Lombard Intelligibility Benefit in Native and Non-Native Speakers and Listeners

Katherine Marcoux, Benjamin V. Tucker, and Mirjam Ernestus

When changing from plain (speech in quiet) to Lombard speech (speech in noise), native speakers increase fundamental frequency and intensity, and shift energy to higher regions [1,2]. The acoustic modifications of native Lombard speech are beneficial to the listener: when both heard in noise, Lombard speech is more intelligible than plain speech [3,4,5]. The question arises whether this Lombard intelligibility benefit holds for non-native Lombard speech to the same extent. Non-native speakers may produce Lombard speech differently than natives [6]. They are influenced by their native language [7,8,9] and experience a higher cognitive load when speaking [10,11]. Our study investigated the non-native Lombard intelligibility benefit, and specifically whether the size of the benefit may differ among native and non-native speakers and listeners.

For our intelligibility experiment, listeners heard English words embedded in noise and were asked to transcribe the words. The participants heard the same 96 English target words twice, once produced by a non-native speaker (native Dutch) and once by a native speaker (American English, AmE), half were plain and half were Lombard speech. The stimuli were spliced from sentences from eight native and eight non-native female speakers from the DELNN corpus [6]. We embedded the stimuli in the same speech shaped noise as was used to elicit the Lombard speech in the DELNN corpus, at a signal-to-noise-ratio of -1.

Our listener groups consisted of 42 Canadians, 46 Dutch, and 47 Spanish listeners. The native Canadians served as our native English listeners and while their vowels may differ from our AmE speakers they are familiar with AmE. By having two non-native listener groups with a similar level of English proficiency (as indicated by their LexTALE scores [12]), we could examine the influence of their native language.

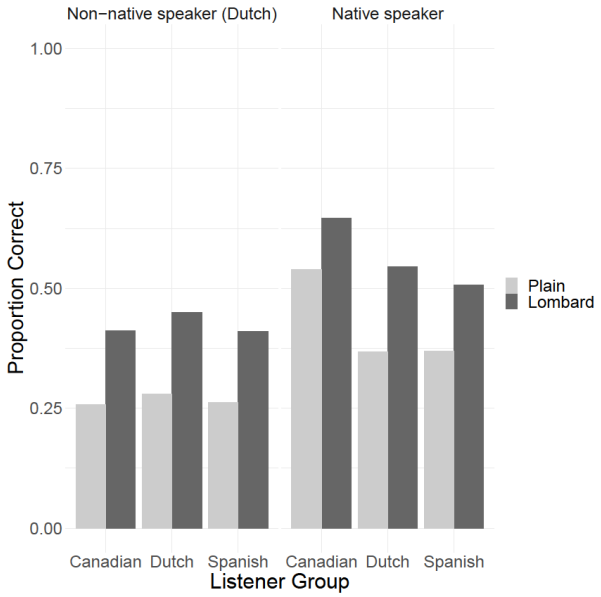
We analyzed participants' responses using generalized linear mixed effects models, scoring participants' responses as correct when the response was a perfect match with the target word or if it was a homophone. We did not allow for any misspellings.

Overall, the non-native speech was less intelligible than the native speech and the non-native listeners did not perform as well as the native listeners. In addition, as can be observed in Figure 1, we replicated the Lombard intelligibility advantage for native speakers. While both the native and the non-native listeners showed this Lombard intelligibility benefit, it was larger for the non-natives than for the natives. One explanation may be that the native listeners already performed better for the native plain speech and consequently were performing at ceiling with not much room for improvement (note the difficulty of identifying words spliced out of running speech).

More importantly, we also found the Lombard intelligibility benefit for non-native speech, both for native and non-native listeners. This result is in line with an acoustic study showing that non-native speakers adapt their speech in noise, albeit with a hint of native language influence [6]. This intelligibility result shows that the non-native Lombard acoustic characteristics are beneficial to all listeners, independently of whether the listener shares the speaker's language background. This is further supported by the fact that we did not find differences between the Dutch and Spanish listeners in our analysis, suggesting the Dutch listeners did not benefit from the shared native language with the non-native speakers, as the interlanguage speech intelligibility benefit would expect. Combined, this indicates that the acoustic modifications of Lombard speech are largely language general and benefit all.

In conclusion, although non-native Lombard speech production may have subtle characteristics of the speaker's native language [6], it results in a general intelligibility benefit. It benefits native listeners and non-native listeners with various native languages.

Figure1: Intelligibility of Native and Non-Native Plain and Lombard Speech by Native and Non-Native Listener Groups.



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