

I like my coffee with cream and sugar.

I like my coffee with cream and socks

I shaved off my mustache and beard.

I shaved off my mustache and BEARD

All turtles have four legs

All turtles have four leg

The bill was due at the end of the month.

The bill was due at the end of the hour.

When you experience a sequence of stimuli (e.g. tones, words), how do you determine that a stimulus is unexpected?

We will be reviewing stimulus parameters that induce changes in ERP component amplitude.

At the physiological level, amplitude changes could reflect:

1. Larger/smaller post-synaptic potentials in the same neurons
2. Activation of greater/fewer neurons in a population
3. More/less temporal synchrony among the generating neurons.

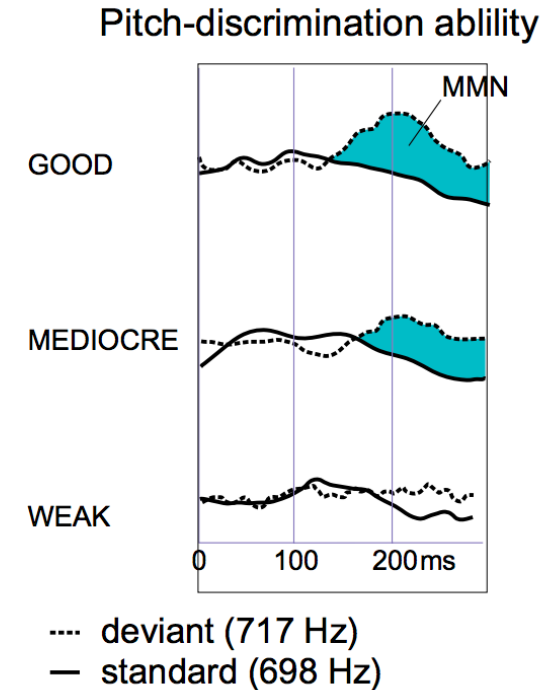
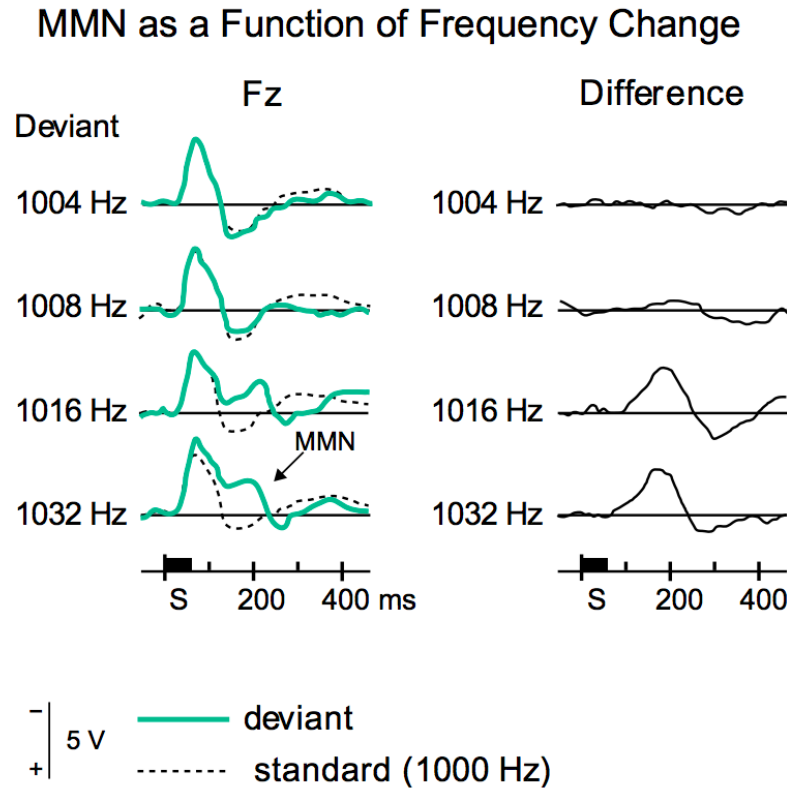
N2a, Mismatch Negativity (MMN)

Negative potential in response to a (e.g. auditory) stimulus change (exceeding a rough discrimination threshold).

A MMN occurs in response to an auditory **deviant** (e.g. at an unexpected pitch, duration, or intensity) at frontocentral electrodes at ~200ms. It can also occur in response to grammar violations.

It is considered an automatic response. It does not require a task to be elicited, and is attention-independent.

An analogous response can be observed in other sensory modalities (e.g. somatosensory, olfactory, or visual stimuli).

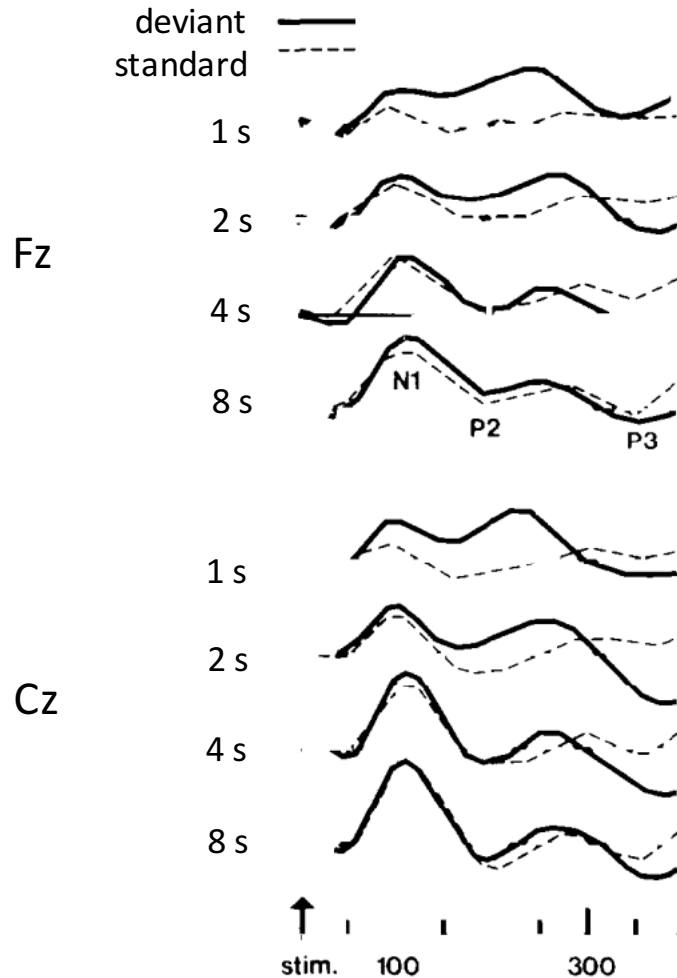


Lang et al., Psychophys. Brain Res., 1990

N2a, Mismatch Negativity (MMN)

The MMN is dependent on the presence of a short-term memory trace.

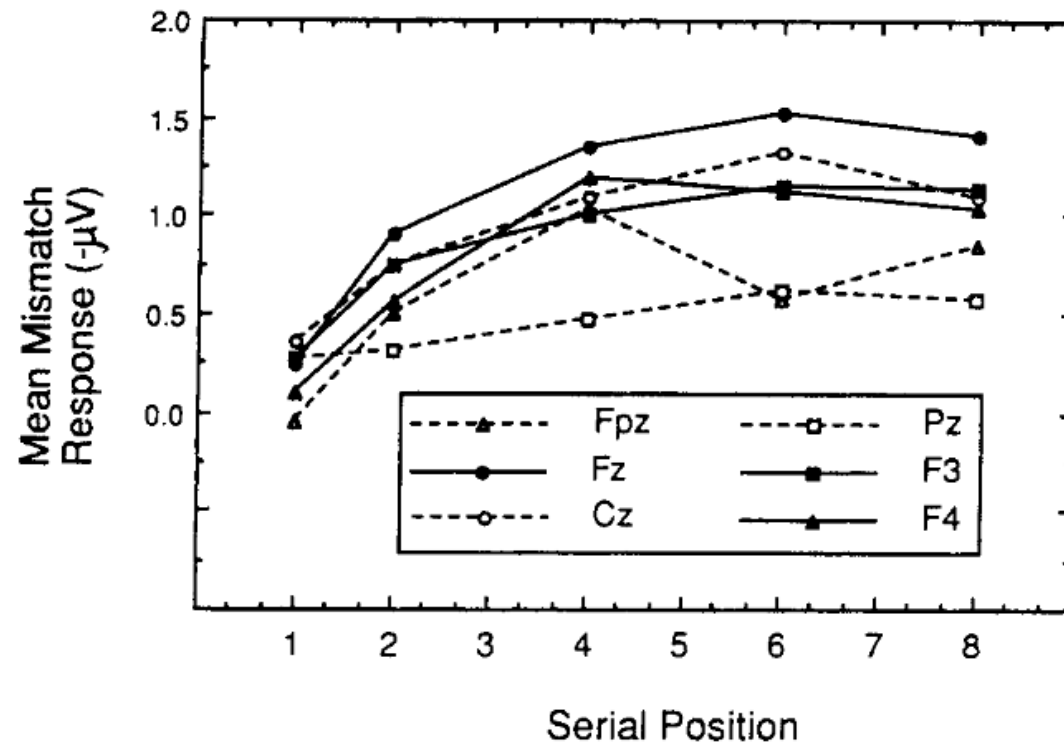
MMN is not observed after long stimulus intervals.



N2a, Mismatch Negativity (MMN)

The MMN is dependent on the presence of a short-term memory trace.

MMN amplitude is dependent upon deviant order in a sequence

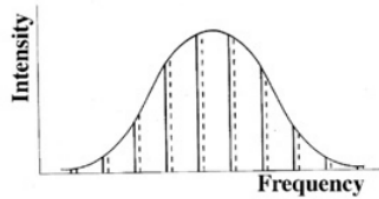


N2a, Mismatch Negativity (MMN)

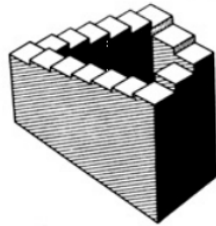
Is it an **exogenous** response to a different stimulus or the outcome of an **endogenous** discrimination process?

MMN to trend violation (descending standards)

a



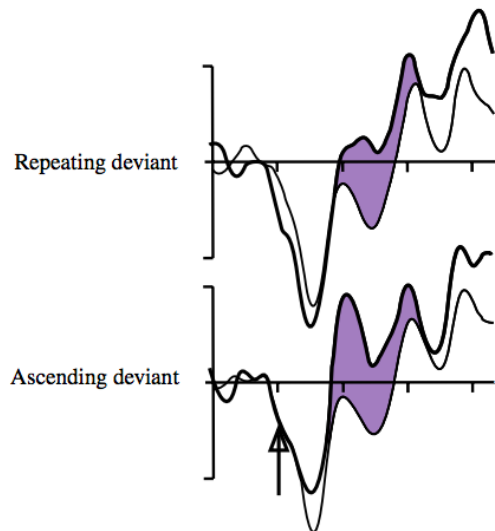
b



In this case there is no adaptation to a repeated tone, and the deviant is the same as the standard immediately preceding it.

c

Shepard tones



Thin line = standard

Thick line = deviant

Fz

Tervaniemi et al., NeuroReport, 1994

MMN is thus hypothesized to be elicited when the sensory input does not “match with” the representation of standards.

It is considered a reflection of difference detection, an objective index for auditory discrimination accuracy, and an indirect probe of the neural representation of the standard stimulus.



<https://www.youtube.com/watch?v=O35trvoVCWI>

Näätänen et al., *Clin. Neurophys.*, 2007

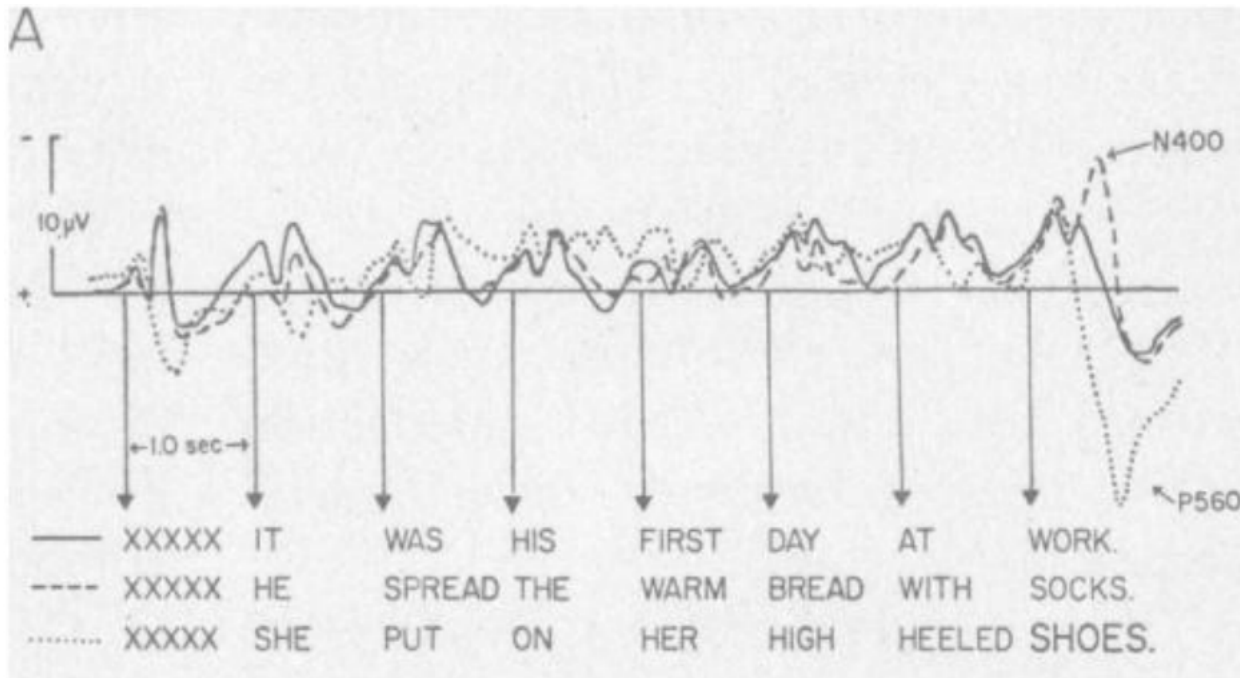
N400

“We use the term N400 as a heuristic label for stimulus-related brain activity in the 200–600 ms post-stimulus-onset window with a characteristic morphology and, critically, a pattern of sensitivity to experimental variables – and hence a common functionality.”

-Kutas and Federmeier, *Ann. Rev. Psych.*, 2011

By determining the variables that do and do not elicit an N400, we identify similarities and differences in our responses to distinct sensory stimuli, and learn more about the processes underlying our comprehension of sensory input.

N400

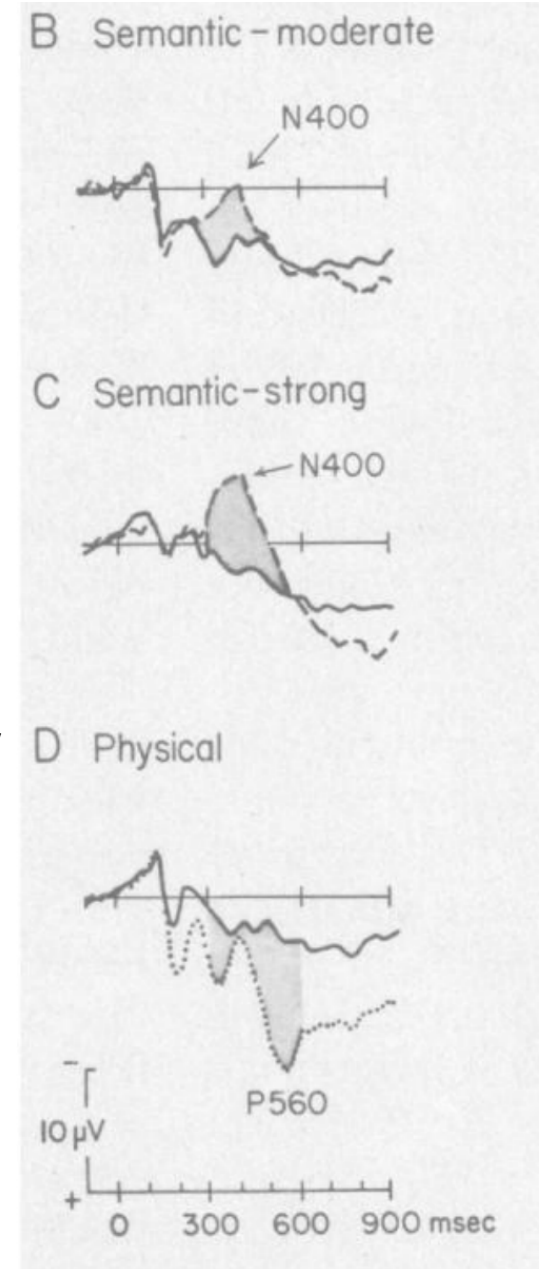


Pz Signal:

Thick line = normal word

Thin line = deviant word

Deviant word is semantically appropriate, but larger in letter size in D.



Undergraduates read 7-word-sentences (one word per second):

- 75% congruent control sentences (e.g., *I shaved off my mustache and beard.*)
- 25% ended "oddly" (e.g., *He took a sip from the waterfall.*)

OR

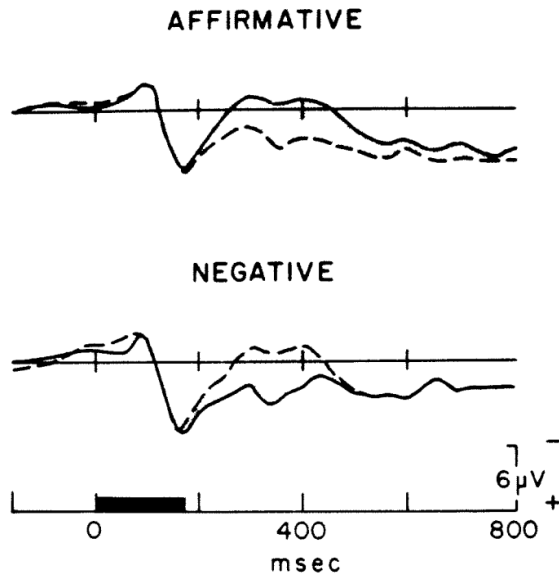
- 25% ended wholly anomalous (e.g., *I take my coffee with cream and dog.*).

N400

Semantic anomalies are neither necessary or sufficient to produce an N400

True affirmative: "A robin is a bird."
 False affirmative: "A robin is a vehicle."
 True negative: "A robin is not a vehicle."
 False negative: "A robin is not a bird."

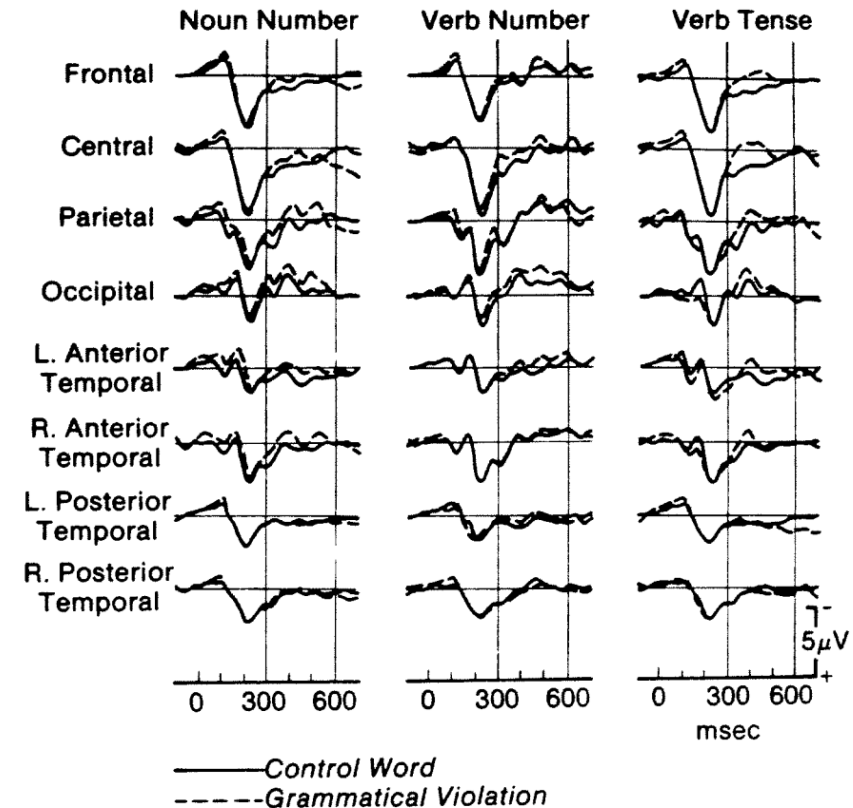
GRAND AVERAGE AT Cz (N=8)



— FALSE
 --- TRUE Fischler et al., *Psychophys.*, 1983

N400 amplitudes determined by the relationship between the first and second noun

Grammatical Violations



Kutas and Hillyard, *Mem. Cog.*, 1983

Grammatical violations do not elicit pronounced N400s

A few additional facts: the N400 does not require a sentential frame (e.g. violation of words in a category), generalizes across input modalities (e.g. spoken word, American Sign Language), and is not observed in response to unexpected musical notes (e.g. note violating a scale or familiar sequence, P3b).

N400

Observed during the processing of jokes and metaphors:

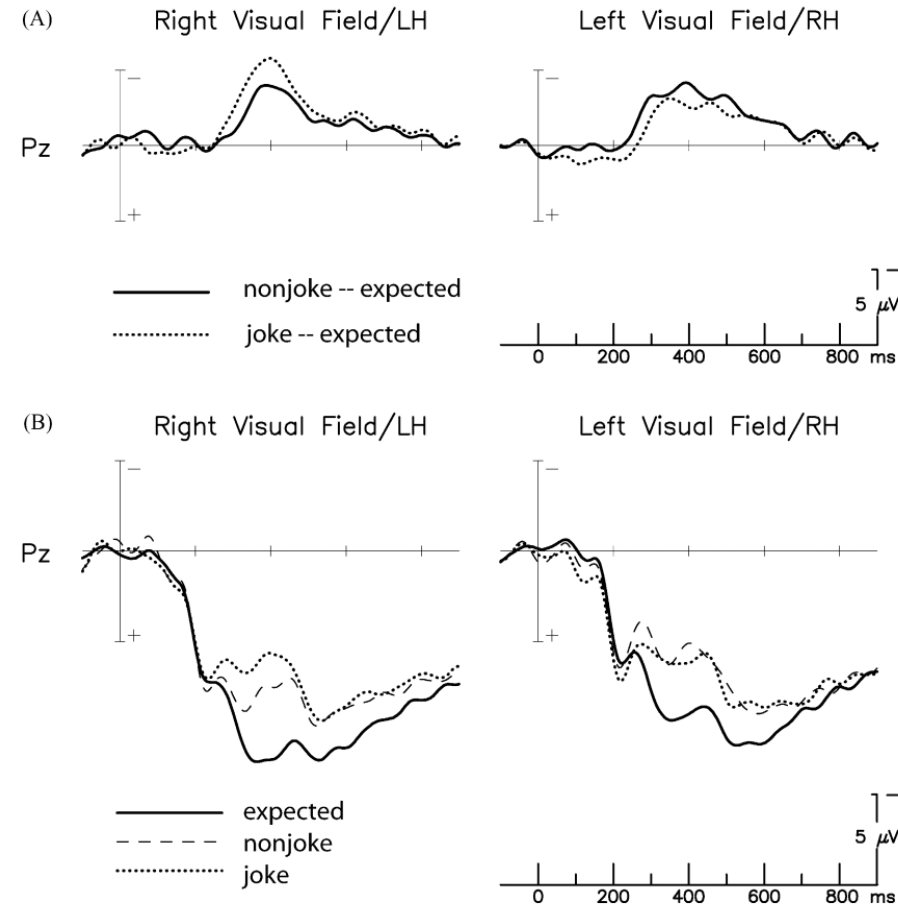
Table 1

Sample stimuli and comprehension questions

Stimulus	I still miss my ex-wife, but I am improving my aim/ego
Joke question	I am shooting at my ex-wife (yes)
Nonjoke question	I am starting to feel better about myself (yes)
Stimulus	It is not hard to meet expenses: they are everywhere/affordable
Joke question	It is easy to pay the bills (no)
Nonjoke question	You should be able to pay all your bills (yes)
Stimulus	The last time a guy in a mask took all my money, I was in surgery/shock
Joke question	I had been mugged (no)
Nonjoke question	I had been mugged (yes)
Stimulus	My mechanic could not fix my brakes, so he fixed my horn/clutch
Joke question	He figures if I cannot stop, I will have to honk at people (yes)
Nonjoke question	My clutch was also broken (yes)
Stimulus	A man who has lost ninety percent of his brain is called a widower/zombie
Joke question	His wife was not very smart (no)
Nonjoke question	A zombie still has an intact brain (no)
Stimulus	The only ones who want me for my body are mosquitoes/losers
Joke question	People find me very sexy (no)
Nonjoke question	Everybody finds me very attractive (no)

N400 amplitude is seen as an index of the difficulty of integrating a word into a given context.

Larger amplitude N400 in LH



Suggests jokes are more difficult to process in the left hemisphere (LH)

When you experience a sequence of stimuli (e.g. tones, words), how do you determine that a stimulus is unexpected?