

# The Electrophysiology of Vegetable Language: A Case Study

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## Introduction

When human subjects read or listen to a sentence, a word which renders a sentence non-sensible leads to measurable changes in electrical brain activity (such as in *The professor likes to eat green trousers*). In such a case, a negative shift in the event-related brain potential (ERP) approximately 400 ms after the mismatching word (*N400 component*) can be observed, especially over central and parietal areas of the scalp (see Kutas & Hillyard, 1980). It has always been taken for granted that this finding is unique to human subjects and that vegetables, for example, are not able to process language. However, until this has been demonstrated experimentally, it cannot be claimed to be a scientific truth. The goal of the experimental study presented in the following is to clarify this issue. To achieve this, we presented semantically congruent and incongruent sentences visually to a human subject and a pumpkin, while recording their electrophysiological activity.

## Methods

### Participants: *Human subject*

A 25-year-old male student (*Homo sapiens sapiens*) from southeastern Germany participated for course credit after giving informed consent. He had normal vision.

### Vegetable subject

For the vegetable's part of the experiment, we recruited a 2-month old red pumpkin (*Cucurbita moschata L.*) from the Berlin area with a girth of 44 cm. Shortsightedness was not a problem and the subject neither objected

to being tested nor did it wish to receive course credit<sup>1</sup>.

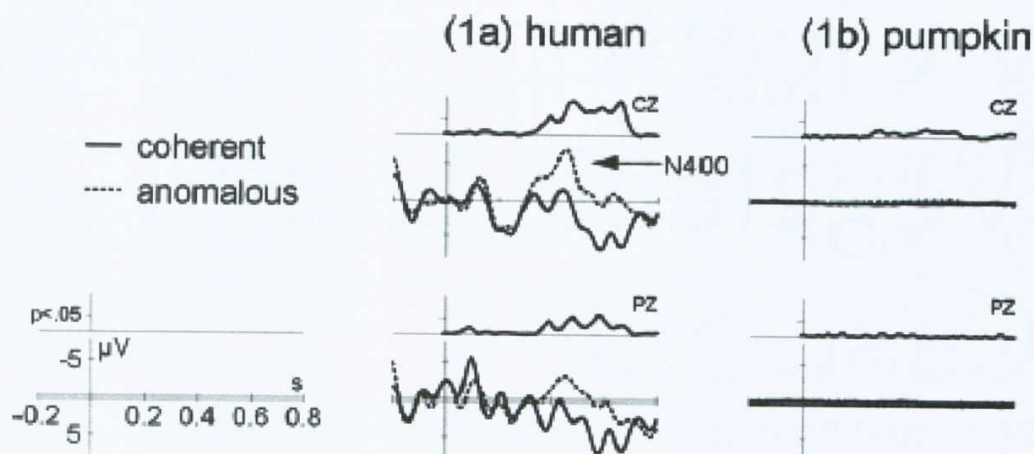
Materials: Participants read German sentences such as in (1a) and (1b) below. The sentence final word (underlined) completed the sentence either correctly (such as in 1a), or rendered it semantically incoherent (such as in 1b).

(1a) congruent control sentence: Anna weiß, daß der Maler den Dichter besuchte. *Anna knows that the painter the poet visited.* ('Anna knows that the painter visited the poet.')

(1b) semantically anomalous sentence: Anna weiß, daß der Maler den Dichter kochte. *Anna knows that the painter the poet cooked.* ('Anna knows that the painter cooked the poet.')

To obtain a good signal-to-noise ratio (Kutas & Van Petten, 1994), 40 sentences in each of the 2 conditions were constructed, plus 160 distractor sentences (half of them incorrect). All 240 sentences were presented in randomized order and word by word in the center of a computer monitor. Each word was presented for 300 ms and followed by 200 ms blank screen. After each sentence, participants had to judge whether the sentence just presented was acceptable or not. Both participants were placed in a distance of 90 cm from the computer screen. Both participants were carefully instructed about the task but were not informed of the purpose of the study. Neither of the participants expressed any problems with either the presentation mode or the task.

EEG recordings: The EEG recording was analogous to the study of Frisch, et al. (2004). ERP averages were computed in each condition for each subject in a 1300 ms window relative to



ERP averages relative to the onset of the critical verb at electrodes CZ and PZ, for the human subject (Figure 1a) and the pumpkin (Figure 1b).

the onset of the critical item (verb underlined in 1a and b) and aligned to a 200 ms pre-stimulus baseline. Knowing that the typical distribution of the N400 is centro-posterior (see Kutas & van Petten, 1994), only the 2 electrodes CZ and PZ were analyzed. Statistical significance was determined via a running t-test procedure in the plots.

## Results

**Behavioral task:** The human participant did quite well: only one error was observed across the 2 critical conditions. The vegetable subject seemed to have some problems with the time restriction since we registered a lot of timeouts. However, no wrong answers were given by the pumpkin, which justified the inclusion of the data in the analysis.

**ERP data:** ERPs exhibit a more negative going pattern on the verb (onset at 0 ms) in the semantically anomalous condition relative to the correct condition for the human subject (see Figure 1a). As revealed by the running t-test, the difference is significant in a time range between approximately 300 to 700 ms. Such an N400 effect, however, cannot be observed for the pumpkin (Figure 1b).

## Discussion

In the present study, we addressed the question whether the well-known results from event-related brain potential research – that a

semantically mismatching word in a sentence induces a N400 component – can be generalized to all species, or whether species-specific differences exist. To investigate this question, we confronted a human and a vegetable subject (pumpkin) with semantically anomalous and correct sentences while recording their electrophysiological activity. The main results were that the human participant showed a clear N400 response as expected, while the pumpkin did not show any ERP response. This is the first time that such a clear difference between species has been experimentally demonstrated and, as such, the results can not be overestimated. In brief, we seem to have shown that language abilities in vegetables are highly diminished in comparison to humans, if not completely absent (though the latter may overstretch our findings at present).

In the following, we want to address several counter-arguments that could be brought forward against our interpretation.

At first sight, there seem to be some interindividual differences. For example, since the subjects came from different regions in Germany, dialectal variants could be claimed to play a role. Although this seems not very likely, given that in German – as well as in many other languages – *there seems to be some consensus that e.g. cooking a poet is semantically odd (despite regional differences)*, we cannot generally exclude this possibility at present.

In this respect, we also have to mention the age difference, of 24 years, and 10 months, approximately. As long as we know so little about the speed of language acquisition in vegetables in general (and of pumpkins in particular) we cannot exclude that this may account for some of the difference.

Furthermore, one could object that the neurophysiology of vegetables may differ completely from that of humans. One might even argue that a pumpkin does not generate any electrophysiological activity at all! The premise must be admitted to some extent. However, the conclusion does not hold: The metabolism of vegetables is grounded on juices flowing through their vessels. Hence, ions in the juice will cause electric currents leading to measurable electromagnetic fields. However, the physiological differences between humans and vegetables raise an important question: Does language processing require zoologically realized neural networks? If this were the case, any attempt towards artificial intelligence would be fruitless. However, ballistic computers, which are computationally equivalent to Turing machines (Bennett, 1982), could be built by networks of hydraulic devices, such as pumps, pipes and vessels. Thus, any vegetable should

be capable of processing language, at least in principle.

Last but not least, we have to mention possible differences in the mental representations underlying the processing differences. That is, we cannot exclude that the semantic networks in humans and pumpkins are fundamentally distinct. In short, what may be a semantic anomaly in a human's world, may be perfectly sensible in the mental universe of a vegetable<sup>2</sup>. Maybe cooking poets is perfectly sensible to a pumpkin, seeing that humans do not differentiate between poet and non-poet pumpkins when cooking them.

Considering the often discussed psycholinguistic assumption that the language of a creature determines its thinking (Whorf, 1956), we may even speculate that not only language, but even the conception of the world, may differ fundamentally between humans and vegetables! This is an exciting, though not yet warranted, hypothesis. To address it can only be investigated in a multidisciplinary effort, making use of the methodologies of such different fields as linguistics, psychology, neuroscience, and botany.

## Acknowledgements

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## Notes

1. The subject ended up in a soup a few days later, but apart from that, all ethical guidelines were strictly observed.
2. This makes clear what Wittgenstein intended when claiming that we could not understand lions even if they had language (Wittgenstein, 1953). If we could not understand lions, how could we ever understand pumpkins?

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