FENS '24

DETAILS

The language of space: Where is this and where is that?

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Introduction and Objective: The hypothesis that language-cognitive system interactions play a role in understanding domain-specific semantic terms is supported by a few neurophysiological studies, mainly on the motor cortex. Our goal was to assess if visuospatial coding affects the semantic comprehension of space-related words differently for peripersonal and extrapersonal space, and the causal role of the posterior parietal cortex (PPC).Methods: Utilizing Unity3D and Oculus Rift S, a virtual reality setup displayed 3D words at peripersonal (60 cm) and extrapersonal (120 cm) space. Participants performed a lexical decision task distinguishing between pseudowords and a near ("this") or far ("that") semantically related words, under conditions with and without tool use. The experiment included baseline, cathodal tDCS over the right PPC, and dual tDCS sessions, measuring Vocal Reaction Times (RTs) and analysing them with repeated measures ANOVA to assess semantic distance effects under various conditions.Results: Baseline conditions showed significantly faster RTs for near-semantically related words in peripersonal space. Tool use decreased RTs for near-semantically related words in extrapersonal space. Cathodal tDCS can revert this latter phenomenon by increasing RTs for near-semantically related words when a tool is used. Dual tDCS globally reduced RTs, regardless for position, semantics, and tool.Discussion and Conclusions: The findings suggest visuospatial coding influences near and far semantic processing, with or without a virtual tool, and highlight a causal role for right PPC. The overall RT reduction following dual tDCS could be due to enhanced reading performance from increased left-PPC excitability and decreased inter-hemispheric inhibition from right-PPC.

CITATION

APA Citation | BibTeX

Quartetti, U., Gambino, G., Brighina, F., Majo, D. D., Musotto, G., Ferraro, G., Sardo, P., & Giglia, G. (2024). The language of space: Where is this and where is that? *Science Communications World Wide*. doi:10.57736/14d5-83bb

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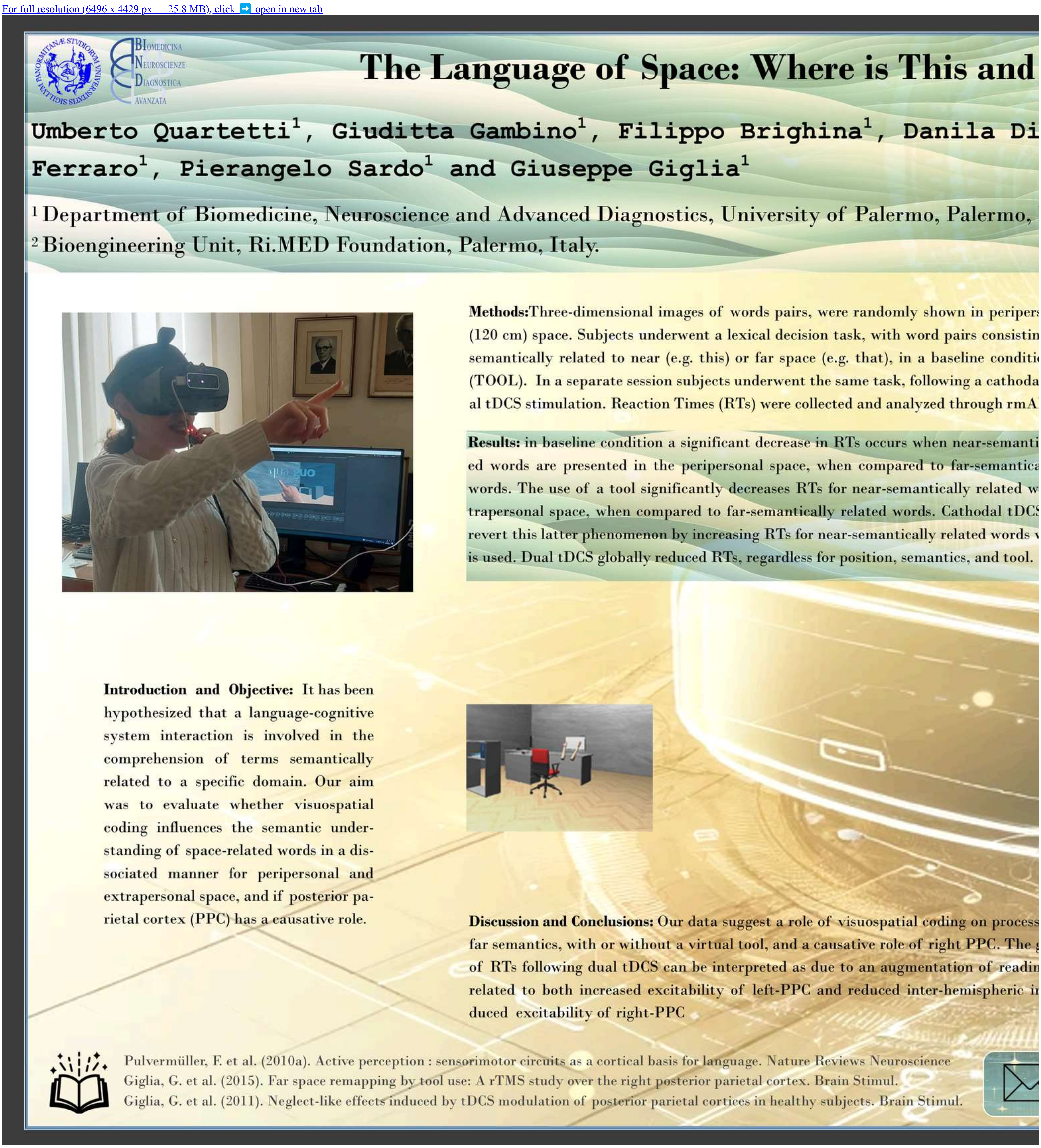

AUDIO BRIEF

0:00 / 5:38

TRANSCRIPT 🗣

Hello everyone and thanks for listening. My name is Umberto Quartetti and I'm from the Department of Biomedicine, Neuroscience and Advanced Diagnostics from the University of Palermo, Italy. Today I want to talk to you about some research we presented in this poster. We wanted to find out if visuospatial processing plays a role in how we understand words that are related to space. Recent studies have shown that semantic processing involves both modality-specific regions and multimodal regions that act as semantic hubs. For example, the primary cortex activates in a somatotopic way when we process action-related words like kick. Building on this idea, we wanted to see if visuospatial processing might also be involved when we process space-related words. It's known that the right posterior parietal cortex is responsible for visuospatial processing. In fact, this area helps divide the space around us in two distinct areas, peripersonal space and extrapersonal space. Peripersonal space is the area within arm's reach where we can interact directly with our hands, while extrapersonal space is beyond arm's reach and requires us to move to interact with it. To test this hypothesis, we created a virtual reality environment where subjects performed a lexical decision task. Here's how it worked. Pairs of words, one being space-related words and the other pseudowords, appeared in front of the subject. They had to read the space-related words out loud and ignore the pseudoword. The pairs of words appeared at two different distances, 60 cm in the peripersonal space and 120 cm in the extrapersonal space. The space-related words were further divided into two categories, words related to peripersonal space, like this and near, and words related to extrapersonal space, like that and far. We measured how quickly subjects reacted after the word pairs appeared. Our hypothesis was that if the stimulus matched the visuospatial processing, e.g. near in the peripersonal space or far in the extrapersonal space, reaction times would be shorter compared to when it didn't match, e.g. near read in the extrapersonal space. As you can see from the top right graph, our results confirm this hypothesis. Words indicating proximity, like near read in the peripersonal space, had significantly shorter reaction times than words indicating distance, like far. Similarly, distance-related words when read in the extrapersonal space had shorter reaction times compared to when read in the peripersonal space. In another experiment, we allowed subjects to use a tool in the virtual reality environment to point at the words. Using a tool has been shown to extend our peripersonal space. This meant that the 120 cm distance, which was extrapersonal space in the first setup, was processed as peripersonal space with the use of the tool. Our hypothesis was that the proximity-related words at 120 cm with the tool would have shorter reaction times than distance-related words. And again, the results supported our hypothesis, as shown in the graphic on the right. In a third experiment, we used cathodal transcranial direct current stimulation to temporarily inhibit the right posterior parietal cortex, which is crucial for visuospatial processing. The results were fascinating. Inhibiting the PPC, the posterior parietal cortex, reversed the space remapping effect caused by the tool use. As you can see in the second graph after TDCS stimulation, reaction times were similar to the first task without the tool, confirming the posterior parietal cortex role in visuospatial processing and its influence on semantic processing of space-related words. Lastly, we tried using dual TDCS stimulation, but the results weren't significant for our hypothesis. In fact, reaction times improved overall, regardless of position, semantic, or tool use. This was likely due to increased excitability of the left posterior parietal cortex and reduced interhemispheric inhibition by reduced excitability of the right posterior parietal cortex. In conclusion, our findings support the idea that visuospatial processing, and particularly involving the posterior parietal cortex, plays a role in the semantic processing of space-related words. Thank you for your attention.

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Abstract Summary

🤖 The study explored how visuospatial coding influences understanding space-related words. Using VR and tDCS, it found faster reaction times for near words in peripersonal space, and tool use altered these effects. The right posterior parietal cortex plays a causal role in this semantic processing.

Brief Transcript Summary

🤖 The researcher, Umberto Quartetti from the University of Palermo, discussed their study on the role of visuospatial processing in understanding space-related words. Utilizing a virtual reality environment, participants performed a lexical decision task with words appearing at different distances representing peripersonal (60 cm) and extrapersonal (120 cm) spaces. The study found shorter reaction times when the semantic meaning of the word matched the space it was displayed in, with tool use extending peripersonal space. Inhibiting the right posterior parietal cortex (PPC) reversed the remapping effect caused by tool use, highlighting the PPC's role in visuospatial and semantic processing. Dual tDCS stimulation improved reaction times overall, likely due to altered hemispheric excitability. The findings suggest that the PPC significantly influences the semantic processing of space-related words.

What info can be found in the Brief that is not in the Abstract?

🤖 The presenter's brief provides additional details not included in the abstract. Specifically: 1. Methodological Clarity: The presenter elaborates on the setup of the lexical decision task in the virtual reality environment, explaining how participants distinguish between space-related words and pseudowords. 2. Contextual Background: An explanation is provided on the role of the primary cortex in processing action-related words, drawing a parallel to the processing of space-related words. 3. Hypothesis Rationale: The researcher discusses the hypothesis that reaction times would be shorter when the semantic meaning of the words matched the spatial location (e.g., "near" read in peripersonal space). 4. Detailed Experimental Observations: More specific details on the use of tools extending peripersonal space and its effects on reaction times are presented. 5. TDCS Experiments: Further insights into the effects of cathodal tDCS and dual tDCS on reaction times are discussed, including the impact on inter-hemispheric inhibition and cortical excitability. 6. Visual Aid Descriptions: Reference to graphical data supporting the results, though the actual graphs are not provided in the brief. By offering this additional context, the presenter's brief enhances the understanding of the experimental design, underlying hypotheses, and the detailed outcomes of their research.

What methodology did the researchers use?

🤖 The researchers used a virtual reality setup with Unity3D and Oculus Rift S to display 3D words at peripersonal (60 cm) and extrapersonal (120 cm) spaces. Participants performed a lexical decision task to distinguish between pseudowords and near ("this") or far ("that") semantically related words. The conditions included baseline, cathodal tDCS over the right posterior parietal cortex (PPC), and dual tDCS sessions. They measured Vocal Reaction Times (RTs) and used repeated measures ANOVA to assess the effects of semantic distance under various conditions. Additionally, tool use was introduced to see its effect on space processing.

What are the results?

🤖 The results showed that: 1. Baseline Conditions: Significantly faster reaction times (RTs) for near-semantically related words in peripersonal space. 2. Tool Use: Decreased RTs for near-semantically related words in extrapersonal space. 3. Cathodal tDCS over Right PPC: Reversed the tool use effect by increasing RTs for near-semantically related words when a tool was used. 4. Dual tDCS: Globally reduced RTs regardless of position, semantics, or tool use, likely due to increased left-PPC excitability and decreased inter-hemispheric inhibition from the right-PPC.

What are the conclusions?

🤖

- Visuospatial coding influences the semantic comprehension of space-related words, differing between peripersonal (near) and extrapersonal (far) spaces.
- Use of a tool can modify reaction times, effectively extending peripersonal space into what would normally be extrapersonal space.
- The right posterior parietal cortex (PPC) plays a causal role in the visuospatial and semantic processing of space-related words.
- Cathodal transcranial direct current stimulation (tDCS) over the right PPC can reverse the spatial remapping effect induced by tool use.
- Dual tDCS improves overall reaction times, likely due to increased left-PPC excitability and decreased inter-hemispheric inhibition from right-PPC.

What are the implications?

🤖 The implications suggest that visuospatial processing, particularly involving the posterior parietal cortex, significantly influences the semantic comprehension of space-related words. This highlights the interaction between language and cognitive systems, suggesting that the spatial positioning of words and tool use can impact reading performance and comprehension. Additionally, the study provides evidence for potential therapeutic applications of tDCS in enhancing cognitive functions related to language and spatial awareness.

Question Ideas

🤖 1. Can you elaborate on the specific neurophysiological studies related to motor cortex that initially supported your hypothesis? 2. How were the pseudowords selected and matched with the real space-related words in your lexical decision task? 3. What was the rationale behind choosing the distances of 60 cm and 120 cm for peripersonal and extrapersonal space in the VR setup? 4. Could you provide more details on how cathodal and dual tDCS were administered and the reasoning behind targeting the right PPC? 5. What were the main challenges in using a virtual reality environment for this type of cognitive and semantic research? 6. How were the vocal reaction times measured and what specific equipment or software was used for this purpose? 7. Can you discuss the statistical methods used in your repeated measures ANOVA and how they account for potential confounding variables? 8. What were the possible reasons behind the dual tDCS providing overall reduced reaction times regardless of condition? 9. How do you interpret the role of visuospatial processing in semantic comprehension given the results from the tool-use experiment? 10. What are the potential practical applications of understanding the interaction between visuospatial coding and semantic processing of space-related words? 11. Did you notice any individual differences among participants that might have affected the reaction times or results in any of the conditions? 12. How might the findings of this study be applied or extended to other semantic domains beyond space-related words? 13. Were there any side effects or adverse reactions observed from the use of tDCS among the participants? 14. What future experiments would you consider conducting to further explore the causal role of the posterior parietal cortex in semantic processing? 15. Can you discuss any limitations of the study and how these might be addressed in future research?

In Lay-Terms (ELI5)

🤖 The researchers wanted to see if how we understand words related to space (like "this" or "that") is influenced by the part of the brain responsible for processing where things are around us. They used virtual reality to show words at different distances and measured how quickly people responded. They found that people were faster to recognize words that matched the space they were shown in. For instance, they reacted faster to "near" when it was close and "far" when it was far. When people used a virtual tool, their reaction times for farther words improved, as if their brain treated farther space as closer. They also used a technique called tDCS to temporarily reduce activity in a brain area called the right posterior parietal cortex (PPC). This reversed the effect of using the tool, showing this brain area is important for understanding space-related words. When they stimulated both sides of the brain (dual tDCS), reaction times improved overall, not just for space-related words. This suggests that stimulating both sides of the brain can generally improve reading speed. In short, the study shows that the brain's processing of space and language are connected, specifically through the right PPC.

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SIMILAR POSTERS

📃 Electrical stimulation over the parietal cortex induces spatial bias by mediating the influence of visuospatial attention on the temporal dynamics of visuocortical processing
Duanghathai Wiwatratana, Sisi Wang, ..., Sirawaj Itthipuripat

- **Common Ground:** Both studies explore the role of the *posterior parietal cortex (PPC)* and the effects of *transcranial direct-current stimulation (tDCS)* on cognition and spatial processing.
- **Key Differences:** The current study focuses on *semantic comprehension of space-related words using VR*; the recommended study examines *visuospatial attention and EEG-based visual processing*.
- **Methodologies:** The current study uses *VR tasks* and measures *vocal reaction times (RTs)*, incorporating *tDCS* over PPC; the recommended study employs *visual attention tasks* with EEG to observe *neural responses*, also incorporating *tDCS* over PPC.
- **Complementary Aspects:** The current study's findings on *spatial semantic processing* under various conditions, including tool use and tDCS, can be enriched by the recommended study's insights on *neural dynamics and visual attention shifts*.
- **Potential Impact:** Combining these studies could enhance understanding of *PPC's role* in *cognitive and perceptual spatial processing*, informing new therapeutic approaches using *tDCS*.

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