Unraveling the interplay between verbal utterances, bodily shape, and beliefs: novel insights into embodied language processing

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UNRAVELING THE INTERPLAY BETWEEN VERBAL UTTERANCES, BODILY SHAPE, AND BELIEFS: NOVEL INSIGHTS INTO EMBODIED LANGUAGE PROCESSING

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ABSTRACT

Embodied cognition theories propose that perception is influenced by our bodily experiences. Here we explored the significance of coherence between verbal utterances and the physical appearance of a speaker - a limbless robot. Our goal was to understand how the lack of limbs on a robot affects our perception when it discusses limb-related actions. We hypothesized that our own bodily experiences allow us to recognize inconsistencies in such situations. To measure this, we utilized the N400 effect, an electrophysiological marker of semantic processing. Additionally, we investigated participants' beliefs about the robot possibly having concealed limbs, a concept popularized in media (e.g., Eve from Pixar's Wall-E). Surprisingly, about 70% of participants believed the robot could have hidden limbs, indicating a prevailing inclination toward beliefs contradicting the robot's physical evidence. Critically, only the 30% of "non-believers" demonstrated the anticipated N400 effect; those who believed in potential hidden limbs had a diminished or non-existent N400 response. These results shed light on the complex relationship between embodied experiences and beliefs and how they jointly influence language comprehension processes.
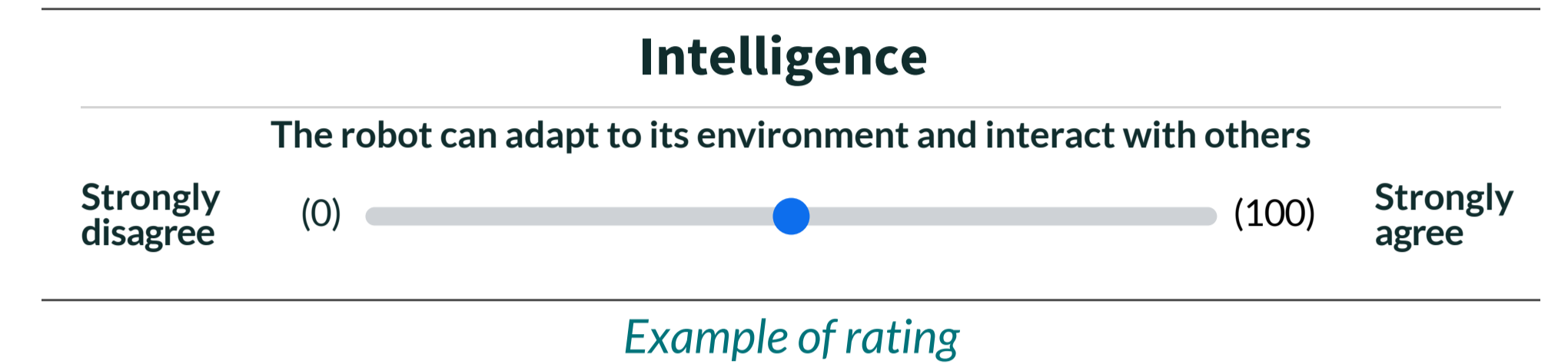
The N400

is a component of the brain's event-related potential (ERP) that is generally induced by semantic incongruence, with a slightly larger amplitude over the right hemisphere, on central & parietal electrode sites [1]

0   500   1000 msec

DATA PROCESSING
EEGLab [2] & MNE Python [3]

- window of interest [500-700ms]
- filter [0.5Hz - 30Hz]
- sampling rate [200Hz]
- epochs [-150ms - 1200ms]
- baseline [-150ms - 0ms]
- 13 electrodes of interest

F7 Fz F8
FT7 FT8
C3 Cz C4
TP7 TP8
PO7 Pz PO8

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METHODS

CONGRUENT
e.g. to talk

INCONGRUENT
e.g. to applaud
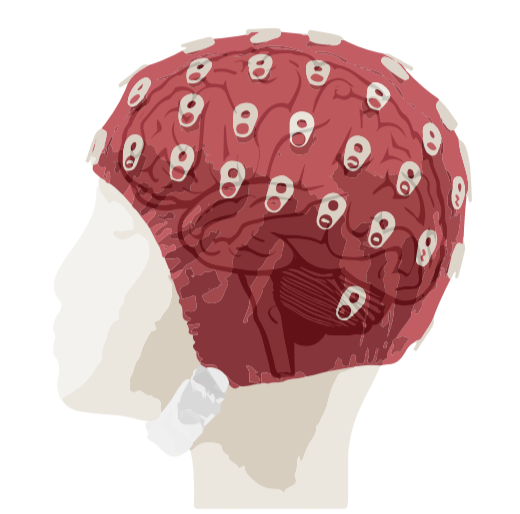
Buddy
(Blue Frog Robotics)

60 videos
comprising 30 where **Buddy** made *contradictory statements* regarding its *physical abilities*

"To go upstairs, I will take the lift/stairs"

Questionnaire

5 items about the robot's cognitive abilities
Imagination, Intelligence, Independence, Creativity, Talkativity

2 items about the possibility that the robot could have hidden arms or legs
*Because popular culture often portrays robots with surprising hidden capabilities

Intelligence
The robot can adapt to its environment and interact with others
Strongly disagree (0) — Strongly agree (100)
Example of rating

Dependent measures
N400 component
Questionnaire assessing perceptions about the robot
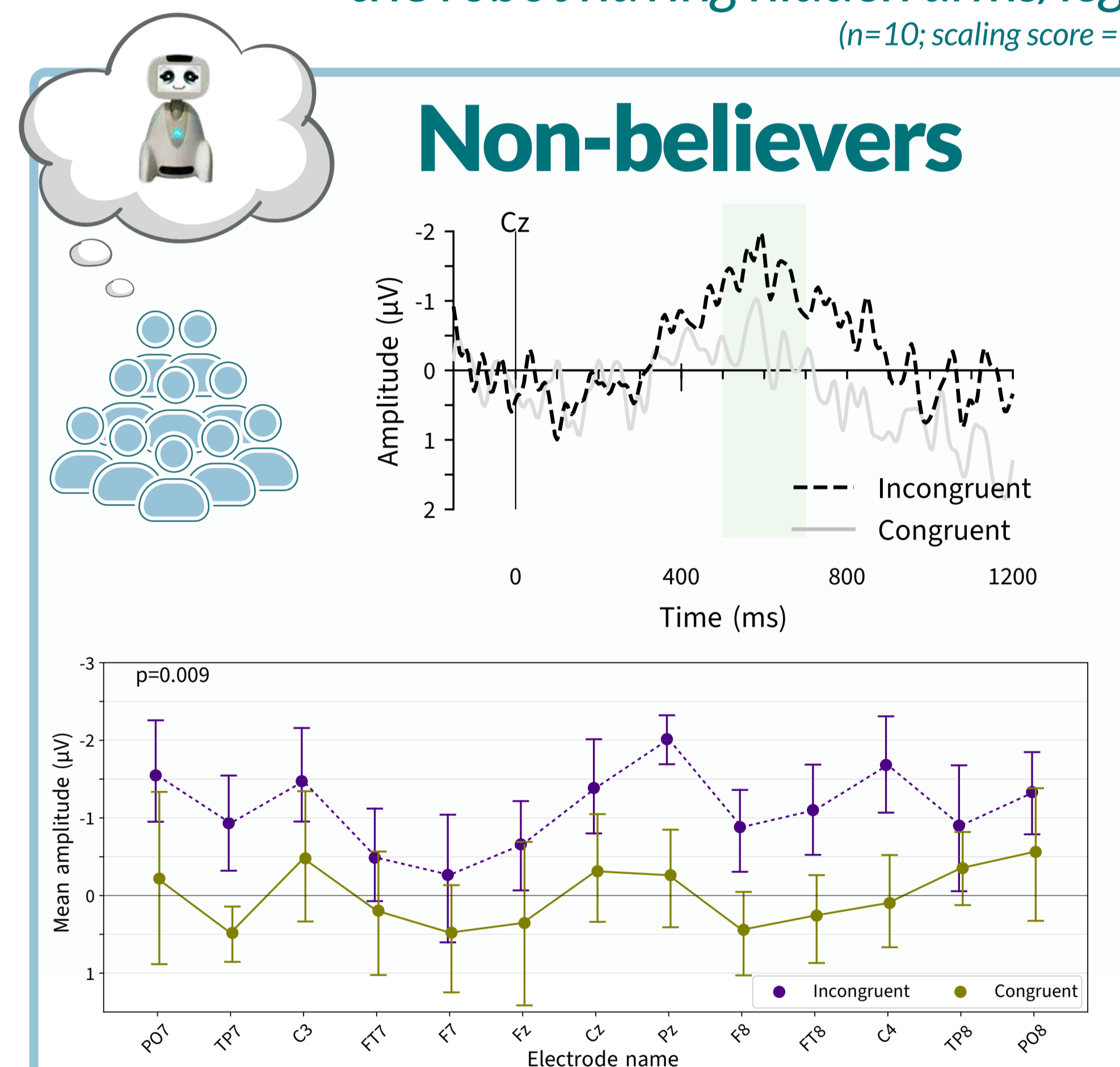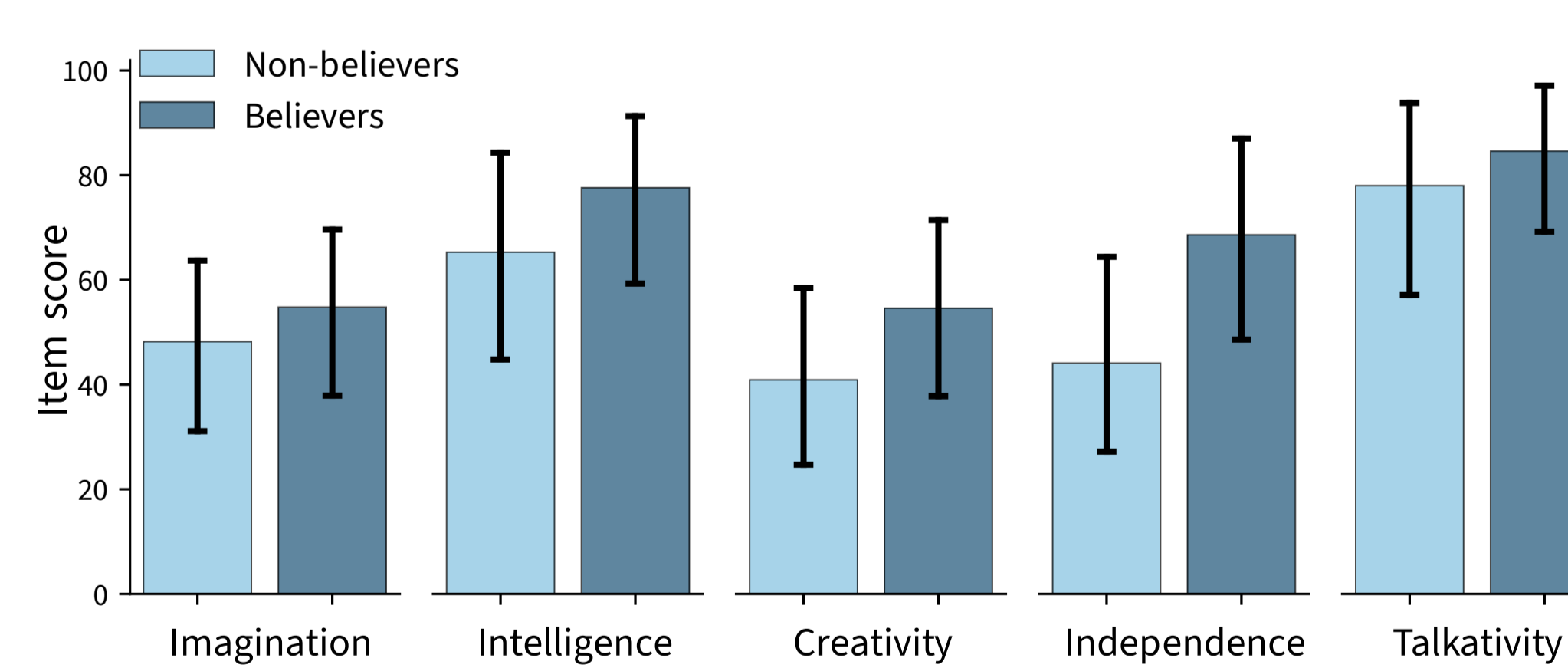
RESULTS

BELIEFS ABOUT HIDDEN LIMBS
Of **27** participants
we separated the participants into **2 groups**:

those **who didn't consider the possibility** of the *robot having hidden arms/legs*
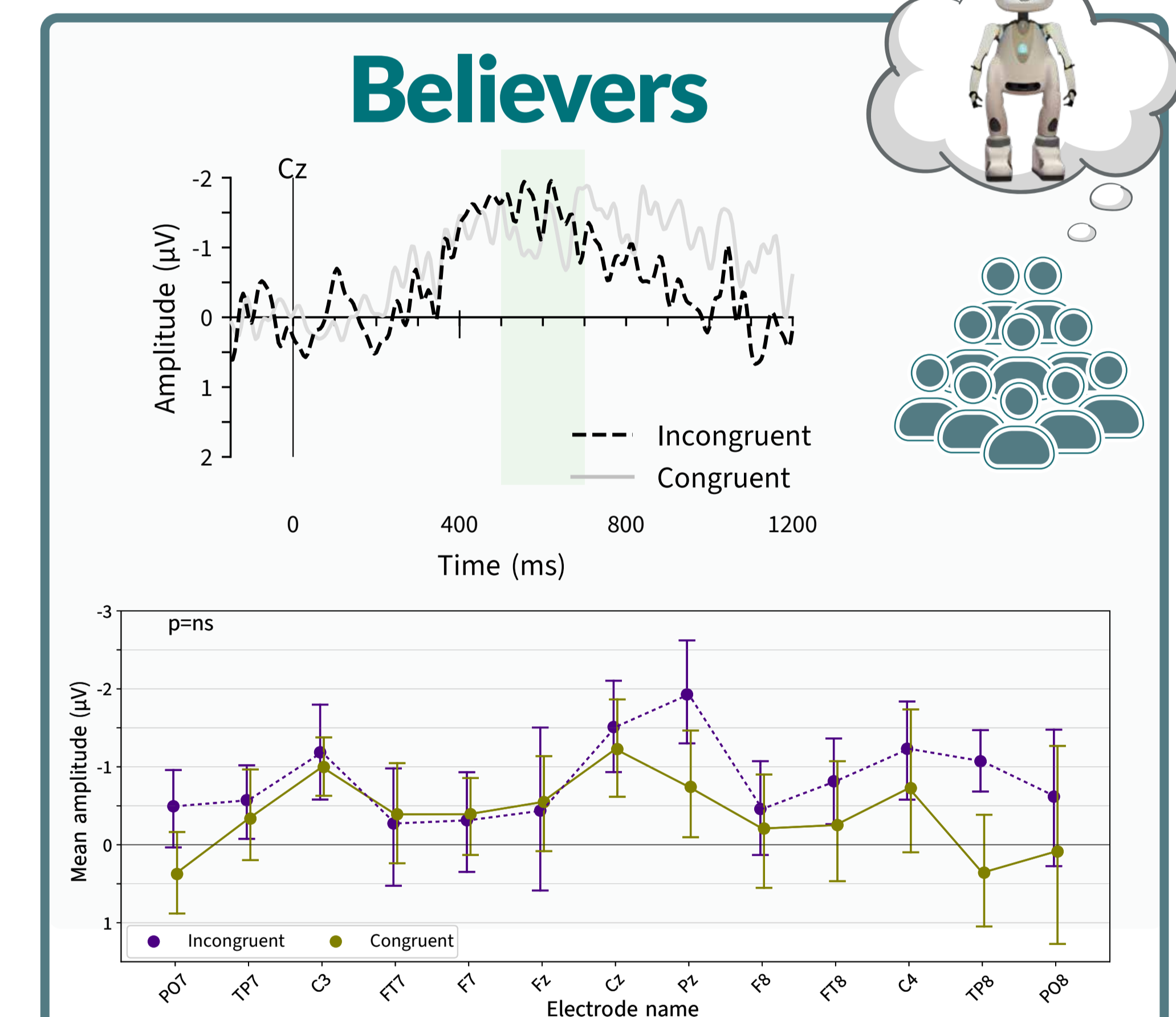(n=10; scaling score = 0)

those **who did consider the possibility** of the *robot having hidden arms/legs*
(n=10; scaling score = [38-86])

Non-believers

Cz — Incongruent / Congruent
p=0.009

↳ an increased N400 amplitude was found when the *sentences* were **incongruent** with the robot's physical appearance

Believers

Cz — Incongruent / Congruent
p=ns

↳ the distinction between **incongruent** & **congruent** sentences nearly disapears

→ Beyond the ERPs, the *cognitive ability* scores also reflect differences.

The Non-believers had a more negative perception of the ASA's capabilities*

*Note that the effect is marginally significant, probably due to the small sample size.

p = 0.057

Non-believers / Believers
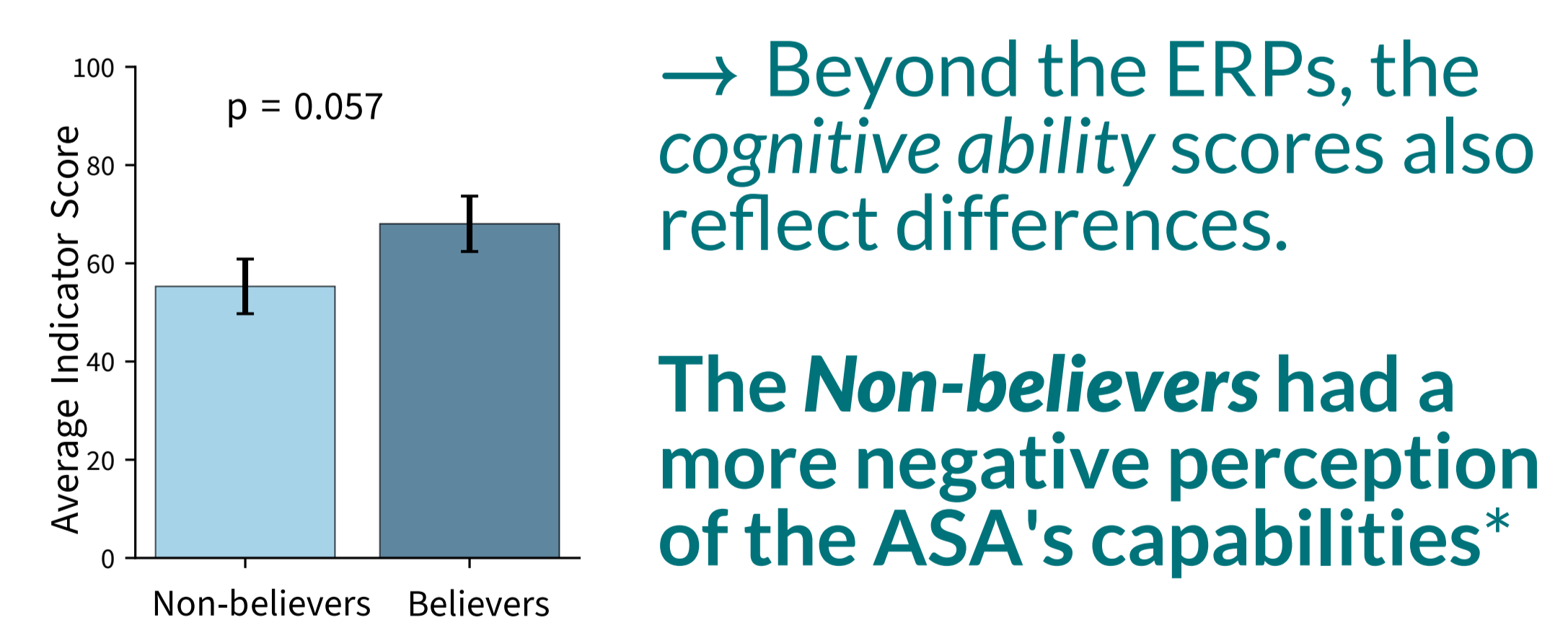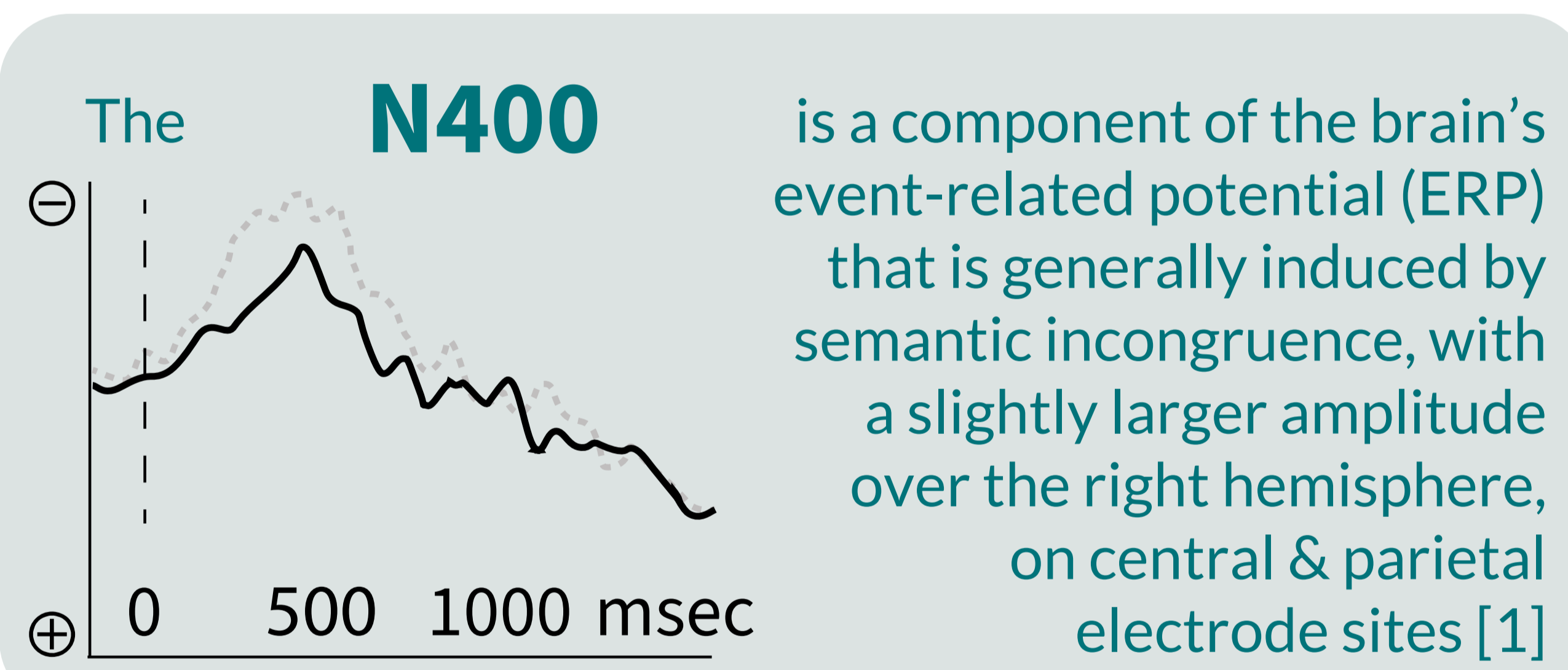Imagination   Intelligence   Creativity   Independence   Talkativity

For the 27 participants: Imagination (54.51), Intelligence (73.48), Independence (53.18), Creativity (52.40), Talkativity (79.77)
For the "non-believers": Imagination (48.2), Intelligence (65.3), Independence (44.1), Creativity (40.9), Talkativity (78.0)
For the "Believers": Imagination (54.8), Intelligence (77.6), Independence (68.6), Creativity (54.6), Talkativity (84.6)

CONCLUSION

Our findings highlight the remarkable human ability to reconcile the discrepancy between the appearance of the robot and the conveyed meaning. The participants' beliefs significantly influenced both their neural and language processing. These results provide valuable insights into the intricate interplay between embodied experience and beliefs, and sheds light on the complex mechanisms underlying the interpretation of information. Preexisting beliefs influenced how we process and understand messages, showcasing the influence of cognitive frameworks during language processing.
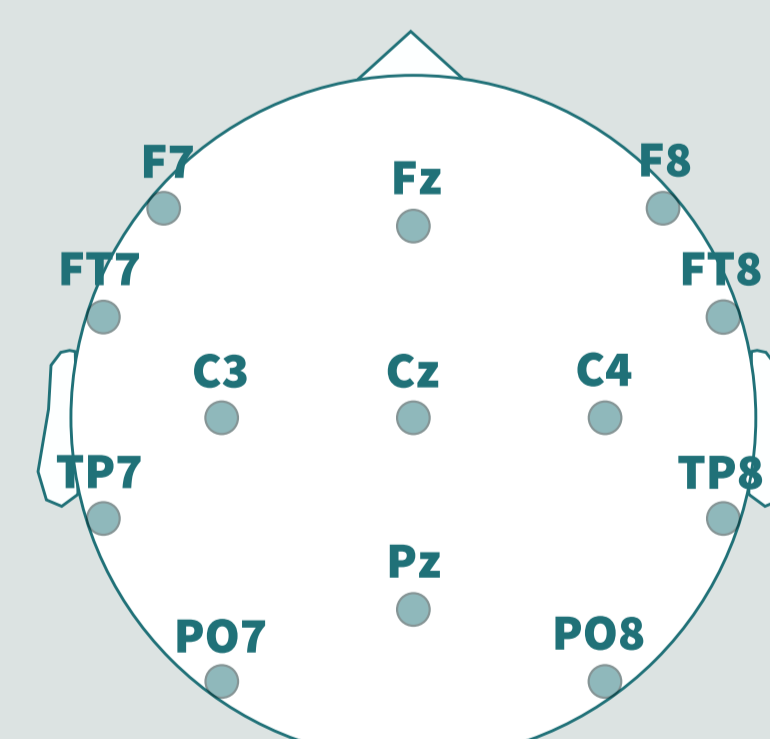
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