Effect of noise on recognition of minimal pairs in (un)predictive sentence contexts

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When listening in the presence of background noise, people sometimes mishear what is being said. Predictability, for example provided by a semantically constraining sentence context, facilitates spoken language comprehension (Dubno, Horwitz, & Ahlstrom, 2000; Sommers & Danielson, 1999). However, it can at the same time lead to an increased effect of false hearing: mishearing an utterance, while being certain that what one (mis)hears is what was actually said (Aydelott & Bates, 2004; Rogers, Jacoby, & Sommers, 2012). In this way, predictability does not help comprehension, but rather hinders it by introducing persistent misunderstandings. The present study investigates the combined effect of listening in background noise and predictive sentence context on word recognition using minimal pairs.

Native speakers of German listened to recordings of German sentences embedded in two levels of babble noise (0 dB SNR and -5 dB SNR) and in quiet. Participants typed in the last word of the sentence they had heard and rated their confidence in giving the correct answer on a 4-point scale (ranging from *unsure/guessed* to *absolutely certain*). The sentence was visually presented on the screen up until the final word to provide a predictive context that was understandable regardless of noise condition. Crucially, the final experimental word either fit the sentence semantically (mean cloze 0.52, high predictability condition, HP), or was unpredictable from the preceding sentence context (cloze value 0, low predictability con-dition, LP). Example stimuli can be found in Table 1. There were no filler items. The experimental words formed minimal pairs differing in one phonetic feature in medial position, and were swapped with the respective sentence frames to create LP items. This allowed us to investigate whether listeners are able to rely on small acoustic cues for word recognition, even in background noise, while keeping sentence contexts equal across conditions. If listeners are able to recover these small cues in noise, we expect to find more accurate recognition scores regardless of sentence predictability. However, if participants make use of sentence context to help comprehension, we expect to find more distractor answers for LP items, because the distractor is a semantic fit, rather than the correct target which is unexpected.

Results from 48 participants (27 males, mean age = 25 years) are shown in Figure 1. Participants' answers were coded on whether they matched the auditorily presented word (e.g., in 1C "Ecken" / "*corners*", *target*), the similar sounding *distractor* (e.g., in 1C "Äckern" / "*fields*"), or were a different word entirely (e.g., in 1C "Bauernhof" / "*farm*", *wrong*). Note here that the LP distractor words mismatched the presented audio, but fit the sentence semantically, while the LP target was presented auditorily. A two-way repeated measures ANOVA with Bonferroni corrections showed a main effect of Noise, $F(2, 94) = 210.08$, $p < .001$, *partial* $\eta^2 = .82$, as well as a main effect of Predictability, $F(1,47) = 484.98$, $p < .001$, *partial* $\eta^2 = .91$. There was a significant interaction effect between Predictability and Noise, $F(2, 94) = 167.86$, $p < .001$, *partial* $\eta^2 = .78$[1]. In HP items, participants predominantly got the experimental word correct, with no differences between noise levels ($p > .12$). In LP items, participants also got the target word correct in quiet. However, in noise, they tended to more often report the distractor word instead, and increasingly so when there was higher noise ($p = .001$). While uncertainty increases in more adverse listening conditions, most participants are still quite or absolutely certain of their responses, showing a false hearing effect.

These results show that listeners rely strongly on the acoustic signal in quiet conditions, but in cases of background noise, they fall back on the information provided by the semantic context, thus 'mishearing' the target word in LP items. This confirmed our hypotheses based on the literature, as predictability does aid word recognition when it is a valid cue, but it hinders word recognition when it gives conflicting information.

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[1]This interaction effect was not additionally modulated by block half (first vs second part of each block), $p > .19$.

Table 1. Example stimuli.

1A	Die Bauern verteilen zu viel Gülle auf den **Äckern**. *The farmers spread too much manure on the **fields**.*	HP
1B	Auch wenn Jennifer sehr sorgfältig putzt, findet ihre Mutter immer noch Staub in den **Ecken**. *Even when Jennifer cleans very carefully, her mother still finds dust in the **corners**.*	HP
1C	Die Bauern verteilen zu viel Gülle auf den **Ecken**. *The farmers spread too much manure on the **corners**.*	LP
1D	Auch wenn Jennifer sehr sorgfältig putzt, findet ihre Mutter immer noch Staub in den **Äckern**. *Even when Jennifer cleans very carefully, her mother still finds dust in the **fields**.*	LP

Note. Highly predictable sentences were constructed based on minimal pairs (1A and 1B), then sentence-final target words were swapped to make low predictable items with the sentence frames of 1A and 1B, resulting in 1C and 1D. English translations have been given in *italics,* sentence-final target words are marked in **bold**.

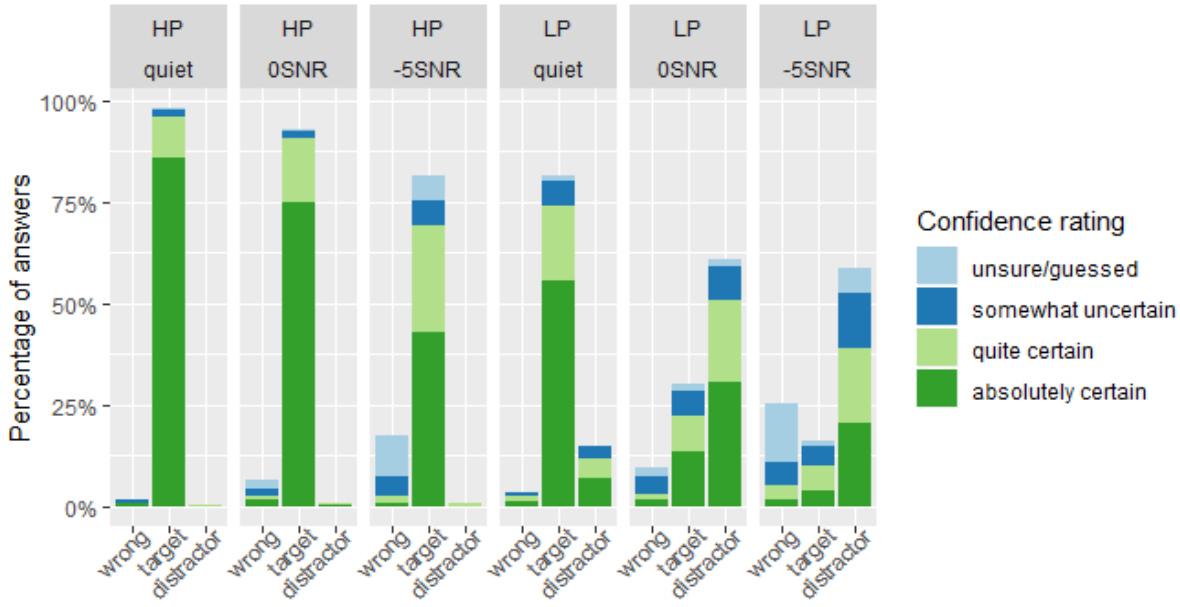

Figure 1. Percentage of answers coded as wrong, target and distractor for both items with highly predictable targets (HP) and items with unpredictable targets (LP), as well as participants' confidence ratings.

References

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