

Evidence for the interaction of global and local knowledge in expectation in the domain-restricted language of aviation

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Introduction

Using a domain-restricted language is often an integral part of being an expert: a medical professional may use the term “hypertension” to refer to high blood pressure, or a ship’s captain may describe their anchor as “foul”, meaning a cable or line is twisted around it. However, expertise rarely equates to simply knowing more words: while all humans rely on global linguistic knowledge (i.e. knowledge that helps us complete the sentence *a female chicken is a ...*), professionals must also rely on domain-specific linguistic knowledge that dictates the usage of specialised referents. A growing body of work (Meyer & Mackintosh, 2000; Barbero & Amaro, 2024) suggests that expert listeners may maintain parallel lexical representations for the same referent, with domain-specific and common lexical nodes coexisting rather than replacing one another.

In Aviation English, the international standardised language used for civil aviation, a completely fixed relationship exists between a term and its referent: for example, the word *climb* should never be replaced with another word (e.g. *ascend*) or phrase (e.g. *go up*), no matter how synonymous it is. Nevertheless, many agency safety reports contain references to nonstandard language use (particularly in specific regions), and minor deviations in phraseology (e.g. using *one hundred* instead of *one zero zero* to refer to a heading) have been shown to contribute to serious incidents (cf. CAP1375). Using EEG combined with a word verification task, we investigated the interaction between global and domain-specific linguistic knowledge in aviation experts (pilots and air traffic controllers with more than 500 hours of flight/duty time).

The Study

Experts are likely to possess not only specialised vocabulary but also an organised understanding of when to use it, and how to accommodate deviations when they occur: therefore, we employed sentences containing completions (e.g. *ILS category two not available due equipment _____*) which either contained standard aviation phraseology (*failure*), nonstandard phraseology (*damage*), or semantically incongruent words (*paper*) in order to elicit the N400, a neural marker of semantic integration (Kutas & Hillyard, 1984). Our prediction centred around the interaction between global and domain-specific language: if global referents are indeed activated alongside domain-specific referents during specialised language processing, then the N400 effects should be graded for the three conditions.

25 monolingual British English pilots and air traffic controllers took part in the experiment. We chose to include both pilots and controllers because, although the operational roles differ, both professions are trained to use and interpret the same specialised language during radiotelephony communication. The task consisted of an auditory sentence processing task combined with immediate word recall: participants were told they would be doing a matching task: after hearing an auditory stimulus, the participant would see a word on a screen: the word either matched or mismatched to a word in the sentence.

All auditory stimuli were recorded by a monolingual British English-speaking aviation professional in the cadence and structure of a typical ATC transmission, with low-level authentic background noise from live recordings of tower communications spliced under the voice recordings¹. The intensity of all stimuli was equalised to 75 dB, with an average signal-to-noise ratio of 22.2 dB. Since our sentences were natural utterances of different durations, our EEG triggers were hand-defined according to onset of the critical word in each stimulus.

The experimental stimuli consisted of 72 test sentence pairs: 24 Standard Aviation English utterances, 24 utterances containing a sentence-final word in Nonstandard phraseology, which was semantically related to the expected exemplar. There were also 24 sentences containing Incongruent sentence-final words. The sentences were matched for overall length, and critical words were matched for number of syllables and phonological length. Semantic distance between the critical items was verified via Latent Semantic Analysis with an embedding space of 300 factors, with Standard and Nonstandard critical

¹ An example stimulus (containing standard phraseology) can be heard here:
https://osf.io/w489e/files/c5st2?view_only=731c46c435cd499fbd5b437dad2622b

words holding high similarity rates (mean cosine value of 0.28). Incongruent items shared very low similarity rates (<0.062) to both Standard and Nonstandard items. In the word recall task, words either matched or mismatched to the critical item.

Results:

Bonferroni-corrected pairwise comparisons revealed significant differences in multiple latency windows: In the early latency window (200-300 ms), Standard trials differed significantly from both Nonstandard and Incongruent, whereas Nonstandard and Incongruent did not differ. In the N400 window (300-400/400-500 ms), all pairwise comparisons were highly significant ($p<.0001^*$), indicating robust differentiation between all conditions (see Figure 2). In the late latency window (600-700 ms), there were no differences between the three conditions.

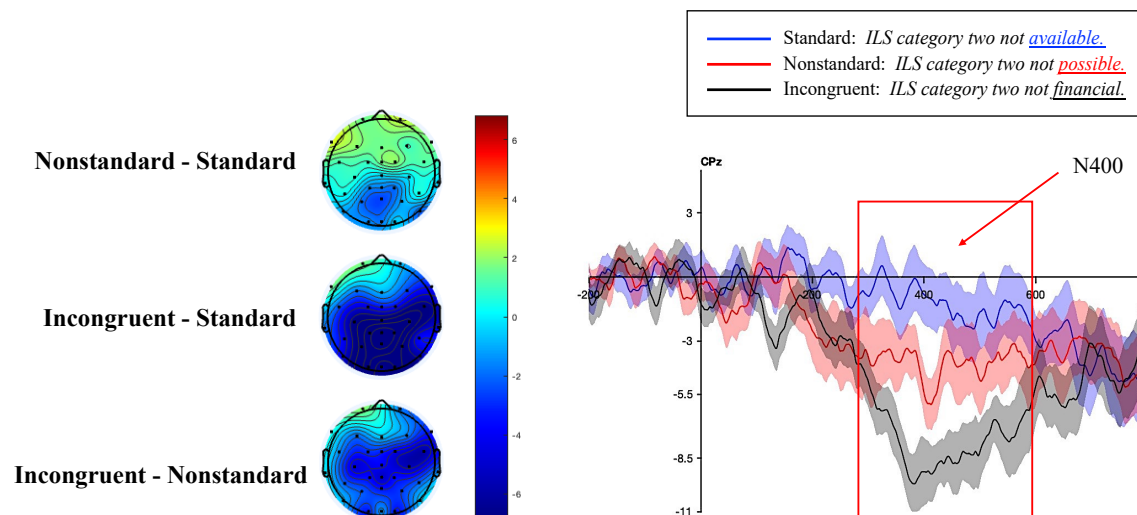


Figure 2: Topographic plots and parietal brainwaves time-locked to the critical word onset for the three experimental conditions.

Our findings were as follows: aviation experts exhibited an N400 effect for both Nonstandard and Incongruent stimuli, with the Incongruent condition eliciting stronger negative amplitudes than the Nonstandard. This effect was strongest in the 300-400 and 400-500 ms latency windows, after which point the effect dissipated. The graded N400 effect indicates that, while experts rapidly evaluate incoming phraseology against their stored expectations for the domain-specific language, this process is still affected by global linguistic knowledge.

To conclude, this study provides ERP evidence that experts in the domain of aviation are indeed sensitive to nonstandard phraseology: hearing just one word of nonstandard phraseology (e.g. *Report runway in *view*) affects semantic integration, as evidenced by the N400 effect. These results will be discussed in relation to current theories of sentence processing, with an additional aim to underline the importance of research that integrates neurolinguistic methodologies into operational concerns.

References

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