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Neural dynamics involved in creative thinking in engineering design

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***Abstract*— Brain activity during creative thinking of engineering design can be different from that during general creativity tasks. This study revealed that the default network (DN_{CORE}, DN_{MTL}, DN_{SUB3}), and the frontoparietal control network (FPCN) are active during engineering design and these areas are more active in creative thinking than in divergent thinking because of specific functional requirements and technical problems.**

I. INTRODUCTION

Creativity is the ability to generate novel and valuable ideas. This unique creativity of human beings is becoming more and more important, and there is a growing demand for technologies that support creative thinking. There is also a growing need to understand the mechanisms of creative thinking.

In this study, to elucidate the mechanism of creative thinking in engineering design, we measured electroencephalogram (EEG) and analyzed source activity during creative thinking task related to engineering design and general creative thinking task.

II. METHODS

Subjects: Participants were a total of 12 healthy right-handed men in their 20s, all of whom majored in mechanical engineering at the University of Tokyo. Written informed consent was obtained from each participant.

Data acquisition: We used a 32-channel BrainAmp DC (Brain Product) to obtain electroencephalogram (EEG) data.

Environmental tasks: Each participant took up a total of six tasks. In the divergent thinking design task, we asked the participants to list as many ideas as possible in engineering design referring to Hay et al.'s product design engineering task, and in the convergent thinking design task, we asked them to combine these ideas into one product idea and sketch it [1]. We also used the alternative uses task as a general divergent thinking task and the Japanese version of the remote associates test as a general convergent thinking task. In addition, a verbal fluency task and an imagery task based on Hay et al.'s imagery manipulation task were used as comparison tasks to eliminate the characteristics of the task content.

Procedure: After measuring EEG at rest, the above six tasks were conducted in different orders for each participant. In each task, the thinking time and the answering time were separated, and EEG data of the thinking time was analyzed.

Analysis: After removing artifacts from the EEG signals using artifact subspace reconstruction, the ratio of five types of band power (δ: 0.5~4Hz, θ: 4.5~7.5Hz, α: 8~12.5Hz, β: 13~30Hz and γ: 30.5~40Hz) were extracted using EEGLAB ver.14.1.2b. We compared the power in source analysis of two different tasks by exact low resolution brain electromagnetic tomography (eLORETA).

III. RESULTS

In both the divergent thinking design tasks and convergent thinking design task, the DN_{CORE}, DN_{MTL}, DN_{SUB3} and FPCN brain regions were activated mainly in the β- and γ-bands, and these brain regions were more activated in convergent thinking design task than in divergent thinking design task [2]. In a comparison between engineering design and general creative thinking, divergent thinking was almost the same, but convergent thinking was activated in the abovementioned areas during engineering design.

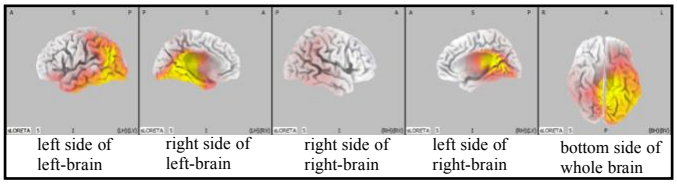

Figure 1. Active areas during convergent thinking design task

IV. DISCUSSION & CONCLUSION

In convergent thinking in engineering design, DN_{CORE} and FPCN are activated by restricting thinking related to technical problems, and DN_{MTL} is activated to explore memory to compare with existing products regarding functional requirements. We hope that this finding will lead to the development of technologies that promote divergent and convergent thinking during engineering design.

REFERENCES

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