Error detection and correction in L1 and L2

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Introduction. Adults acquiring a second language (L2) rarely learn to speak without a foreign accent[3]. Native speakers are known to constrain variability and maintain precise speech targets while talking by monitoring their auditory feedback and correcting productions that begin to veer off-target [4]. In order to produce native-like speech in a second language, speakers must be able to compare their ongoing speech to an internal auditory target so that they can calculate error and a correction trajectory. The studies here test whether unfamiliar targets may hinder detection and correction processes in a second language.

Our previous work has shown both greater variability and reduced self-correction in L2[1]. Here, we investigate how speakers' sensitivity to errors in their auditory feedback may contribute to these differences between their native language (English, L1) and a language acquired in adulthood (French or German). In Experiment 1, access to auditory feedback is modulated with masking noise during speech production. In Experiment 2, the second formant (F2) is altered in real time and fed back to speakers over headphones so that they hear themselves producing a vowel that sounds either more front or more back than what they actually produced. **Hypothesis 1:** Masking noise will prevent self-correction to a greater extent in L1 than in L2, because speakers are less sensitive to their auditory feedback in L2. **Hypothesis 2:** Stronger auditory targets in L1 will yield greater opposition to the altered feedback than in L2.

Experiment 1: masked feedback. Participants completed the entire experiment in both their L1 and L2. Participants spoke words (top 3 rows of Table 1) as they appeared on a computer screen into a head-mounted microphone. While speaking, participants also heard one of three levels of noise over headphones: no noise, soft noise (∼60 dB), or masking noise (∼80 dB). Noise levels were presented in blocks of 30 trials. Participants received feedback on their volume to limit the degree to which they could hear themselves over noise.

Results: variability. Formant values were calculated in two time windows for each trial by averaging F1 and F2 values over the first 50 ms (onset window) and over the the middle 50% (middle window) of the utterance. Variability at a time window was measured as the mean Euclidean distance from the 2D (F1-F2) median across trials. Further analysis was carried out on the third of trials with the greatest variability (furthest from the median).

French learners (n = 9) had greater variability in both time windows in French than in English (initial window, $p < 0.001$, trending middle window $p = 0.11$). The target location, though, was dependent on noise, where vowels produced in noise were more centralized. Pilot data from German (n = 3) similarly shows greater variability in German than in English at both time windows (both $p < 0.001$), at all noise levels. However, these data do not show a consistent effect of noise on target location.

Results: centering. Centering (self-correction) was defined by the difference in variability between the first and second time windows. French showed greater centering than in English, suggesting that self-correction mechanisms exist in L2. However, given that the midpoint variability is trending greater in French than in English, this greater self-correction is perhaps not as successful in L2 as in L1. In the German pilot data, there was greater centering in English than in German, indicating both greater and more successful self-correction in English.

For French learners, there was an effect of noise in English only, where there was greater centering in loud masking noise than in quiet. Access to auditory feedback did in some way affect speech, though not in the way that was hypothesized. These speakers may have relied more heavily on their articulatory rather than acoustic targets in the presence of noise, and the greater centering observed in full noise may reflect a stronger ability to use tactile information to reach vowel targets in L1 than in L2. Better-defined targets in both articulatory and acoustic space in L1 may thus account for the differences by noise level. In contrast, pilot German data support the hypothesis: in English only, there was significantly greater centering in quiet than in masking noise, suggesting that access to auditory feedback may be driving the observed self-corrective behavior. The lack of difference by noise level in German may indicate speakers' reduced ability to use auditory feedback to fine-tune their speech.

Experiment 2: Altered auditory feedback. Five of the French learners and all three German learners from Experiment 1 also participated in Experiment 2. Subjects produced words from Table 1 (all rows), and on one-third of trials, subjects heard their own speech with a real-time perturbation [2, 5]. During perturbation trials, F2

English	(L2 French)	French		English	(L2 German)	German	
Eve	[iv]	Yves	[iv]	Zee	[zi]	Sie	[zi]
eff	[ɛ]	hais	[ɛ]	debt	[dɛt]	des	[dɛs]
add	[æd]	oeuf	[œf]	add	[æd]	öde	[œdə]
vee	[vi]	vie	[vi]	vee	[vi]	Wie	[vi]
fed	[fɛd]	fait	[fɛ]	said	[sɛd]	sekt	[zɛkt]
sad	[sæd]	neuf	[nœf]	bad	[bæd]	böse	[bœsə]

Table 1: Experiments 1 stimuli (top 3 rows) and 2 (all rows).

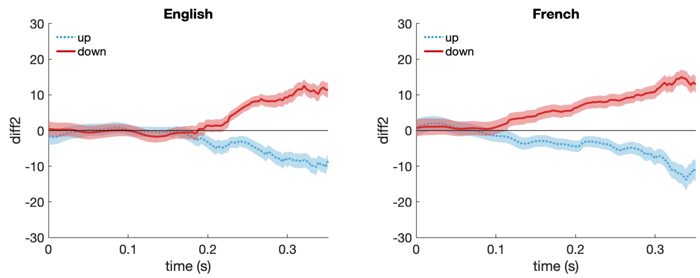

Figure 1: Preliminary results: Experiment 2, French learners. Response latency in L2 is smaller than in L1.

was either raised or lowered by 100 mels for the length of the trial.

The F2 produced during perturbation trials was analyzed relative to F2 produced during unperturbed trials. In the French study, there was a significantly greater response latency when speaking English (L1) than when speaking French (L2) ($p < 0.0001$, Figure 1). This may be evidence that speakers are relying more heavily on their auditory feedback while speaking their second language, possibly because their feedforward motor plans are less well-developed in L2 than in L1. The related study in German is ongoing.

Conclusions. Results from Experiment 1 suggest that while the error-detection and -correction mechanisms are in place in both native and learned languages, they are generally less successful in the latter, as evidenced by the greater variability in L2. Noise does not seem to have a consistent effect across the two L2s, but it seems that in both populations, speakers are probably using their auditory feedback in a different way depending on if they are speaking in their L1 or L2. Results from Experiment 2 suggest that for larger, categorical errors, speakers may be relying more heavily on information from their auditory feedback in L2, as evidenced by the smaller latency in compensation for altered feedback. Together, the experiments suggest that speakers are indeed sensitive to error in their auditory feedback, but the way they use this feedback to guide their speech depends on nativeness.

References

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