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The Spatial Updating Mechanism of Different Field-Cognitive Styles in Various Perspective

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INTRODUCTION & AIM

Spatial updating is a key cognitive function in the navigation process, which directly affects an individual's path integration ability and navigation efficiency. Although existing studies have shown that field cognitive style and perspective orientation may influence spatial updating performance, the underlying cognitive and neural mechanisms have not yet been systematically investigated.

To explore this issue in depth, this study adopted a 2 (field-dependent/field-independent) ×2 (memory-consistent/sensorimotor-consistent) mixed experimental design, combining the relative direction judgment paradigm with functional near-infrared spectroscopy (fNIRS) brain imaging technology. Through a virtual navigation task, the study simultaneously recorded participants' behavioral performance and brain activation patterns.

The results reveal the synergistic effects of field cognitive style and perspective orientation on spatial updating at both behavioral and neural levels. These findings not only deepen the understanding of individual differences in spatial navigation but also provide an important theoretical basis for the development of personalized navigation systems based on users' cognitive characteristics.

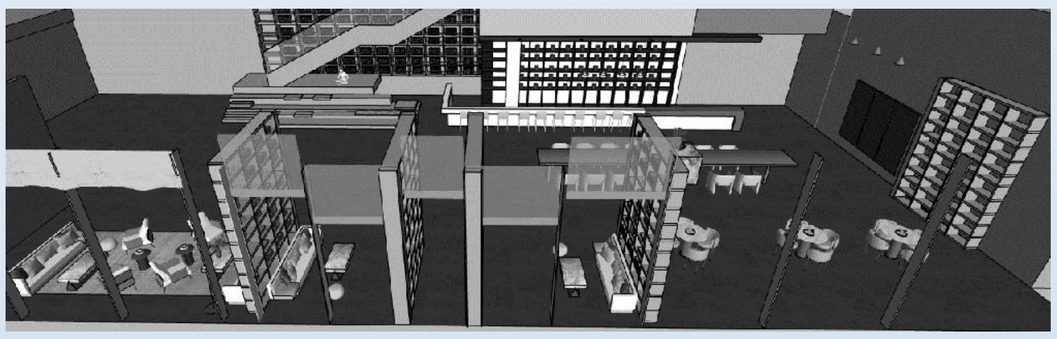
METHOD

●Participants

A total of 105 college students (48 males and 57 females) were selected as participants in this study, with a mean age of 19.08years.

●Experimental Scenario

The experimental scenario was presented in the form of a 90-second video, which consisted of six spatial components: a sofa, a bookshelf, a round table, a long table, a bar counter, and stairs.



●Experimental Materials

The experimental stimuli were presented via a Python/PsychoPy program. Meanwhile, a 49-channel fNIRS system produced by NIRx was used to record the brain activity in the frontal-parietal cortex of the participants during the task.

●Experimental Procedure

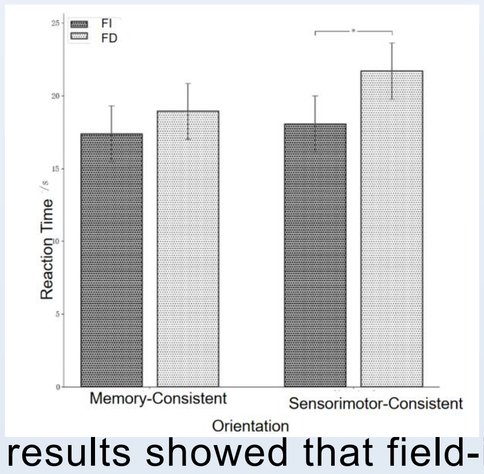
After learning the layout of the virtual hall, the participants completed 96 spatial pointing tasks under two perspective conditions, with fNIRS brain activity data collected simultaneously.

●Data Analysis

The behavioral data were analyzed using a repeated-measures analysis of variance (ANOVA), while the fNIRS data, after preprocessing with Homer2, were analyzed using a mixed-design analysis of variance (ANOVA) in SPSS.

RESULTS & DISCUSSION

●Behavioral Results



The behavioral results showed that field-independent individuals performed significantly better in the spatial pointing task than field-dependent individuals, specifically manifested in shorter reaction times and higher accuracy rates. Meanwhile, task performance under the memory-consistent perspective was also comprehensively better than that under the sensorimotor-consistent perspective.

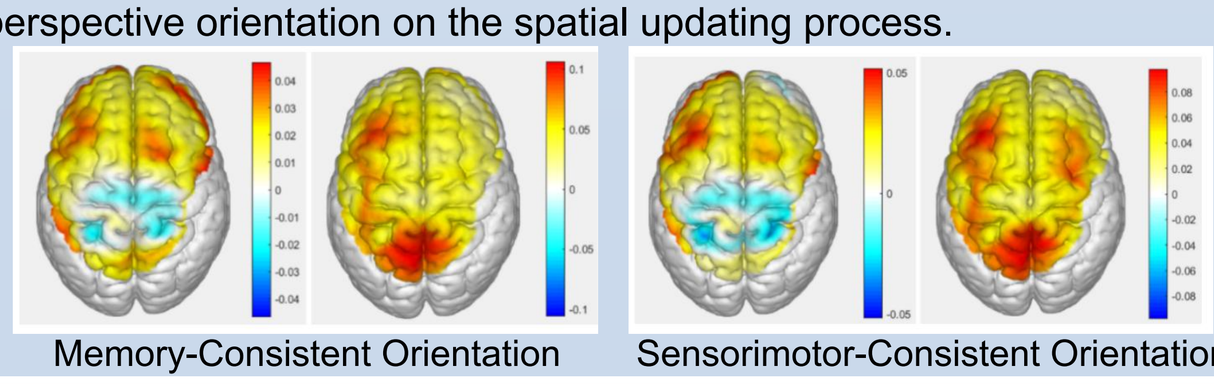
Notably, there was a significant interaction between field cognitive style and perspective orientation: under the more challenging condition of sensorimotor consistency, field-independent individuals demonstrated a greater response advantage. This reveals that they possess special cognitive flexibility in situations that require flexible adjustment of reference frames.

●fNIRS Results

The fNIRS results indicated that field-independent individuals exhibited significantly stronger activation intensity in multiple brain regions compared to field-dependent individuals. These brain regions include the precentral gyrus, postcentral gyrus, precuneus, and superior parietal lobule.

At the same time, the memory-consistent perspective also induced significantly stronger brain activation in the medial part of the superior frontal gyrus and the precuneus than the sensorimotor-consistent perspective.

These findings confirm, at the level of neural mechanisms, the independent and interactive effects of field cognitive style and perspective orientation on the spatial updating process.



Memory-Consistent Orientation Sensorimotor-Consistent Orientation

CONCLUSION

The study reveals the synergistic advantages of field-independent cognitive style and memory-consistent perspective in spatial updating tasks. Individuals with field independence demonstrate superior behavioral performance and stronger brain region activation by virtue of their ability to flexibly adjust internal reference frames.

This study provides an important theoretical basis for the personalized design of intelligent navigation systems. The results suggest that navigation systems can be adaptively optimized according to users' cognitive styles: providing more environmental cue support for field-dependent users, while retaining efficient operation modes for field-independent users, thereby significantly improving navigation efficiency and user experience.