Influence of speech rate and information density on recognition:

The Moderate Dynamic Mechanism

Emma Rodero

Pompeu Fabra University (UPF), Barcelona, Spain.

emma.rodero@upf.edu

Abstract

This paper analyzes whether recognition in the news may be affected by speech rate and information density and addresses what the optimal level would need to be for information on the radio to be encoded and recognized as effectively as possible. The key question is whether the combination of these two factors has a decisive influence on cognitive processing, especially in the distribution of resources allocated and required to encode the message. The findings indicate that it does have a decisive influence on recognition of information since it modifies the resources available for encoding the message. The higher the speed, the lower the information density should be and vice versa. The best result in order to achieve the greatest recognition is between 170 (high density) and 190 (low density) words per minute, confirming that a Moderate Dynamic Mechanism takes place.

Keywords: speech rate, information density, radio, news, recognition

Influence of Speech Rate and Information Density on Recognition:
the Moderate Dynamic Mechanism

One topic of interest for cognitive psychologists, media researchers and linguists is how the brain processes media messages and, particularly, speech. The way in which a person says something can be as relevant as the content of the message. Therefore, an examination of how a listener processes media messages, analyzing a prosodic strategy such as speech rate, forms a substantial topic of research related to cognitive processing of speech. Accordingly, this research analyzes the extent to which speech rate and information density may affect a listener's ability to recognize news, examining the optimal level required for information on the radio to be recognized as effective. By applying the analysis to radio messages, this study can make developments in determining the impact of prosodic features on human processing of auditory messages, strengthening the theory on which it is founded: the Limited Capacity Model of Motivated Mediated Message Processing -LC4MP- (Lang, 2009, 2006, and 2000).

The LC4MP is an information-processing model of cognition that focuses on the attention and recall processes. Limited capacity refers to the fact that the human cognitive system does not have capacity to thoroughly process all the information contained in a media message. The degree to which cognitive resources are assigned to encoding, retrieval, and storage of the message is determined by processes that range from being more or less automatic to consciously controlled. Processes that require automatic resources do not demand an excessive amount of attention and the listener has a subjective impression of having made little effort. In contrast, processes that require controlled resources demand attention and the individual has the impression of having made considerable effort. Of all the resources necessary in processing, those conditioned by the characteristics of the message are called 'required resources'; and those which individual actually uses for the processing are

‘allocated resources’. The difference between required resources and allocated resources is called “available resources.” This study continues a line of theoretical development initially tested by Lang et al. (2006), which establishes a measure for available resources. When the level of available resources is high, the message is thoroughly processed because far more resources are allocated to processing the message than required. On the contrary, when the available resources are low, the message is less thoroughly processed and task performance would decrease (Lang et al., 2013; Lang et al., 2006). The number of available resources an individual requires to process a message depends on the two conditions of stimuli: structural or formal complexity and information density. Structural features automatically allocate resources to processing the message while content-related features determine the required resources to be processed. As a result, to understand cognitive processing it is important to identify the structural and formal features of the message which can automatically attract the attention of the listener. Consequently, this study examines the independent effects of a structural complexity variable (speech rate) used to manipulate automatic resource allocation, as well as an information density variable used to manipulate required resources in order to test available resources and task performance (measured by audio recognition). According to LC4MP, the structural features of a message, such as voice, have an important impact on the limited capacity of the human cognitive system. These properties elicit orientating responses and, therefore, resources are automatically allocated to encoding the message (Potter, Lang, & Bolls, 2008; Potter, 2000). A large body of research has been carried out concerning television (camera changes, sudden movement, etc.), radio (voice changes, music onsets, sound effects, etc.) and the Internet (animation, emotional pictures, etc.). But “these lists are not yet complete” (Lang, 2009, p. 196). This theory has not yet been tested in an analysis of verbal processing with changes in prosodic elements basic to the speech process, such as speech rate.

The other factor that determines the encoding process and the number of required resources is content and, especially, information density (Fox, Park, & Lang, 2007). In this respect, there are numerous studies applied to television messages which look into the impact of information density on cognition; however, few are applied to an auditory stimulus like a radio message. As the results may also apply to other types of communicative processes based on sound stimuli, this study also aims to develop research relating both to the processing of audio messages and to the factors determining the process of message encoding. In fact, research on both how mediated messages are processed in the brain and how they can affect cognitive processing is a highly theoretical sphere of study. In recent years has become increasingly interdisciplinary in regard to media effects (communication), speech perception (linguistics) and cognitive processing (psychology). Furthermore, the conclusions drawn from this research are of great interest to the audio industry and may be directly applicable to the teaching of sound, audio production and audio message complexity across platforms (e.g., radio, TV audio tracks, audio on the Internet, podcasts or public and interpersonal communication).

The cognitive processing of an audio stimulus such as radio news is determined largely by the structural or formal characteristics comprising the message as well as by information density in said message (Fox et al., 2007). With regard to structural or formal characteristics, one of the most crucial elements, which determines the listener's understanding, is speech rate, especially in news programmes based only on information. Information contained in news, based on many data, should be harder to understand than, for example, the content delivered in entertainment shows. The second important variable, which can affect the encoding process of a message, is information density (Potter et al., 2006).

Lang and her colleagues conducted two studies applied to television which employed these two variables (Lang et al., 2007). They represented structural complexity by the number

of camera changes per second, on two levels, and information density by the amount of information introduced by the camera changes, on three levels. They found that increasing structural complexity with low levels of information density led to an improvement in the degree of recognition. At medium levels of information input, increasing structural complexity yielded a good degree of memory. However, when information density was high, increasing structural complexity resulted in a poor degree of recognition, indicating that there were insufficient resources allocated to the encoding process.

In the case studied in this paper, at least in theory, if structural characteristics introduce complexity, for example, by increasing the speech rate, the individual will need additional resources to encode the content. A valuable aspect to consider is that if speech rate is very fast it prevents the listener from understanding the information because radio is a sound medium operating on the basis of a short-term memory with limited capacity. Therefore, fewer resources will remain available. If, however, these few resources are still sufficient to encode the message, recognition would remain stable. Contrariwise, if insufficient resources remain available, a cognitive overload may arise; in other words, the number of required resources will exceed the number allocated. This leaves few resources available hindering recognition. The result would be a cognitive overload (Fox et al, 2007), meaning the encoding performance (measured by recognition) would decrease. “Indeed, in general a decrease in encoding has been the primary indicator that the encoding process is overloaded” (Lang et al., 2007, p. 320). This overload is produced in an automatic rather than a controlled manner because it is not understood to be a complete collapse but “a state of relative insufficiency in one or more sub-processes lasting for a specific amount of time” (Lang, 2009, p. 197). Therefore, the process would not be noticed by listeners. This overload is the risk that might exist in a radio news message which is characterized both by high information density and the complex nature of the content conveyed in a continuous manner

with no opportunity to recover the information and, more often than not, at high speed (Rodero, 2012). In this case, the phonological loop may be affected or eliminated because the speed at which the stimulus occurs is either faster than the persistence of the Short Term Memory or reaches a level beyond the capacity of the STM. The consequence is that the phonological loop would not function. The phonological loop is a component of verbal processing to store verbal information in the working memory. It is composed of a phonological store and a sub-vocal rehearsal process. This sub-vocal process is an inner vocalization, involved in the processing and storage of speech-based information, that helps to hold the information in the STM (Baddeley, 2003). In an extreme case, if the phonological loop collapses, the cognitive overload would be particularly severe.

On the other hand, in theory at least, slow speech rate should make it easier to recognize the information as it allows the listener more time to process the message. A slow speech rate with pauses allows a listener extra time for processing speech. However, the problem is that some research has shown that if the speech rate is too slow, understanding may be adversely affected. A presentation that unfolds at a slow pace can lead difficulty maintaining attention (Berlyne, 1960) and can result in weakened comprehension (Mastropieri, Leinart, & Scruggs, 1999) due to a conscious effort on the part of the listener. In Nelson's research (1948), low speech rate was not well evaluated. This can be explained by the fact that a slow rate reduces attention and interest with respect to the message (Mastropieri et al., 1999; LaBarbera & MacLachlan, 1979; Berlyne, 1960). Specifically, the studies of LaBarbera and MacLachlan (1979) concluded that the fastest commercials were found to be substantially more interesting and, probably due to increased attention, the ability to recall them was greatly improved. For this very reason, Murphey et al. (2003) state that: "In general, it has been found that moderately fast speech is preferred over slow speech", especially to improve persuasion (Miller et al., 1976).

Some authors have found that recall and recognition of the news can be affected by speech rate (Hudson, Lane, & Pullen, 2005; Murphey, Dobie, & Grant, 2003; Meyerson, 1974). Along these lines, Goldstein (1940) showed that lower scores for comprehension were obtained at faster rates, especially when more difficult materials were used. Lawton (1930) conducted research on students listening to radio speakers. In 34 cases, this author noted that the speaker delivered the message too swiftly to be understood, while in 12 cases delivery was too slow and, as a result, lacked interest. Borden (1927) came to the conclusion that the best average rate was 165 wpm, and that delivery should contain certain marked variations in rate. Additionally, Lumley (1933) determined that the average syllable rate was in the region of 240 per minute and the word rate was 160 per minute. Other research on reading speed has shown that understanding becomes difficult at 200 wpm or more (Ellis, 1993). Similarly, in a test comparing four different rates, Nelson (1948) established that the most satisfactory rate for newscasters was 175 wpm. The findings of LaBarbera and MacLachlan (1979), when applied to advertising, suggest that broadcasters should be cautious in avoiding slower than normal rates of speech (145 wpm) and should strive to maintain a pace that is more or less 30% faster than the typical rate of speech (150 wpm). In this respect, a study by Foulke and Sticht (1967) determined that the preferred rate was approximately 25% faster than the normal rate. Although these studies demonstrate these data, they are not recent and there are no current sources.

According to LC4MP, an increase in both variables, structural complexity and information density, should produce an even more negative effect on recognition. If the resources required to process an audio message with a high level of information density delivered at high speed are greater in number than the allocated resources, a cognitive overload may arise. Therefore, the listener should make a conscious effort to understand that

would hinder the encoding process, which in turn would affect recognition of the information.

Taking into consideration this theoretical review, it could be concluded that, to be correctly encoded, the optimal rate of news delivery should involve a pace that must be sufficiently swift to grab the attention of the listener, though always within a regulated spectrum in order to avoid affecting understanding. Consequently, this process is what we may call a Moderate Dynamic Mechanism (MDM). It is a dynamic mechanism because speech rate requires a certain level of liveliness in order to stimulate the listener's attention and, accordingly, for more automatic resources to be allocated to processing the message. However, this energy or vivacity, together with the information density, must be moderated in order to avoid interfering with recognition by increasing the required resources. Therefore, an increase in the degree of complexity has to be regulated by a reduction in the other factor. The greater the delivery speed, the lower the information density.

In conclusion, it can be deduced, first, that listeners could be aware of changes in speed and information density, experiencing a subjective impression of working hard on processing the message and, second, that the optimal rate of news delivery to be recognized should be determined by the MDM. This suggested MDM will be tested in the following hypotheses:

- H1: Moderate levels of speech rate and information density will produce optimal levels of recognition with little conscious effort to understand on the part of the listener.
- H2: Fast levels of speech rate and high information density will reduce the level of recognition and the conscious effort to understand on the part of the listener.
- H3: Slow level of speech rate and high information density will reduce the level of recognition and conscious effort to understand on the part of the listener.

Method

Design

In order to assess the hypotheses, 5 information items (national, international, society, culture and sports) at 5 speech rates (150, 170, 190, 210 and 230 wpm) with 2 information density conditions (low and high) were subject to repeated measures ANOVA on the dependent variables. The news items were distributed in a within-subjects design while speech rate and information density were in a between-subjects design.

Participants and Procedure

A sample of 200 communication students was selected ($N = 200$), 109 female students and 91 males. The overall sample was divided at random into ten groups of twenty people keeping the gender balance. Each group listened to five news items delivered with the same speech rate and one information density condition. For example, group 1 listened to 5 information items (national, international, society, culture and sports) corresponding to 150 wpm and with low density, group 2 listened to 5 news items corresponding to 150 wpm and with high density and so on.

Participants were randomly assigned to an order of presentation prior to their arrival. As an initial instruction they were merely informed that they were going to listen to radio news about which they would subsequently be required to answer some questions.

Once the news had been listened to, the questionnaires were handed out in order to assess self-perception and recognition. The questionnaire as a whole was the same for the various groups and news items, and the total test lasted 40 minutes. The method is summarized in Table 1.

[Table 1 here]

Stimuli

Recordings from the Spanish public radio network RNE were used because the sample chosen to assess those recordings was Spanish. The corpus was formed by 100 radio news items. The analysis of delivery speed of the news items, counting the words per minute (wpm)/total time as recommended by Franke (1939) and Darley (1940), yielded an average speed of 210, a figure which supports earlier findings (Rodero, 2007). This speech rate can be considered too fast and, therefore, inappropriate for reading news, as indeed several radio authors have advised (optimal rate about 180 wpm). In fact, it is a characteristic of Spanish radio news that cannot be found in other countries (Rodero, 2012).

Of these news items, five of them bearing this average speech rate were chosen for use in the experimental design: national, international, society, culture and sports; thus, five information items were selected maintaining approximately the same length (about 1 minute). Subsequently, the texts for these actual news items were analyzed to determine their level of information density. The data load was measured following the codification used by Rodero (2014). This codification establishes the percentage between keywords expressing the main ideas in the content of each news item, understood as the content that corresponded to the six Ws (What, Who, When, Where, hoW and Why) and the total number of words in each news item, understood as the secondary data. The findings indicated that the average information density for the five news items was about 62.3%, with no significant variations among the news items. This density rate was considered high since it was over 50%. It meant that every news item introduced more than 50% of ideas (an average of six per news item) in relation to text devoted to explanations and clarifications, a considerable amount of new data. These news items formed the high-density condition. The information density of these news items was then reduced by eliminating some data, words or expressions which were not strictly necessary for comprehension of the information (i.e., numbers or subordinate clauses). This

modification left each item only with four new ideas and a resulting average density of 40.7%. These news items formed the low-density condition. In this case, the total number of words corresponding to new ideas was reduced, but explanations about the main information were added in order to maintain the same number of words and length for both conditions: low and high density. An example is shown in the Appendix 1. As a consequence, the five news items (national, international, society, culture and sports) had a length of between 140 and 150 words, but always the same for low and high conditions. Once this part of the stimulus was prepared, three trained informants coded the messages in independent sessions obtaining an inter-coder reliability of $KALPHA = .89$.

Having performed these transformations, the last step was to get a professional newsreader to record the completed news items in a studio, varying the delivery speed; first with a high and then with a low information density. The difference in speech rates among various information items was set at 20 wpm. This decision was made, firstly, with regard to the *SD* of these news items (20) and, then, subsequent to a prior pilot study involving 25 students of communication chosen at random from a class list, where the perception of variation was gauged when the delivery speed of the news item was increased by 5, 10, 15 and 20 wpm. The individuals were asked about the extent to which they noticed differences in speech rate and information density on a three-point scale. Significant differences in the perception of speech were evidenced at a change of 20 wpm, while significant differences in the perception of information density were also noticed in 40.7% of cases. In addition, the trial was initially conducted using the speech rate that several authors considered to be normal in a conversation: 150 wpm, and the interval matched the average speech of the pilot news items: 210 wpm. Therefore, a 20 wpm variation was established between the news items, meaning that the various speech rates were as follows: 150 (normal), 170 (a 13.7% increase over normal speech), 190 (a 26.5% increase), 210 (37.5%) and 230 wpm (50%). The

minimal deviations in the average speeds obtained from the newsreader were corrected using software *Wedw* (Bunnell, 2005) in which the desired duration can be obtained. In total, five news items were recorded at five different speech speeds, combined with high and low information density.

Measures

Self-perception questionnaire. The sample was asked to evaluate the speaker's speech rate and the information density. First, participants had to assess the perception of speed. A five-point scale was established where respondents had to state whether they considered it was: very fast (1), fast (2), normal (3), slow (4) or very slow (5). Then, the second question was intended to ascertain whether this information density was conducive to understanding the news, again where a five-point scale was provided to show whether understanding was considered to be: very difficult (1), difficult (2), normal (3), easy (4) or very easy (5). This self-report measure was relevant to rate the listener's conscious effort to understand the information. The purpose of these two measuring instruments was to assess the listener's subjective impression on being subjected to changes both in speed and in the levels of effort produced on understanding the information.

Recognition. The second part of the questionnaire sought to measure the level of information recognition and, therefore, the encoding process of the audio message (Lang, 2009). This part was formed by multiple choice questions relating to the content of the five news items, three for each news item, with the same level of difficulty in each case (about the content that corresponded to the six Ws – What, Who, When, Where, hoW and Why). By means of this recognition test involving compelled choice, the sample had to select the right information from four options, only one of which was true. In order to gauge this, a count was made of the total number of right answers or hits (H), the total number of errors (E), the total number of unanswered questions (U) and, lastly, a coded variable on the overall recall

rate (R) formed by the total number of correctly answered questions minus errors divided by the three possible replies, $R = H - (E / 3)$. This is an overarching calculation which quantifies correct answers and errors, as well as blank responses. The formula gives preference to successes, from which errors are subtracted and divided by the three optional responses contained in the sample. Thus, answers left blank are also calculated. This formula has been employed in certain studies (Rodero, 2013).

Results

5 information items (national, international, society, culture, and sports) at 5 speech rates (150, 170, 190, 210, and 230 wpm) with 2 information density conditions (low and high) were subject to a repeated measures ANOVA. The data showed that the assumption of sphericity was not violated and the homogeneity of covariance was not significant. The combined dependent variables resulted in significant primary effects in the case of speech rate, $F(4, 196) = 52.62, p < .001$, partial $\eta^2 = .51$, and the interaction with density, $F(4, 195) = 12.56, p < .001$, partial $\eta^2 = .29$. Information density, $F(1, 198) = .10, p < .425$, partial $\eta^2 = .04$, and the five news items, $F(4, 195) = 13.12, p < .157$, partial $\eta^2 = .03$, were statistically non significant. All the results are shown in Table 2.

[Table 2 here]

The aim of the first part of the questionnaire was to examine the extent to which the participants in the sample were able to perceive the speech rate of the news items by themselves. The differences were statistically significant regarding speech rate, $F(4, 195) = 71.63, p < .001$, and also for the interaction between speech rate and density, $F(4, 195) = 5.55, p < .001$. The differences were not significant, on the other hand, for density, $F(1, 198) = .15, p < .697$. The results in response to the question asking the participants about the

speech rate at which the reader delivered the news indicated that both versions of the 150-wpm news items were considered to be slow; both versions of the 170-wpm and 190-wpm news items were considered to be normal; both versions at 210 wpm were considered fast; and, lastly, both versions at 230 wpm were closest to receiving the fastest rating. The pairwise comparisons showed that the differences were significant for all comparisons made, except when comparing 170 and 190 wpm ($p < .220$), which showed highly similar values.

In relation to the second question where the individuals had to classify the perception of speed and the conscious effort to understand news items, the differences were significant regarding speech rate, $F(4, 195) = 59.97, p < .001$, and the interaction between speech rate and density, $F(4, 195) = 12.45, p < .001$, but not in the case of density, $F(1, 198) = 2.48, p < .116$. Both news item variants, 150 and 210 wpm, were considered difficult to understand, with the lowest rating being given for 150 (low density, LD) and 210 (high density, HD). Both versions at 170 and 190 wpm were considered normal and easy to understand, particularly 190 LD which was almost rated as being very easy. Lastly, both versions at 230 wpm were considered the most difficult to understand, especially 230 HD. The pairwise comparisons showed that the differences were substantial in all comparisons, except in relation to 150-210 wpm ($p < .381$), 150-230 wpm ($p < .167$), and 210-230 wpm ($p < .028$) which had more similar values.

The concluding part in this analysis was confirmed by fifteen closed-ended questions aimed at gauging the extent to which certain information from each of the five news items in the news was recognized. The differences between the news items were substantial in the case of speech rate, $F(4, 195) = 70.69, p < .001$, and speech rate in relation to interaction with density, $F(4, 195) = 16.34, p < .001$. Information density was statistically non significant, $F(1, 198) = .10, p < .741$, as were the five news items, $F(4, 195) = 1184, p < .316$. In this case, the final order of recognition was: 170 HD, 190 LD, 170 LD, 190 HD, 150 HD, 210

LD, 210 HD and 230 LD. In last position, having attained the worst rating, were 150 LD and 230 HD, which were remembered to the lowest degree by all the participants. The pairwise comparisons and post-hoc tests involving Bonferroni test showed that the differences were significant in the case of all comparisons, except between the 150- and 210-wpm ($p < .381$), and the 170- and 190-wpm news items ($p < .994$).

Moderate levels of speech

The first hypothesis of this study postulated that the moderate levels of speech rate and information density would produce optimal levels of recognition with little conscious effort to understand on the part of the listener. This is the application of the Moderate Dynamic Mechanism. In this case, the data showed that, overall, the greatest level of recollection of the news items was with 170 HD and 190 LD followed by 170 LD and 190 HD. Together with the data already discussed, these data confirmed this first hypothesis. Both 170 and 190 are speeds which, with moderate information density, can be considered suitable for recognition and also sufficiently dynamic to gain the listener's attention. In addition, both versions were considered normal and easy to understand, particularly 190 LD, which was almost rated as being very easy; therefore, it was perceived consciously with little effort for the listener. Figure 1 illustrates the process of recognition.

[Figure 1 here]

Fast levels of speech

Hypothesis two established that the fast levels of speech rate and high information density would reduce the level of recognition by generating a cognitive overload and a conscious effort to understand on the part of the listener. This hypothesis was supported because this is the mechanism observed in the news items delivered at speeds of 210 and 230.

These news items were assessed in this order: 210 LD, 210 HD, 230 LD and 230 HD, which was remembered to the lowest degree by all participants. With regard to self-perception, both versions at 210 wpm were considered fast and difficult to understand; and both versions at 230 wpm were perceived as very fast and very difficult to understand. Therefore, conscious effort to understand was perceived by the listener.

Slow level of speech

Hypothesis three stated that the slow levels of speech rate and high information density would reduce the level of recognition and generate a conscious effort to understand on the part of the listener. The data lead us to conclude that this hypothesis can also be confirmed. This is the mechanism observed in the news items delivered at a speed of 150 with low information density: the news items that recorded the second worst results for data recognition; and 150 HD which registered poor recognition. In addition, both variants for the 150-wpm news items were considered to be slow and difficult to understand, in other words, giving rise to conscious effort on the part of the listener.

Discussion

The theoretical approach proposed in this study places emphasis on one of the salient features of media messages to the human brain: speech rate. Indeed, how this prosodic feature must be employed and combined in communicative strategies by the speaker to improve the cognitive processing of the listener is an issue that is not thoroughly examined in the most relevant theories and especially in LC4MP. In addition, this project analyzes the least studied model of message processing: auditory stimulus through radio messages. Therefore, the findings presented here reinforce and build on the theoretical framework developed in LC4MP.

Primarily, the contributions of this study have been: a) to explain the distribution of allocated resources required to encode an audio-verbal message, as a measure of available

resources, in line with the previous research of LC4MP; b) to define the Moderate Dynamic Mechanism that takes place in the processing of speech; c) to show a severe cognitive overload produced by the collapse of the phonological loop with the highest speech rate and information density; and, d) to determine that listeners have been aware of and perceived changes in speech rate and the level of difficulty in understanding.

The results of this study illustrate that the level of recognition of news on the radio is affected by the pace of the reader's delivery. Also, self-perception on the part of the individuals surveyed matches the findings obtained regarding recognition. Therefore, these data reinforce the studies of several authors demonstrating that delivery speed is a factor which directly and clearly affects persuasion (Hudson et al., 2005; LaBarbera & MacLachlan, 1979; Meyerson, 1974; Nelson, 1948; Goldstein, 1940; Lawton, 1930; Borden, 1927; Lumley, 1933). News items perceived as having a normal pace (170 and 190 wpm) and considered easier to understand were recognized to the greatest extent. However, those that were perceived as slower (150 wpm) and swifter (210 and 230 wpm) were assessed as difficult to understand and were recognized to the lowest degree, particularly the fastest delivered item. In contrast, information density was not a decisive variable on its own, but rather on account of its interaction with delivery speed. This fact may simply be explained by the method employed to measure it and the number of data assigned to each level. This is something that would need revising in future research.

The findings of this study indicate that any stimulus needs to be sufficiently fast or dynamic to gain the listener's attention, but always at a moderate speed ranging between 170 and 190 words per minute so as not to impede suitable processing. At this optimal level, the characteristics of the message do not require a large number of cognitive resources for the processing function. Consequently, when the listener is exposed to the radio message in a comfortable yet dynamic delivery speed, does not need to allocate an unreasonable volume of

resources to achieve the correct encoding. Moreover, many of these attention resources are automatic, so the listener still has available resources for storage of information. For this reason, the level of recognition is the highest. However, since the combination of both variables exercises a significant effect on the level of recognition, raising the degree of complexity, an increase in one of these variables needs to be offset by a reduction in the other. Thus, the greater the delivery speed, the lower the information density; news achieving the best results (170 HD/190 LD) must be compensated in this way. In the perceptive part of this study, the listener acknowledges that in these conditions news items are easier to understand, requiring little processing effort. Therefore, a good final level of information recognition is attained. This result matches the studies of LaBarbera and MacLachlan (1979), and Foulke and Sticht (1967) who determined that, in the case of the former, the optimally delivered speech entails an increase of 25% and, in the case of the latter, it was determined to be 30%, when compared to normal speech rate. Indeed, the 190-wpm news items have a percentage increase of 26.5%. These data also match the results of Miller et al. (1976), Nelson (1948), Borden (1927) and Lumley (1933). Figure 2 shows this scheme.

[Figure 2 here]

In contrast, when the complexity of the message is increased by raising the delivery speed and the information density, the demand for required resources and allocated resources for suitable processing of information increases progressively. When being exposed rapidly and non-stop to incessant stimuli, the listener is obliged to assign a large number of attention resources in a very short time. As the majority of the resources become controlled, the listener becomes aware of the difficulty understanding. The significant number of resources assigned to processing deprives the listener of resources for other sub-processes which aid in

later recognizing and remembering the information. This is because the additional resources needed to continue processing the information that continues to be delivered are being used up. As a result, the level of recognition is low at 210 words per minute, especially with high information density, but it is much worse at 230. At 230, the listener is incapable of maintaining and processing the incoming information. This is because the speed at which the stimulus occurs is faster than their permanence in the Short Term Memory – STM – (15-30 seconds). Additionally, the information density reaches a level beyond the STM's capacity (input of between 7 and 8 words every two seconds) and there is no strategy in place to facilitate retention. This leads to continual interference in the phonological loop (Baddeley, 2003). Therefore, if any interference is produced in this process, the retention of information is hindered or eliminated. The complexity of the task is such that a situation of cognitive overload occurs and with it, a reduction in recognition to minimum levels, especially when there is a high data load, in line with the LC4MP (Lang, 2009 and 2006). In this extreme case, as the phonological loop stops working, the cognitive overload is particularly severe or even completely collapses. At this point, the feeling of effort becomes completely conscious. In this situation, listeners are sensitive to this overload and consider understanding to be very difficult. Although this phenomenon was not proven in the LC4MP, this extreme overload could be attributed to the complexity of verbal processing. In this case, the MDM continues to produce the best recognition, which is always moderate for information density. The greater the speech rate, the lower the information density (210 LD/210 HD/230 LD/230 HD).

At the opposite extreme, although the message is less complex with a lower delivery speed and news with lower density, the levels of recognition are low. This is probably due to the scarce allocation of attention resources to the message. The number of required resources for processing does not seem high but this somewhat unusual combination for radio news items, especially undynamic, causes a lack of attention by the listener and, therefore, an

intermittent assignment of attention resources to processing. The listener recognizes that the message is difficult to understand because processing does not occur in a stable manner. Therefore, there are not always resources available and the listener is not always willing to assign additional resources to the encoding task. All of these factors lead to a low level of information recognition. However, this does not occur to the same extent as with the previous group of news items because, although the encoding process is impaired, no cognitive overload occurs. Therefore, the data for 150 and 210 wpm were very similar, but for a different reason. The recognition was low in 150-wpm due to a probable lack of attention while that in 210 the listener had difficulties processing the incoming information. On the contrary, albeit in line with the MDM the greater the information density, the lower the speech rate (150 HD/150 LD). This is because the low speech rate needs to be regulated or compensated for the information density to achieve sufficient dynamism and, accordingly, to stimulate the attention of the listener. Table 3 illustrates the MDM.

[Table 3 here]

If we consider that a key goal of radio communication is for the listener to understand the news items, it is clear that the results of this study may have significant repercussions for newscasters and radio stations. Moreover, the findings may also be applied to improve the processing of audio message complexity across platforms (e.g., radio, TV audio tracks, audio on the Internet, podcasts or public and interpersonal communication). Other potential areas could benefit from the results: political communication, educational activities or where prosody takes on a relevant function such as language learning or speech synthesis.

Limitations and future research

The specific choice of different speech rates applied to the news items analyzed may have distorted certain outcomes. The results of this study place the greatest level of recall at a reading rate of between 170 and 190 wpm, but it has not been possible to determine what specific reading pace between these values would lead to the greatest level of recognition. In addition, the limitation to five specific delivery speech rates meant that it was not possible to verify whether the results of the study would have varied in the case of other ranges. Consequently, this study may be extended by using different combinations that will definitively confirm the best delivery pace for achieving optimal recognition of news items.

References

- Baddeley, A.D. (2003). Working memory and language: an overview. *Journal of Communication Disorders*, 36, 189–208. doi: 10.1016/S0021-9924(03)00019-4
- Berlyne, D. E. (1960). *Conflict, arousal and curiosity*. New York: McGraw-Hill.
- Borden, R. C. (1927). The principles of effective radio speaking. *Modern Eloquence*, XV, 9-17.
- Boyd, A. (2003). *Broadcast journalism. techniques of radio and television news*. Oxford: Focal Press.
- Bunnell, H. T., & Mohammed, O. (2005). EDwave-a pc-based program for interactive graphical display, measurement and editing of speech and other signals. [Computer software] presented at the 66th Annual Meeting of the Linguistic Society of America. Philadelpha: Linguistic Society of America.
- Darley, F. L. (1940). A normative study of oral reading rate. Unpublished Master's Thesis, State University of Iowa.
- Ellis, R. (1993). The structural syllabus and second language acquisition. *TESOL Quarterly*, 27 (1), 91-113. doi: 10.2307/3586953
- Franke, P. E. (1939). A preliminary study validating the measurement of oral reading rate in words per minute. Iowa: M.A. Thesis, State University of Iowa.
- Foulke, E., & Sticht, T. G. (1967). The intelligibility and comprehension of time compressed speech. *Proceedings of Louisville Conference on Time-Compressed Speech*. Louisville, KY: University of Louisville.
- Fox, J.R., Park, B., & Lang, A. (2007). When available resources become negative resources: the effects of cognitive overload on memory sensitivity and criterion bias. *Communication Research*, 34, 277-296. doi: 10.1177/0093650207300429

- Goldstein, H. (1940). *Reading and listening comprehension at various controlled rates*. New York: Teachers College, Columbia University.
- Hills, G. (1987). *Los informativos en radiotelevisión* (News on radio and television). Madrid: IORTV.
- Hudson, R. F., Lane, H. B., & Pullen, P. C. (2005). Reading fluency assessment and instruction: What, why, and how? *The Reading Teacher*, 58, 702-714. doi: 10.1598/RT.58.8.1
- LaBarbera, P., & MacLachlan, J. (1979). Time-compressed speech in radio advertising. *Journal of Marketing*, 43 (1), 30-36. doi: 10.2307/1250755
- Lang, A. (2009). The limited capacity model of motivated mediated message processing. In R. Nabi, R. and M.B. Oliver, M.B. (eds). *The SAGE handbook of mass media effects* (pp. 193-204). USA: Sage publication.
- Lang, A. (2006). Using the limited capacity model of motivated mediated message processing to design effective cancer communication messages. *Journal of Communication*, 56 (s1), S57-S80. doi: 10.1111/j.1460-2466.2006.00283.x
- Lang, A. (2000). The limited capacity model of mediated message processing. *Journal of Communication*, 50 (1), 46–70. doi: 10.1093/joc/50.1.46
- Lang, A., Gao, Y., Potter, R., Lee, S., Park, B., Bailey, R. (2013). Conceptualizing audio message complexity as available resources. *Communication Research*.
- Lang, A., Park, B., Sanders-Jackson, A.N., Wilson, B.D., & Wang, Z. (2007). Cognition and emotion in TV message processing: how valence, arousing content, structural complexity, and information density affect the availability of cognitive resources. *Media Psychology*, 10 (3), 317-338. doi: 10.1080/15213260701532880

- Lang, A., Bradley, S.D., Park, B., Shin, M., & Chung, Y. (2006). Parsing the resource pie: Using STRTs to measure attention to mediated messages. *Media Psychology*, 8 (4), 369-394. doi: 10.1207/s1532785xmep0804_3
- Lawton, S. P. (1930). Principles of effective radio speaking. *Quarterly Journal of Speech*, 16 (3), 225-277. doi: 10.1080/00335633009360886
- Lumley, F. H. (1933). Rates of speech in radio speaking. *Quarterly Journal of Speech*, 19 (3), 393-403. doi: 10.1080/0033563309379965
- McLeish, R. (1995). *Radio production*. Oxford: Focal Press.
- Mastropieri, M. A., Leinart, A., & Scruggs, T. E. (1999). Strategies to increase reading fluency. *Intervention in School and Clinic*, 34, 278-283. doi: 10.1177/105345129903400504
- Meyerson, M. D. (1974). An exploration of comprehension differences in time-compressed Japanese, Chinese, Hindi and English speech. In S. Duker (Ed.), *Time compressed speech: an anthology and bibliography* (pp. 730-735). Metuchen, NJ: The Scarecrow Press, Inc.
- Miller, N., Maruyama, G., Beaber, R. J., & Valone, K. (1976). Speed of speech and persuasion. *Journal of Personality and Social Psychology*, 34 (4), 615-624. doi: 10.1037//0022-3514.34.4.615
- Murphey, C., Dobie, K., & Grant, J. (2003). Time versus pause manipulation in communications directed to the young adult population: does it matter? *Journal of Advertising Research*, 43, 281-292.
- Nelson, H. E. (1948). The effect of variation of rate on the recall by radio listeners of "straight" newscasts. *Communication Monographs*, 15 (2), 173-180. doi: 10.1080/03637754809374955

- Potter, R. (2000). The effects of voice changes on orienting and immediate cognitive overload in radio listeners. *Media Psychology*, 2 (2), 147-177. doi: 10.1207/S1532785XMEP0202_3
- Potter, R.F., Lang, A., & Bolls, P.D. (2008). Identifying structural features of audio: orienting responses during radio messages and their impact on recognition. *Journal of Media Psychology: Theories, Methods, and Applications* 20, 168-177. doi: 10.1027/1864-1105.20.4.168
- Potter, R.F., Wang, Z., Angelini, J.R., Sanders-Jackson, Ashley, Kurita, Satoko, Koruth, Jacob, & Lang, A. (2006). The effect of structural complexity and information density on cognitive effort and arousal during audio message processing. *Psychophysiology*, 43, S79–S79.
- Rodero, E.; Larrea, O.; Vázquez, M. (2013). Male and female voices in commercials. analysis of effectiveness, adequacy for product, attention and recall. *Sex Roles*, 68 (5), 349-362.
- Rodero, E. (2014). Serial position and attention resources to improve the recall of radio ads. *Revista Latina de Comunicación Social*, 69, 1-11.
- Rodero, E. (2012). A comparative analysis of speech rate and perception in radio news. *Text and Talk*, 32 (3), 391-411.
- Rodero, E. (2007). Characterization of proper news presentation in audio-visual messages. *Estudios del mensaje periodístico*, 13, 523-542.
- Utterback, A. S. (2000). *Broadcast voice handbook*. Chicago: Bonus Book.

Appendix 1

Example of news item in the two conditions

High information density (6 main ideas)

1. The next *local elections*, to be held *in two years' time in our country, in 2012*, will see an *important increase in the electoral roll*.
2. There will be *one million new voters from 15 different countries*, where *Spaniards* can already *vote in local elections*.
3. *The National Statistics Institute* has sent *communications to 322,633 potential voters* in these countries.
4. With these reciprocal agreements, these new voters will be able to vote in local elections in our country if they have *resided in Spain for more than 5 years*.
5. *Peru and Colombia*, which were *approved by the cabinet a week ago*, will soon be joined by *Ecuador, Venezuela, Bolivia, Chile, Paraguay, Uruguay, Argentina, and Trinidad and Tobago*.
6. *The government will not reach an agreement with Morocco, the country of origin of most non-EU citizens, 23,876*, because it *requires major constitutional changes*.

Words for main ideas: 89 of 139 words: 62,5%

Low information density (4 main ideas)

1. The next *local elections* will see an *increase of the electorate: a million new voters from various Latin American countries*. Several *letters* have been sent *to the potential voters* in these countries to *inform* them that they will be able to vote, as well as about the *procedure* to be followed.
2. One of these requirements is to have *resided in Spain for 5 years*.

3. So far, this arrangement has been entered into with *Peru* and *Colombia*, but soon *Ecuador, Venezuela, Bolivia, Chile, Paraguay, Uruguay, Argentina and Trinidad and Tobago* will follow suit.

4. The *government* has *not reached an agreement* with other non-Latin American countries such as *Morocco*, because it *requires* that this country make *major constitutional changes*. Nevertheless, this *agreement is not ruled out* in the future on account of the *significant number of immigrants* from this country.

Words for main ideas: 54 of 138 words: 39.1%