Does French listeners' ability to use accentual information at the word level depend on the ear of presentation?

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Abstract

In two long-term repetition priming experiments, we investigated how accentual information is processed and represented in the French listeners' mind. Repeated prime and target words either matched (/bɑ̃'**do**/ - / bɑ̃'**do**/ 'headband') or mismatched in their accentual patterns (/bɑ̃do/ - /bɑ̃'**do**/). In experiment 1, the target words were presented in the left ear only, and attenuation in the repetition priming effect was observed when the primes and the targets mismatched in their accentual pattern. The differential priming effect between match and mismatch primes was no longer observed in Experiment 2 when the targets were presented in the right ear only. Together, these results showed that accentual variation at the word level in French is treated as related-talker variation, and only influences word recognition under specific circumstances, in particular, when we push word processing in the right hemisphere.

Index Terms: spoken word recognition; French prosody; primary accent; hemispheric dominance.

1. Introduction

Most of Germanic and Romance languages use lexical stress. Stress placement is thus assigned at the word level and the position of stress within word can change its meaning. In these languages, stress information appears to be a nondetachable aspect of phonemic information and the two types of information similarly influence word recognition. Contrary to these languages, French does not have lexical stress and French listeners have been found to experience stress deafness ([1]). On the other hand, French has phrasal accent, meaning that accent always affects the last syllable of a larger unit than the word, that is the accentual phrase (e.g., [2], [3], [4]). As a result, the same word receives accent ([*un petit* ***'CHOU***]) "a little cabbage" or not ([*un CHOU* ***'bleu***]) "a blue cabbage" depending on its position within the accentual phrase. Since accent in French signals the end of accentual phrases and thus the end of words occurring at the end of accentual phrases, it has a demarcation function ([5]). Nonetheless, in French, accent has not a lexically contrastive function, and as indicated in the preceding example, the word *CHOU,* whether accented or not, conserves the same meaning. Does this mean however that accentual information never influences spoken word recognition in this language? This is precisely the question we addressed in this study by examining how accentual information is processed and represented in the mind of French listeners.

Because in French accent always affects the last syllable of words located at the end of accentual phrases, several studies have shown that French listeners use it to segment speech into words, and in particular to locate word offset/onset in continuous speech ([6], [7], [8], [9], [10]). For example, [8] showed that accent helps French listeners to resolve competition between overlapping lexical candidates. The authors asked participants to detect a target word (e.g., *CHAT* "cat") in sentences like [*Le CHAT grin'****cheux***] "the grumpy cat" in which only the word *grincheux* bears accent on its last syllable or in sentences like *[Le* ***CHAT'****] [grim'****pait***] "the cat climbed up" in which both the words *chat* and *grimpait* bear primary accent. They found slower detection times in [*Le CHAT grin'****cheux****]* than in [*Le* ***CHAT'****] [grim'****pait***]. The slower detection of CHAT in *[Le CHAT grin'****cheux****]* has been interpreted as resulting from competition between *CHAT* and its competitor *CHAGRIN* "sadness". In this case, since there is no accent on *CHAT* to indicate its end, the word *CHAGRIN* remains active and competes with the word *CHAT*. The results of Christophe et al.'s thus suggest that French listeners insert a word-final boundary each time they encounter an accented syllable. Consequently, accentual information in French appears to boost word recognition process by preventing activation of inappropriate lexical candidates.

In a recent study ([11]), we have examined whether accentual information could be stored in the French mental lexicon. This question is particularly relevant for models of spoken word recognition assuming that multiple variants of a same word encoding fine-grained acoustic details are stored in memory ([12]). Because French listeners are inevitably exposed to the accented and unaccented versions of words, a possibility within this class of models is that French listeners have created lexical traces corresponding to the accented and unaccented forms of words. In our study, participants heard a first block of stimuli, the prime block, followed by a second block of stimuli, the target block. Some of the words from the prime block were repeated in the target block. The repeated primes and targets either matched (e.g., (/bɑ̃'**do**/ - /bɑ̃'**do**/ 'headband') or mismatched (/bɑ̃do/ - /bɑ̃'**do**/) in their accentuation. In comparison to a control condition in which primes and targets were unrelated (/maʁɔ̃/ - / bɑ̃'**do**/ "chestnut-headband"), we reported that match and mismatch primes were equally effective in facilitating the subsequent processing of the target words. The observation that a change in the accentual pattern of words has no impact on the magnitude of the repetition priming effect indicates that accented and unaccented variants of words activate the same-form based representations. Hence, words in their different accentuation appear to be associated with a single representation in the French mental lexicon. Our results are thus more compatible with the view of an abstract lexicon that does not encode fine-grained acoustic details ([13], [14], [15], [16], [17]).

Given this finding, we ask here how French listeners used accentual information during spoken word recognition. The starting point of this study is a paper published by Gonzalez and McLennan in 2007 [18]. These authors have examined how surface variation in words related to talker specificities is represented and influences spoken word processing by manipulating the ear of presentation of the words in a series of long-term priming experiments. They reported an attenuation of the repetition priming effect in case of a talker change between the first and second presentation of the repeated target word when the words were presented in the left ear, and thus are, due to contralateral projections, predominantly processed by the right hemisphere. In contrast, no modulation in the magnitude of the repetition priming effect was found in case of a talker change between the first and second presentation of the repeated target word when the words were presented in the right ear and thus are predominantly processed by the left hemisphere. This differential priming effect as a function of the ear of word presentation is particularly interesting since it shows that surface information related to talker identity is processed differently by the two hemispheres. In particular, it appears that only the right hemisphere benefit from a match in talker identity between the repeated prime and target words. By contrast, for the left hemisphere, it does not matter whether talker identity matches or mismatches between the repeated prime and target words, because in both cases the input seems to be primarily mapped onto abstract representations that are devoid of the surface information associated with talker identity. On a more general way, this study suggests that variation in talker identity can affect spoken word processing even if this type of variation is not integrated into the lexical representations.

In this study, we make the strong assumption that accentual variation is represented and processed as related-talker variation in French, and we tested it in a design similar to that of [18]. Rather than to change the identity of the talker between the first and second presentation of the repeated prime and target words, we changed the accentual patterns and the words were presented either in their accented version (/bɑ̃'**do**/ *bandeau* 'headband') or in their unaccented version /bɑ̃do/. As in [18], the ear of presentation of words was manipulated. In both experiments, the primes were binaurally presented while the target words were presented in the left ear only in Experiment 1 and in the right ear only in Experiment 2. Similarly to what was observed by [18], an attenuation in the repetition priming effect in case of a change in the accentual pattern should only be observed in Experiment 1 when we push processing in the right hemisphere, and thus when words are presented in the left ear.

2. EXPERIMENT 1: left-ear presentation

2.1. Participants

Forty-eight right-handed native speakers of French participated in the experiment.

2.2. Materials

Forty-eight words with a CVCV disyllabic structure were selected from Lexique, a lexical database of the French language ([19]) and were used both as primes and targets. They have a mean frequency of 7.60 occurrences per million. 16 additional words of the same syllabic structure were selected and were used as control primes. They have a mean frequency of 6.96 occurrences per million.

In order to obtain the accented and unaccented versions of each of the stimulus, we asked a native speaker of French to produce the 64 words within carrier sentences in which the target word bore primary accent on its last syllable or was unaccented depending on its position within the utterance (e.g. *On m'avait parlé [d'un bandeau* ***'bleu****]qui était joli* "I had been told about a blue headband which was nice" vs. *On m'avait parlé [d'un petit ban****'deau****] qui était joli* "I had been told about a small headband which was pretty"). To avoid coarticulation effects due to contextualized-speech, each word was first extracted from its carrier sentence and then auditorily presented to the speaker in isolation. The speaker had to repeat each word in its accented and unaccented versions. The 128 tokens thus obtained were recorded at a sampling frequency of 44 100 Hz, segmented and then normalized in intensity at a level of 70 dB.

Acoustic analyses using Praat software ([20]) were then conducted to ensure that the 48 target words were produced with the expected accentual patterns. Pre-boundary lengthening and fundamental frequency (f0) rises, the two main correlates of primary stress in French, were measured. As expected, the final syllable of the target words was longer ($t(47) = 17.73$, $p < .0001$) and associated with a stronger f0 rise ($t(47) = 21.26$, $p < .0001$) than the first syllable only in their accented versions.

For the purpose of the lexical decision task, 64 disyllabic pseudo-words with a CVCV structure were created by changing the last phoneme of real words not previously used (e.g. /bezi/ created from the word /beze/ 'kiss'). This allowed us to have non-word like words, and to constrain the participants to listen to the stimuli up to the end prior to giving their response. The non-words followed the same criteria as the words, and thus were recorded and produced in their accented (e.g. /be'**zi**)/ and unaccented (e.g. /bezi)/ versions.

In addition, a 510 ms audio file was created containing pink noise. The 510 ms corresponded to the duration of the longest target word. RMS amplitude was equated to 40 dB. As in [18]'s study pink noise was chosen because as for speech, its spectral level decreases with increasing frequency.

2.3. Design

Two blocks of stimuli were presented. The first consisted of the primes and the second of the targets. Within each block, half of the stimuli was accented, and the other half was unaccented. The targets block consisted of 48 target words and 48 pseudo-words. Among the 48 target words, 16 served in the matched priming condition, 16 in the mismatched priming condition and 16 in the control priming condition. Within each priming condition, half of the target words was presented in their accented version, and the other half was presented in their unaccented version. The prime block also consisted of 48 words and 48 pseudo-words. Among the prime words, 16 consisted of the repetition of the targets with the same accentual pattern (e.g. /bɑ̃'**do**/ - /bɑ̃'**do**/), 16 consisted of the repetition of the targets with a different accentual pattern (e.g. /bɑ̃do/ - /bɑ̃'**do**/), and the 16 others were the control primes and were unrelated to the targets. Among the control primes, half of them was presented in their accented version and the other half was presented in their unaccented version. Also for the pseudo-words, 16 consisted in the exact repetition (with the same accentual pattern) of pseudo-words used in the target block, 16 consisted in the repetition of pseudo-words used in the target block but with a different accentual pattern, and 16 were unrelated.

Because each target word was paired with three different primes (match, mismatch, control) and no participant was presented with the same target twice, three experimental lists were created. The three lists were then divided into two sub-lists so that each stimulus of the prime and target blocks was heard in its accented and unaccented version.

2.4. Procedure

The participants were tested individually in a sound attenuated booth, and stimuli were presented over calibrated headphones at 70 dB. The presentation of the stimuli was controlled by a computer thanks to the software E-Prime (version 2.0, Psychology Software Tools). In both the prime and the target blocks, participants were asked to make a lexical decision as quickly and accurately as possible with "word" responses using their dominant hand on a button-box that was placed in front of them. Response times (RTs) were recorded from the onset of stimuli. Within each block, the stimuli were presented randomly. An inter-trial of 2000ms elapsed between the participant's response and presentation of the next stimulus. The participants were tested on only one experimental list and the experiment began with 12 practice trials. During the target block, the stimuli were presented in the left ear only, and the noise was presented in the opposite ear.

1.5. Results

Statistical analyses were performed on the target words. Five items that gave rise to an error rate of more than 40% were removed from the analyses. RTs analysis was performed on correct responses, thus removing 240 data (11.6%) out of 2064 data. 6 outliers (> 2500ms) were also excluded from the analysis. The mean RT and percentage of correct responses in each condition are presented in Figure 1. RTs were analyzed using a linear mixed-effect regression model. For the model to meet the assumptions of normally-distributed residuals and homogeneity of the variance, a log transformation was applied to RTs. The model was run on 1818 data points. The model included prime type (match, mismatch, control) as fixed effect, random intercepts for participants and items, random slopes by participants and by items for the prime type factor.

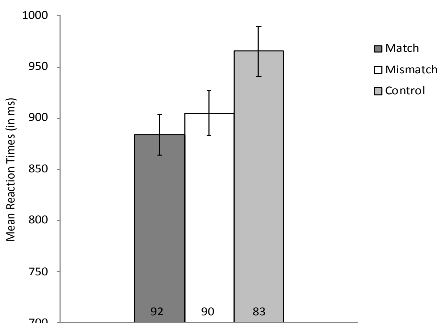

Figure 1. Mean Reaction Times (in ms) and Standard Errors as a function of prime type. Percentage of correct responses are shown below the bar for each condition.

With the control prime condition as intercept, the model revealed that RTs were faster for target words preceded by match primes than for target words preceded by control primes (β = -0.09, SE = 0.01, t = -7.10, p < .0001). RTs were also faster for target words preceded by mismatch primes than for target words preceded by control primes (β = -0.07, SE = 0.01, t= -5.60, p < .0001). To test the difference between the match and the mismatch conditions, the model was releveled such that the match prime condition was the intercept. Critically, RTs were faster for target words preceded by match primes than for target words preceded by mismatch primes (β = 0.03, SE = 0.01, t = 2.10, p < .05).

Accuracy data (1 = correct responses, 0 = incorrect responses) was analyzed using a mixed-effect regression model with a logistic linking function. The model was run on 2064 data points. It included prime type (match, mismatch, control) as fixed effect, participants and items as random intercepts and random slopes by participants and by item for the prime type factor. Since our data set was too large for the default fitting methods in glmer.nb, it was necessary to implement the function option "nAGQ=0" for the model-fitting process to converge ([21]). With the control prime condition as intercept, the model revealed that participants gave more correct responses for target words preceded by match primes than for target words preceded by control primes (β = -1.11, SE = 0.22, z = -5.09, p < .0001). Participants also gave more correct responses for target words preceded by mismatch primes than for target words preceded by control primes (β = -0.67, SE = 0.19, z = -3.49, p < .001). To test the difference between the match and the mismatch conditions, the model was releveled such as the match prime condition was the intercept. The difference between the match and mismatch prime conditions failed to reach significance (β = 0.44, SE = 0.26, z = 1.69, p = .09).

To sum-up, the results of Experiment 1 replicated the observation made by [18] regarding talker-specificity effect. In particular, when we constrain processing in the right hemisphere, accentual-related effect emerges so that mismatched primes in the accentual pattern are less effective than matched primes in facilitating target word processing. Such a result has strong theoretical implications since it suggests that in French, the right hemisphere plays an important role in processing accentual information during spoken-word recognition. Before discussing the implications of our findings in more details, we re-ran Experiment 1, but we changed the ear of presentation of the target words, which were thus presented in the right ear. If indeed, it is the right hemisphere which is more reliant for the encoding and processing of accentual information in French, accentual effect should diminish when we push processing in the left hemisphere, and so when the target words are presented in the right ear.

3. Experiment 2: right-ear presentation

3.1. Participants

Forty-eight new participants were recruited. They were right-handed native speakers of French.

3.2. Materials & Procedure

The stimuli and the procedure were the same as in Experiment 1 except that during the target block, the stimuli were presented to the right ear only, and the noise was presented in the opposite ear.

3.3. Results

As in Experiment 1, statistical analyses were performed on the target words. Five items that gave rise to an error rate of more than 40% were removed from the analyses. RTs analysis was performed on correct responses, thus removing 242 data (11.7%) out of 2064 data. Three outliers (one RT = 310 ms and the two others > 2500ms) were also excluded from the analysis. The mean RT and percentage of correct responses in each condition are presented in Figure 2. RTs were analyzed using a linear mixed-effect regression model. For the model to meet the assumptions of normally-distributed residuals and homogeneity of the variance, a log transformation was applied to RTs. The model was run on 1819 data points. The model included prime type (match, mismatch, control) as fixed effect, random intercepts for participants and items, random slopes by participants and by items for the prime type factor.

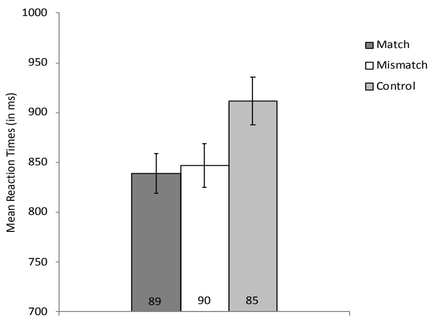

Figure 2. Mean Reaction Times (in ms) and Standard Errors as a function of prime type. Percentage of correct responses are shown below the bar for each condition.

With the control prime condition as intercept, the model revealed that RTs were faster for target words preceded by match primes than for target words preceded by control primes (β = -0.08, SE = 0.01, t= -5.87, p < .0001). RTs were also faster for target words preceded by mismatch primes than for target words preceded by control primes (β = -0.07, SE = 0.01, t = -6.31, p < .0001). To test the difference between the match and the mismatch conditions, the model was releveled such that the match prime condition was the intercept. Critically, the difference between the match and the mismatch conditions was not significant (β = 0.01, SE = 0.01, t = 0.56, p > .20).

Accuracy data (1 = correct responses, 0 = incorrect responses) was analyzed using a mixed-effect regression model with a logistic linking function. The model was run on 2064 data points. It included prime type (match, mismatch, control) as fixed effect, participants and items as random intercepts and random slopes by participants and by items for the prime type factor. As in Experiment 1, it was also necessary to implement the function option "nAGQ=0" for the model-fitting process to converge ([21]). With the control prime condition as intercept, participants gave more correct responses for target words preceded by match primes than for target words preceded by control primes (β = -0.82, SE = 0.22, z = -3.71, p < .001). Participants also gave more correct responses for target words preceded by mismatch primes than for target words preceded by control primes (β = -0.59, SE = 0.21, z = -2.87, p < .01). To test the difference between the match and the mismatch conditions, the model was releveled such that the match prime condition was the intercept. The difference between the match and mismatch prime conditions was not significant (β = 0.23, SE = 0.23, z = 0.98, p > .20).

4. Discussion

The aim of this study was to examine how French listeners use accentual information at the word level. Because in our previous study [11], we showed, in contrast to multiple traces model of spoken word recognition, that fine-grained acoustic details related to accentual information in French is not integrated into lexical representation, here, we make and test the strong assumption that accentual information in French is processed in the same way as talker-related variation. As in [18], the repetition priming paradigm was used and the target words were either presented in the left-ear (Experiment 1) or in the right-ear (Experiment 2). Similarly to what was observed by [18] for talker-related variation, we predicted that accentual information could impact word recognition in French when processing is pushed in the right hemisphere and thus when the words are presented in the left ear.

In line with our hypothesis, Experiment 1 showed that a change in the accentual pattern diminished the magnitude of the repetition priming effect when the words were presented in the left ear, and thus when we pushed processing in the right hemisphere. Crucially, Experiment 2 showed that the accentual-related effect was no longer observable when the target words were presented in the right ear, and thus when the processing was pushed in the left hemisphere. Together, these results suggest that accentual information is processed in the same way as related-talker variation, and influences word recognition provided that we push processing in the right hemisphere.

Our results are important because they suggest that in French, the right hemisphere plays an important role in processing accentual information during spoken-word recognition, so that a mismatch in the accentual pattern has a negative effect on the magnitude of the repetition priming effect. To our knowledge, this study is the first to demonstrate cerebral asymmetries in accentual processing during French word recognition. In a more general way, our results suggest that the right hemisphere is more reliant than the left hemisphere to process accentual information at the word level. This observation is in line with [22]'s hypothesis claiming that prosodic information is differently lateralized in the brain depending on the linguistic functions of prosody in the language. Because prosodic information in French is not relevant at the word level, we showed that this information is primarily processed by the right hemisphere.

To sum up, despite the fact that accentual information in French is not integrated into lexical representations, here we showed that we can modulate the contribution of this information during spoken word recognition by changing the ear of presentation of stimuli, and thus the hemisphere that initially processes the words. In a more general way, we showed that accentual information is processed by French listeners as related-talker variation and that it affects word recognition only under specific circumstances, and in particular here when the processing is constrained in the right hemisphere. The challenge now for future works is to determine the precise cognitive structure which is involved in the storage and use of accentual information in French. Also, since related-talker variation have been shown to influence word recognition in other circumstances (e.g., when words are rare [23] or when the processing is slow and effortful [24]) additional studies are required to determine whether it exists other circumstances in which accentual information could influence spoken-word recognition.

5. References

[1] E. Dupoux, C. Pallier, C., N. Sebastian, & J. Mehler, "A destressing "deafness" in French*?", Journal of Memory and Language*, vol. 36, no. 3, pp. 406-421, 1997.

[2] S. A. Jun, & C. Fougeron, "A phonological model of French intonation", in A. Springer (Eds.), *Intonation*, pp. 209-242, 2020.

[3] S. A. Jun, & C. Fougeron, "Realizations of accentual phrase in French intonation". *Probus*, vol. 14, no. 1, pp. 147-172, 2002.

[4] P. Welby, "French intonational structure: Evidence from tonal alignment", *Journal of Phonetics*, vol. 34, no. 3, pp. 343-371, 2006.

[5] J. Vaissière, "Rhythm, accentuation, and final lengthening in French", in J. Sundberg, & R. Carlson (Eds.), *Music, language, speech, and brain*, pp. 108–120, New York: Macmillan Press, 1991.

[6] C. M. Rietveld, "Word boundaries in the French language", *Language and Speech*, vol., no. 23.3, pp. 289-296, 1980.

[7] M. H. Banel and N. Bacri. "On metrical patterns and lexical parsing in French", *Speech Communication,* vol. 15, pp. 115-126, 1994.

[8] A. Christophe, S. Peperkamp, C. Pallier, E. Block and J. Mehler. "Phonological phrase boundaries constrain lexical access I. Adult data", *Journal of Memory and Language,* vol. 51, pp. 523-547, 2004.

[9] E. Spinelli, P. Welby, and A. Schaegis. "Fine-grained access to targets and competitors in phonemically identical spoken sequences: the case of French elision", *Language and Cognitive Processes*, vol. 22, pp. 828-859, 2007.

[10] E. Spinelli, N. Grimault, F. Meunier, and P. Welby. "An intonational cue to word segmentation in phonemically identical sequences", *Attention, Perception, & Psychophysics*, vol. 72, pp. 775-787, 2010.

[11] A. Michelas and S. Dufour. "Are Prosodic Variants Stored in the French Mental Lexicon?", *Experimental Psychology*, Hogrefe, vol. 66, no. 6, pp. 393-401, 2019.

[12] S. D. Goldinger, "Echoes of echoes? An episodic theory of lexical access". *Psychological review*, vol. 105, no. 2, pp. 251, 1998.

[13] W. D. Marslen-Wilson and A. Welsh. "Processing interactions and lexical access during word recognition in continuous speech", *Cognitive psychology*, vol. *10*, no. 1, 29-63, 1978.

[14] J. L. McClelland, and J.L. Elman, "The TRACE model of speech perception", *Cognitive psychology*, vol. 18, no. 1, pp. 1-86, 1986.

[15] W. Marslen-Wilson, and P. Warren "Levels of perceptual representation and process in lexical access: words, phonemes, and features", *Psychological review*, vol. *101*, no. 4, pp. 653, 1994.

[16] D. Norris "Shortlist: A connectionist model of continuous speech recognition", *Cognition*, vol. *52*, no. 3, pp. 189-234, 1994.

[17] J. M. McQueen, A. Cutler, and D. Norris, "Phonological abstraction in the mental lexicon", *Cognitive science*, vol. *30, no.* 6, pp. 1113-1126.

[18] J. González, and C. T McLennan, "Hemispheric differences in indexical specificity effects in spoken word recognition", *Journal of Experimental Psychology: Human Perception and Performance*, vol. *33*, no. 2, pp. 410, 2007.

[19] B. New, C. Pallier and L. Ferrand. "Manuel de Lexique 3", 2005. *Available at: http://www. lexique. org*.

[20] P. Boersma, P. and D. Weenink, "Praat. Doing phonetics by computer" (Version 6.1.09, 2020) [Computer program]. Retrieved from https://www.praat.org, 2020.

[21] D. Bates, M. Maechler, B. Bolker and S. Walker, "Fitting Linear Mixed-Effects Models Using lme4" *Journal of Statistical Software*, vol. 67, no. 1, pp. 1-48, 2015.

[22] D. Van Lancker, "Cerebral lateralization of pitch cues in the linguistic signal*", Research on Language & Social Interaction*, vol. 13, no. 2, pp. 201-277, 1980.

[23] S. Dufour, & N. Nguyen, "Access to talker-specific representations is dependent on word frequency", *Journal of Cognitive Psychology*, vol. 26, no. 3, pp. 256-262, 2014.

[24] C. T. McLennan, & P. A. Luce, "Examining the time course of indexical specificity effects in spoken word recognition", *Journal of Experimental Psychology: Learning, Memory, and Cognition,* vol. 31, pp. 306–321, 2005.