did not have language disorders such as dyslexia, or any hearing problems. All participants gave written informed consent for the experiment.

Materials and procedures

Working memory capacity

Working memory capacity was measured using a forward-backward digit span task, which was part of the WISC intelligence test (Wechsler, 2003). This type of task is commonly used in studies on working memory capacity (e.g., Juffs & Harrington, 2011; Kormos & Sáfár, 2008). Other common working memory tasks are non-word repetition tasks and reading/listening span tasks as proposed in Daneman and Carpenter (1980). However, these tasks have been demonstrated to measure proficiency and experience rather than working memory capacity (MacDonald & Christiansen, 2002). Additionally, scores on forward-backward digit span tasks have been shown to correlate very highly to listening comprehension as compared to scores on non-word repetition tasks (Kormos & Sáfár, 2008). Therefore, a forward-backward digit span task was administered as a measure of working memory. In this task, the participants were asked to listen to a series of digits and to reproduce the digits in the same order (in case of the forward version) or in reverse order (in case of the backward version). The series increased with one digit per two trials, beginning with two digits and ending with nine digits for the forward version and eight for the backward version. The digits were orally produced by one of the researchers and had 1 second in duration. Each series was produced once. The outcome measure of the task was represented by the highest number of correctly repeated series. All participants were in a classroom and finished this working memory task well within 15 minutes.

Self-paced listening

In this study, real-time listening speed was measured using the auditory moving window technique as described by Ferreira, Henderson, et al. (1996). This technique was successfully used in many previous studies on adult listening comprehension (e.g., Ferreira, Anes, & Horine, 1996; Heredia & Vaid, 2002; Waters et al., 2002) and provides the processing time per segment. Each word of the sentence is one segment (as in Ferreira, Henderson, et al., 1996, determiners are integrated in the same segment as the noun). Participants listen to sentences divided into segments, which are presented one-by-one. To proceed and listen to the next segment participants need to push on a pacing button once the segment's word has finished. The reaction time is assumed to reflect processing efficiency.

The materials for the self-paced listening task consisted of 40 sentences which were used to test the effects of two linguistic factors: Syntactic Complexity and Word Frequency. More specifically, 20 sentences were classified on the basis of Syntactic Complexity (10 complex vs. 10 simple) and 20 sentences were classified on the basis of Word Frequency (10 high frequency vs. 10 low frequency). Regarding Syntactic Complexity, the syntactic complexity of sentences was defined as the presence vs. absence of embeddedness. The complex sentences contained relative constructions such as in *Aujourd'hui/#le lien/#qu'il/#entretient/#avec/son équipe/est/important* 'Today the link he maintains with his team is important,' while the simple ones did not as in *Aujourd'hui/#il/#entretient/#le lien/#avec/son équipe* 'Today he maintains the link with his team.' To avoid potential transfer effects from the participants' L1 on processing efficiency, these constructions exhibited a similar syntactic structure in L1. The # indication shows the segment on which reaction times have been measured. The region of measurement contained exactly the same number of words, but differed with respect to the syntactic complexity of the sentence. More precisely, it contained a pronoun (*il*), a verb (*entretient*) and a noun (*le lien*). The last segment (*avec*) was measured to account for potential spill-over effects.

Sentence pairs manipulated for Word Frequency were also identical but were different for the lexical frequency of one particular segment. More precisely, the segment of measurement was a high-frequency word such as in *Aujourd´hui/je/sais/#l'heure/exacte* 'Today I know the exact time' or a low-frequency word as in *Aujourd'hui/je/sais/#la règle/exacte* 'Today I know the exact rule.' Based on the Brunet (2014)'s corpus for word frequency in spoken French, the frequency of the selected words was determined. High-frequency words were words belonging to the 9000–10,000 frequency band or above, while low-frequency words were words belonging to the 1–1000 frequency band. The selected high- and low-frequency words revealed to differ significantly with respect to their frequency (*t*

(9) = 10.88, $p < .001$). To avoid an effect of animacy on word processing (cf. Weckerly & Kutas, 1999), all selected words were inanimate in both test conditions. Furthermore, all words contained one or two syllables.

All stimuli used in this experiment have been created in accordance with the specifications described in Marinis (2010) and Ferreira, Henderson, et al. (1996). As such, they only contained low-frequency words (except for the high-frequency condition) to avoid a potential effect of lexical frequency on processing efficiency across test conditions (cf. Matthews & Cheng, 2015). Furthermore, all segments in the region of measurement exhibited a low level of imageability as the imageability of lexical items has been shown to affect language processing (Deloche et al., 1987). Since cognates have been found to be processed faster than non-cognates (Brenders et al., 2011), the stimuli used did not contain any cognate in the region of measurement. To avoid the effect of wrap-up on sentence processing in the sentence-final segment this particular segment was not taken into account for the region of measurement.

In a soundproof room, the test stimuli were recorded by a female research assistant. As Ferreira, Anes, et al. (1996)showed that sentence processing is affected by prosodic cues, the segments were recorded one-by-one and edited in PRAAT (Boersma & Weenink, 2005) to remove pauses in the segments' audio files. In the audio editor program AUDACITY, the segments' audio files were combined to create the test stimuli. After editing the stimuli, the self-paced listening software (ZEP) was installed on a Linux laptop. Four practice items were added so that participants became familiar with the experiment before it started. After a random set of stimuli, a yes-no comprehension question popped up to be sure that participants paid attention to the stimuli and understood the sentences. The participants' answers were registered to verify whether all participants understood the stimuli. In a quiet room, participants were seated in front of a computer screen and received oral input by means of a headphone. They proceeded to the next segment of the sentence by pushing on a button box and were instructed to proceed at their own pace. If the button was pressed before the end of the segment, it was terminated and the next segment was played. At the end of each sentence participants heard a signal so that they knew that the next sentence started. All 40 stimuli were integrated in one and the same self-paced listening task and the presentation order was counter-balanced for each participant. Since the stimuli yielded different target constructions (i.e., simple/complex, low frequency/high frequency and idioms), no filler items were added. The task took approximately 15 minutes.

Data analysis

As mentioned above, reaction times were measured on the segments with the # indication. These reaction times (in milliseconds) were the interresponse times (i.e., the duration between the segment's offset and the button press). The interresponse time of segments comprises the temporal duration to play the segment and the participant's processing time. As segments differed in temporal duration (e.g., because of differences in length), corrected reaction times per segment were calculated by subtracting the segment's temporal duration from the interresponse time (procedure described by Ferreira, Henderson, et al. (1996)). As such, the corrected reaction time per segment only reflects the participant's processing time. The segment's corrected reaction time was removed if it exceeded the predetermined cutoff point of 2000 milliseconds or if it had a negative value due to button presses before the segment has ended (as in Waters & Caplan, 2004). For each participant, the mean of corrected reaction times was calculated per segment of measurement for each condition. Outliers were removed by winsorizing the data. This statistical procedure involves the replacement of outliers with the next highest or lowest score that is not an outlier (as described in Field, 2013).

Based on these means of reaction times in the Syntactic Complexity stimuli, a mixed ANCOVA was run to analyze differences between the segments of measurement and the type of sentence. The dependent variable was the mean of the corrected reaction times per segment, the within-subjects independent variable was Type of Segment which contained four levels: Pronoun, VP, NP and

NextSegment. The between-subjects independent variable was Sentence Type which contained two levels: complex and simple sentences. The working memory scores were included in the analysis as covariable. Since the assumption for sphericity was not met ($p < .05$), degrees of freedom were corrected using Greenhouse–Geisser estimates of sphericity. The assumption for normality was tested for all segments in both types of sentences and was found to be met in only the Pronoun and NextSegment listening times and the working memory scores ($p > .05$). As ANCOVA is robust for a violation of normality assumptions, this statistical analysis is adequate for data analysis. Post hoc contrast analyses with Bonferroni correction were run to account for potential differences between the levels of Type of Segment and Sentence Type.

Regarding the listening times in the Word Frequency stimuli, Kolmogorov–Smirnov normality tests showed that the data were not normally distributed ($p < .05$). Therefore, a Wilcoxon signed-rank test was run to analyze a potential difference between the reaction times in high vs. low-frequency words. To test the potential role of working memory capacity during listening comprehension, the working memory scores were regressed against the corrected reaction times per condition by means of a Spearman correlation test. The α level of significance was set at .05 for all statistical analyses.

Results

As described above, the dependent variable in this study was the corrected reaction time as a measure of processing efficiency. In Figures 1 and 2, the corrected reaction times are presented for the segments of measurement in the Syntactic Complexity and the Word Frequency stimuli respectively. The working memory scores are given in Table 1.

For Syntactic Complexity, the mixed ANCOVA revealed a significant main effect for Sentence Type, $F(1, 95) = 6.38$, $p = .013$, $\eta^2 = .06$. Complex sentences were processed more slowly than simple ones. A significant interaction effect between Sentence Type and Type of Segments was also found, $F(2.50, 332.3) = 7.0$, $p < .001$, $\eta^2 = .06$, indicating that the differences in listening times between complex and simple sentences differed between segments of measurement. More specifically, the NP and NextSegment element were found to trigger higher listening times in complex sentences as compared

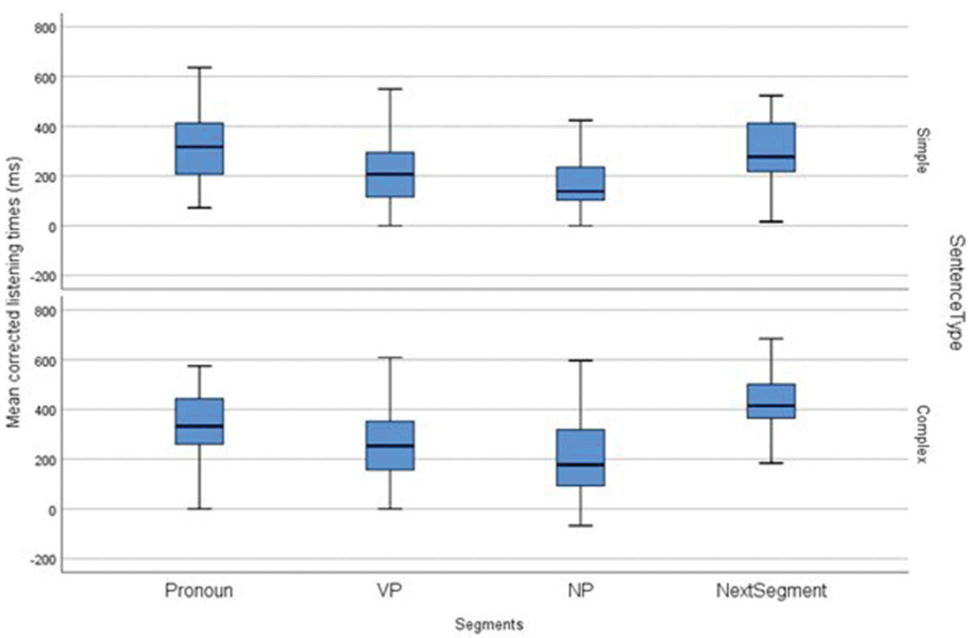

Figure 1. Mean corrected listening times (ms) per segment and per sentence type.

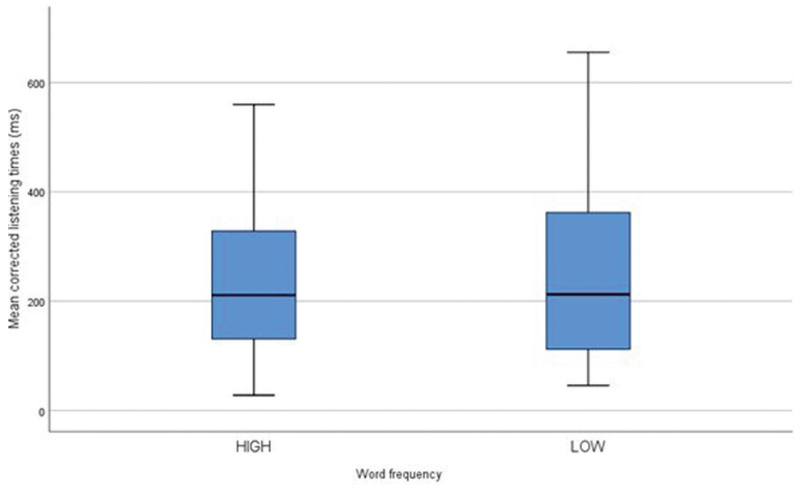

Figure 2. Mean corrected listening times (ms) per word frequency.

TABLE 1. Working memory scores.

	M	SD	range
Working memory	20.0	3.0	13–27

to simple sentences, whereas the pronoun and VP element did not. However, no main effect was found for Type of Segments, $F(2.50, 237.3) = .64$, $p = .56$, $\eta^2 = .007$. This means that the listening times did not differ between the segments of measurement. Furthermore, working memory capacity did not moderate the listening times in any segment, $F(2.50, 332.3) = .49$, $p = .65$, $\eta^2 = .005$.

The Wilcoxon signed-rank test did not show a significant difference for Word Frequency, $T = 747$, $p = .29$, $r = .11$. This means that the listening times in high- vs. low-frequency words were equal. Concerning working memory, no significant correlation was observed between the working memory scores and the reaction times in the high- or low-frequency condition ($p > .05$).

Discussion and Conclusions

The results showed that the processing of syntactically complex sentences such as relative constructions, is cognitively more demanding during listening than simple sentences. Under the assumption that the speed of pacing in self-paced listening experiments reflects the efficiency of comprehension, one can assume that the comprehension of syntactically complex sentences in L2 listening is more difficult than simple sentences. This confirms our first hypothesis. However, our second hypothesis cannot be confirmed based on the results of this study. As the speed of processing high-frequency vs. low-frequency words revealed to be equal, the efficiency of comprehension seems to be similar in words varying with respect to their lexical frequency in the real-time L2 listening process. With respect to working memory, this cognitive factor did not reveal to correlate to the speed of processing oral input in any condition. Therefore, it cannot be taken as a factor of individual variation in the efficiency of real-time listening comprehension in L2. This confirms our third hypothesis.

Interestingly, the effect of the syntactic complexity of sentences on L2 listening observed in this study contrasts with previous studies (e.g., Norris & Ortega, 2009; Révész & Brunfaut, 2013; Ying-hui, 2006) in which no effect of any subconstruct of syntactic complexity on listening has been shown. This contrast may be explained by the component of listening comprehension under investigation in previous studies. More precisely, in these studies, the focus was on the offline component of listening and not on the online component. Listeners' performances in tests focusing on the offline component of listening are not similar to those obtained in online tests. Sagarra and Herschensohn (2010), for instance, showed that the participants' performances in tests targeting number and gender agreement processing differed in online vs. offline tests in both L1 and L2 learners of Spanish. In a similar vein, Roberts et al. (2008) found that the L2 learners' performances in pronoun resolution were different in offline vs. online methodology. Syntactic complexity, thus, seems to only play a role in online processes of L2 language comprehension. This difference may be explained by the level of interpretation during real-time vs. offline comprehension. Whereas interpretation of linguistic input during real-time comprehension mainly concerns processing at a sentence level, offline interpretation of linguistic input is related to communicative contexts at a discourse level (cf. Buck, 2001). Text characteristics and text complexity, for instance, are related to L2 listening performances at a discourse level and not at a sentence level (Révész & Brunfaut, 2013). In offline interpretation of linguistic input listeners must create a situational model of the discourse in which overall text characteristics and text complexity play a role. At this level, specific linguistic factors such as the syntactic complexity of individual sentences, do not significantly affect the comprehension of the discourse. Andringa et al. (2012) for instance, demonstrated that overall linguistic knowledge (vocabulary and grammatical knowledge) is the main contributor to successful L2 listening comprehension at a discourse level. Our findings are in line with previous studies on the effect of structural complexity on real-time L1 listening (e.g., Ferreira, Henderson, et al. (1996); G. Waters & Caplan, 2004; Waters et al., 2003) and seem therefore to provide evidence for the fact that linguistic factors found to affect L2 listening comprehension in the online component are not always generalizable to the offline component and vice versa. In view of the dual nature of linguistic competence, this demonstrates that the effects of linguistic factors may differ between both components of L2 listening.

With respect to word frequency, our findings were in contrast with those described in Ferreira, Henderson, et al. (1996))for online L1 listening. In this study, a significant difference in processing efficiency was observed between high-frequency and low-frequency words in American English speakers. For online L2 listening, however, no difference in processing efficiency was found in the present study. This interesting contrast may be related to the fact that the speaker's language experience in the L2 influences L2 frequency effects (Whitford & Titone, 2012). More specifically, L2 exposure has been shown to be negatively correlated to L2 frequency effects in the sense that lower degrees of L2 exposure lead to higher L2 frequency effects. As the participants tested in this study are advanced L2 learners, they received much L2 exposure and consequently, showed no significant L2 frequency effects in their listening performances.

Another interesting finding is the fact that the listener's working memory capacity was not demonstrated to correlate to real-time L2 listening. This is in line with studies (e.g., MacDonald & Christiansen, 2002; G. S. Waters & Caplan, 1996) in which working memory is considered as a system that is not separate from other cognitive processes involved in language comprehension. Instead, theories assuming that working memory capacity equates to experience in language processing (Ericsson & Kintsch, 1995; MacDonald & Christiansen, 2002) may be more appropriate for the processing of oral input. The native speakers' processing of oral input for instance, has been shown to highly correlate to working memory capacity (Andringa et al., 2012). Within the context of these experience-based theories of working memory, Andringa and colleagues claimed that the contrast between L1 and L2 listeners may be explained by the difference in text processing experience. Listeners having much linguistic knowledge and the ability to process oral input quickly, can be taken as more experienced with text processing. Since the working memory task used in this experiment measures working memory capacity by means of language-independent digits, no correlation between working memory and real-time L2 listening can be expected if working memory indeed is a non-autonomous cognitive system and equates to experience in language processing. This may explain why a lack of a role of working memory has been found in the present study. Since only one measure of working memory capacity has been used in this study, this conclusion needs to be interpreted carefully. Further research needs to focus on the question whether working memory measured by means of language-dependent digits such as listening span digits (cf. Daneman & Carpenter, 1980), will be a more appropriate instrument to explain individual variation in L2 listening performances.

Overall, our suggestion for further research is to focus on the dual nature of listening comprehension by including both online and offline measures in experimental designs in order to complement our idea of L2 listening comprehension. These insights may be relevant for foreign language education.

Disclosure Statement

We declare that this manuscript is original, has not been published before and is not currently being considered for publication elsewhere. We know of no conflicts of interest associated with this publication, and there has been no financial support for this work that could have influenced its outcome.

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Appendix A. Experimental stimuli Self-Paced Listening

Syntactic Complexity

Simple

	Intro	Pro	VP	NP	Seg5	Seg6	Seg7	Seg8	Seg9	Seg10
1	Aujourd'hui	il	entretient	le lien	avec	son équipe				
2	Ce week-end	il	réserve	la rencontre	dans	Le restaurant				
3	Vendredi	il	décrit	la tâche	à	effectuer				
4	Cet après-midi	il	discute	la vision	avec	son collègue				
5	Heureusement	il	décrit	l'accent	de	cette fille				
6	Maintenant	il	essuie	le défaut	de	cet appareil				
7	Normalement	il	trace	la chute	du	pilote				
8	actuellement	il	surmonte	la terreur	dans	ce pays				
9	Normalement	il	protège	la chance	de	sa famille				
10	ce matin	il	révèle	la perte	financière	actuelle				

Complex

	Intro	NP	Pro	VP	Seg5	Seg6	Seg7	Seg8	Seg9	Seg10
1	Aujourd'hui	le lien	qu'il	entretient	avec	Son équipe	est	important		
2	Ce week-end	la rencontre	qu'il	réserve	dans	Le restaurant	a	lieu		
3	vendredi	La tâche	qu'il	décrit	est	à	effectuer			
4	Cet après-midi	la vision	qu'il	discute	avec	Son collègue	fait	du	bruit	
5	heureusement	l'accent	qu'il	décrit	est	à	Cette fille			
6	Maintenant	le défaut	qu'il	essuie	est	à	Cet appareil-ci			
7	Normalement	La chute	qu'il	trace	est	celle	du	pilote		
8	actuellement	La terreur	qu'il	surmonte	est	dans	Ce pays			
9	Normalement	La chance	qu'il	protège	est	celle	de	Sa famille		
10	ce matin	La perte	qu'il	révèle	est	de	type	financier		

Lexical Frequency

High frequency

	Seg1	Seg2	Seg3	Seg4	Seg5	Seg6	Seg7	Seg8	Seg9	Seg10
1	Aujourd'hui	Je	sais	l'heure	exacte					
2	Ce week-end	elle	a	Le temps	de	Sortir				
3	Heureusement	la	deuxième	fois	est	la bonne				
4	Sûrement	ça	vaut	Le coup	d'essayer					
5	Aujourd'hui	C'est	vraiment	Le moment	de	La vérité				
6	Maintenant	je	vois	La chose	exceptionnelle					
7	Normalement	on	a	un jour	libre	seulement				
8	actuellement	C'est	vraiment	La vie	en	rose				
9	Normalement	on	entend	Une voix	claire					
10	ce matin	je	vois	L'air	du	printemps				

Low frequency

	Seg1	Seg2	Seg3	Seg4	Seg5	Seg6	Seg7	Seg8	Seg9	Seg10
1	Aujourd'hui	je	sais	La règle	exacte					
2	Le week-end	elle	a	L'angoisse	de	tomber				
3	Heureusement	La	deuxième	tâche	Est	La meilleure				
4	Sûrement	ça	vaut	Un mensonge	pieux					

(*Continued*)

(Continued).

	Seg1	Seg2	Seg3	Seg4	Seg5	Seg6	Seg7	Seg8	Seg9	Seg10
5	Aujourd’hui	C’est	vraiment	Une bande	chaotique					
6	Maintenant	je	vois	Le lien	exceptionnel					
7	Normalement	on	a	Une rencontre	par	mois				
8	actuellement	C’est	vraiment	La chasse	au	trésor				
9	Normalement	on	entend	Une discussion	structurée					
10	ce matin	je	vois	La chute	des	feuilles				