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The performance difference of interdisciplinary teams in the field specific and general innovation tasks

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Abstract. Collaborative innovation in interdisciplinary teams is a collaborative approach to accomplish cooperative tasks and achieve innovative goals through a multidisciplinary intersection in the form of member combinations. The purpose of this study was to reveal the neural mechanisms underlying the impact of interdisciplinary collaboration on groups and individuals. Each group of subjects consisted of two people with and without a design background, who were asked to solve two realistic presented problems (RPP), and two design innovation tasks based on RPP adaptations. The study used hyperscanning of functional near-infrared spectroscopic (fNIRS) brain functional imaging techniques to simultaneously record the neural responses of interacting participants in each group. The study compared the innovation performance of interdisciplinary teams with design backgrounds in domain-specific versus domain-general innovation tasks, and the results showed differences in individual and group performance in different types of innovation tasks, with individual fluency being the most significant. The study may provide empirical evidence for the performance benefits of interdisciplinary teams in real-world collaborative co-innovation.

Keywords: Interdisciplinary cooperation; Domain specificity; fNIRS; Hyperscanning; Interpersonal brain synchronisation

1. Introduction

As the global digital transformation continues to deepen, successful cases of interdisciplinary and multi-field "group intelligence innovation" are gaining more and more attention in society. The trend that individuals with different disciplinary backgrounds are becoming normalized to participate in group work suggests that the promotion of interdisciplinary collaborative innovation is inevitable. Collaborative innovation in interdisciplinary teams can enhance independent innovation capability and improve cutting-edge innovation output [1], and a large number of studies have demonstrated the advantages of interdisciplinary teamwork in innovation performance [2], but few studies have investigated the process mechanism of collaborative innovation in interdisciplinary teams and analyzed the mechanism of excellent innovation performance in interdisciplinary teams. In this study, the following hypotheses were proposed and observed with the question "Are there differences in innovation performance of interdisciplinary teams in domain-specific and domain-general innovation tasks?" as the research objective.

First, the same group performs differently on different types of innovation tasks. lu et al [3] compared the innovation performance of interdisciplinary and non-interdisciplinary teams on the alternative uses task (AUT) and found that the innovation performance of interdisciplinary teams was instead lower due to less transpersonal thinking behavior and less cooperation among team members. Other studies have also found that transpersonal thinking behavior is an important factor affecting the innovative performance of teams with different levels of creativity [4]. The AUT task, like the RPP task, is a domain-general creative thinking task, and subjects from different disciplinary backgrounds do not differ significantly in their innovative performance on this task [5]. However, in realistic collaborative tasks, there are often members of interdisciplinary teams who are better at the target task and have more relevant experience, such as design students who have a significant advantage in domain-specific design innovation tasks [6], and they may provide more

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effective information and gain the trust of other members, thus increasing team transpersonal behavior and cooperation and achieving higher team innovation performance. Based on this, this study hypothesized that team task fluency and team cooperation indices are significantly different by innovation task type and that domain specificity is greater than domain generality.

Second, individuals from different disciplinary backgrounds perform differently on different types of innovation tasks. In this study comparing team co-innovation performance on domain general and domain specific innovation tasks, the subject group consisted of one subject from a design background and one from a non-design background. Teng et al. found that design and non-design students' AUT task and the figural version of the Torrance Test of Creative Thinking for the same domain general creativity task showed no significant difference in fluency scores, but design students' overall performance scores on the domain-specific product design task were significantly higher than those of non-design students. Based on this, this study hypothesized that individual task fluency differs significantly by type of creative task and professional background, and that tasks that fit the professional domain stimulate individual performance.

Third, the wavelet transform coherence (WTC) index of the team's left prefrontal lobe and bilateral inferior frontal gyrus was correlated with the type of innovation task. WTC is a method for assessing the frequency and temporal function of interpersonal brain synchronisation (IBS) between two participants [7]. Xue et al [8] observed IBS in the inter-subject prefrontal cortex (PFC) under the RPP task using the fNIRS device, and found that groups with different levels of cooperation and innovation performance (high creativity group, low creativity group, and high-low creativity group) differed significantly in IBS in the three channels, with stronger IBS in the group with higher levels of cooperation. Lu et al. found differences in IBS in the right middle temporal gyrus, angular gyrus, and primary somatosensory cortex during the AUT task between groups with different levels of cooperation and creative performance (interdisciplinary vs. non-interdisciplinary), but did not focus on IBS in the PFC. Mayseless et al [9] compared interbrain IBS in a product design task with a non-creative task (splicing 3D models) and found that the left prefrontal functional connectivity between the anterior, posterior superior temporal gyrus, temporoparietal gyrus, and inferior frontal gyrus was higher during the product design task than during the model splicing task. Based on this, this study hypothesized that the WTC indices of the team's left anterior parietal lobe and bilateral inferior frontal gyrus were significantly different by innovation task type and that domain specificity was greater than domain generality.

2. Methods

2.1 Participants

Collects the behavioral and cerebral blood oxygen data from 5 groups of participants in domain-specific and domain-general innovation tasks. The study recruited 10 participants (5 females, age: 41.74 ± 6.38 years) whose professional background was design or non-design background, and each group contained a design background and a non-design background. The study balances the influence of gender differences by grouping, and each group of participants has no intersection with the other before the experiment. Before the experiment, the participants read and signed the informed consent form for the experiment. After the experiment was completed, each subject received a participation fee of 100 RMB. This study was approved by the Medical Ethics Committee of Huaqiao University School of Medicine.

2.2 Experimental task and procedures

Research tasks include domain-specific and domain-specific innovation tasks. The general innovation task in the field is RPP. It’s a divergent thinking task related to creativity. The test group is required to give as many solutions as possible within a certain period of time according to the given realistic situation. The field-specific innovation task is a design innovation task adapted from

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the RPP task in this study, and the subjects are required to give as many design ideas as possible within the same time period according to the given design goals.

The research includes 2 sessions, each session includes two 60-second rest blocks, two 60-second instruction blocks, one 300-second RPP task and one 300-second design innovation task, RPP and design in each session The order of the innovation tasks was randomized, and the participants took turns answering one idea at a time. The formal experiment takes about 28 minutes.

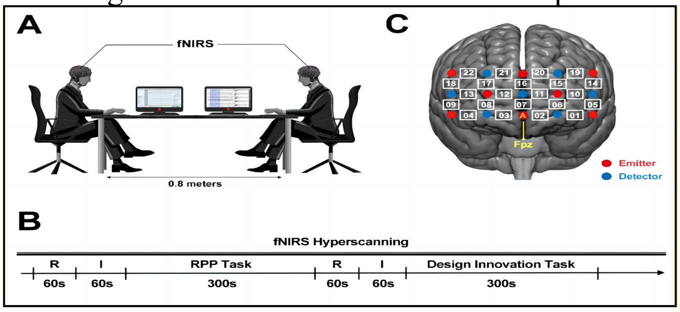

Fig. 1 Experimental design of this study. (A) Experimental measurement setup. (B) Hyperscan procedure. R: 60-second resting state session; I: 60-second instruction introduction session; RPP: 5-minute RPP session; Design Innovation: 5-minute innovation design session. The order of reporting between the two participants was alternating. (C) Optode probe setup in the prefrontal cortex.

2.2.1 Instructions for general RPP tasks in the field are:

a)"You have to go to a concert immediately after school, so you make an appointment with a friend to meet directly at the seat in the concert hall. There is a reservation retail department outside the concert hall, and there is your ticket. You rush to Tell the ticket inspector your name at the scene, but he said that the concert has started and your friends have already entered, and you need to provide him with something that can prove your identity. But you realized that you did not bring your wallet and ID card! How or what can you use to get tickets and watch this show?"

b)"Your deskmate likes to talk to you very much, and often interrupts you when you are studying hard. Sometimes you will be distracted because of him and miss the important content of the teacher. Many times, because of his interruption, You can’t finish your homework on time. What should you do? How will you solve this problem?"

2.2.2 Instructions for field-specific design innovation tasks are:

a)"The physical condition, psychological problems, unsolvable problems, falls or faints of the elderly living alone need to be monitored and dealt with in a timely manner. How to monitor the problems encountered by the elderly in a timely manner? How to effectively deal with these problems, not local What kind of person or institution should the children seek help to deal with the problem? How to monitor and deal with the problem to ensure respect for the elderly and take care of the privacy of the elderly? What methods or things can you use/create to help solve the monitoring of the special situation of the elderly and dealing with the problem?"

b)"Most of the elderly and their children live in different places in the current society. Due to the busy work of the children, it is difficult for the elderly and their children to find a suitable time to communicate. In addition, the thinking methods, values, life attitudes, hobbies, etc. of the new and old generations The difference also affects the communication between the two parties, making long-distance communication more difficult. In what ways or what can you borrow/create to help solve the problem of long-distance communication between the elderly and their children?"

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2.3 Data Collection

2.3.1 Cerebral blood oxygen data

Collected by two sets of Artinis Brite 24 fNIRS equipment, observe the cerebral blood oxygen changes in the prefrontal cortex (left and right brain) of each subject during RPP and design innovation tasks.

2.3.2 Behavioral data

a)Experimental cooperation willingness and emotional measurement. The willingness to cooperate before the test was measured by the Group Preference Scale (GPS, group preference scale), which contains 10 questions and is evaluated in the form of a 5-point Likert scale. The emotional measurement before and after the test was completed through the Self-Assessment Scale of Emotional Experience (SAM, self-assessment Manikin), and the five cartoon pictures were evaluated on a 9-point scale of valence and arousal. The mood measurement after the test set 6 questions on task completion, preference, satisfaction, difficulty, etc., and used a 5-point scale to evaluate..

b)Innovation performance (originality, fluency) and cooperation index of RPP and design innovation tasks. The innovation performance is evaluated for a single subject. Five trained raters use a 5-point Likert scale to score the innovation of the subjects' answers. The average score is the originality. Recorded on a 5-point scale.

2.4 Data Analysis

2.4.1 Cerebral blood oxygen data

Low-pass filtering and discrete cosine transform (DCT, discrete cosine transform) were performed on the raw data of oxygenated hemoglobin (HbO) concentration changes in 24 channels of the prefrontal cortex during the 5-minute innovation task. Wavelet coherence was performed on the 24-channel HbO data of the frontal cortex of the two subjects, and the frequency band data with a period of 12.8 seconds to 51.2 seconds was extracted to calculate the mean value, which was recorded as the WTC index to evaluate the relationship between the oxyhemoglobin time series of the two participants in each group . Whether there is a significant difference between the RPP and the WTC index of the design innovation task was compared by independent t-test.

2.4.2 Behavioral data

ANOVA test and t test were used to compare the degree of originality and fluidity of subjects with design background and non-design background under RPP and design innovation tasks, and t test was used to compare the degree of cooperation of the test group under RPP and design innovation tasks.

3. Results

3.1 Behavioral expression

3.1.1 Individual performance

a)Individual fluency: In terms of the performance of the two tasks, Different professional background, Individual fluency was not significantly different ($t=0.78$, $P=0.23$), The mean fluency rate was 4.25 ($SD=0.41$), The mean fluency of subjects with non-design background was 4.05 ($SD=1.07$); In the performance of the domain general RPP innovation tasks, Different professional background, Individual fluency was significantly different ($t=1.97$, $P=0.05$), Fluency of the design background subjects ($M=5.7$, $SD=0.57$) higher than non-design background test fluency ($M=3.8$, $SD=2.08$); In the performance of special Design innovation tasks in the field, Different professional background, Individual fluency was also significantly different ($t= -2.18$, $P=0.03$) and, contrary to

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the former, The mean fluency rate was 3.2 (SD=0.91), The mean fluency of the subjects with a non-design background was 4.3 (SD=0.67).

b)Individual originality: In terms of performance of the two tasks, there is no significant difference in individual originality due to different professional backgrounds (t=1.07, P=0.16). The average originality of subjects with design background is 2.15 (SD=0.88), and the average originality of subjects with non design background is 1.55 (SD=0.89); In terms of performance of general RPP innovation tasks in the field, there is no significant difference in individual originality (t=1.25, P=0.12) due to different professional backgrounds. The originality of subjects with design backgrounds (M=2.9, SD=1.29) is higher than the fluency of subjects with non design backgrounds (M=1.8, SD=1.48); In terms of the performance of special design innovation tasks in the field, there was no significant difference in individual fluency between subjects with different professional backgrounds (t=0.32, P=0.38) and the former was the same. The originality of subjects with design backgrounds (M=1.4, SD=0.55) was higher than that of subjects with non design backgrounds (M=1.3, SD=0.45).

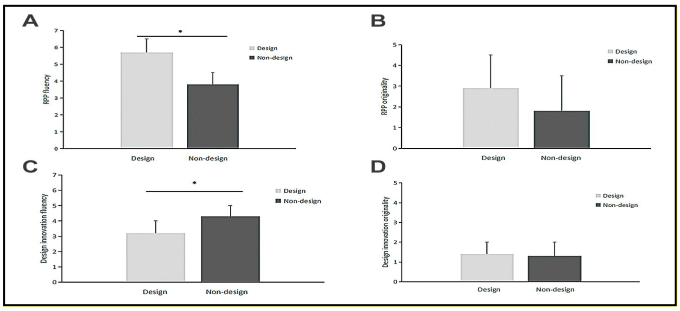

Fig. 2 Design versus non-design subjects, individual differences in task performance.(A)RPP fluency.(B)RPP originality.(C)Design Innovation fluency.(D)Design Innovation originality.

3.1.2 Team performance

a) Team fluency: Different types of innovation tasks have significantly different team fluency (t=1.53, P<0.05). The fluency of general tasks in the field (M=9.5, SD=2.55) is higher than that of special tasks in the field (M=7.5, SD=1.41).

b) Team originality:With different types of innovation tasks, team originality is significantly different (t=1.73, P<0.05). The fluency of general tasks in the field (M=4.7, SD=2.41) is higher than that of special tasks in the field (M=2.7, SD=0.91).

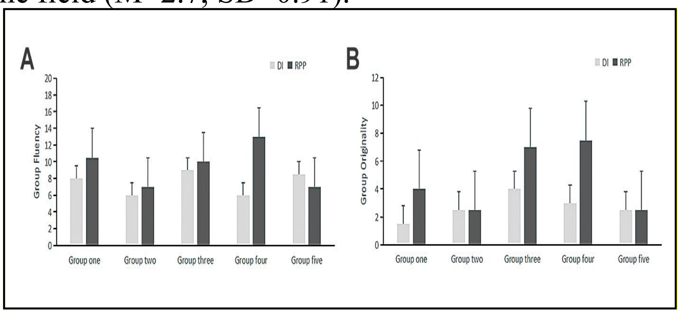

Fig. 3 Team differences between RPP and Design innovation tasks.(A)Group fluency.(B)Group originality.

3.2 Cerebral oxygenation

The Polhemus Patriot was used to locate 24 channel points, and the NIRS-SPM tool kit was used in MATLAB 2013b for spatial registration of light poles. It was found that 0.37447 of channel 7 may cover the dorsal lateral prefrontal cortex (DLPFC) of Brodmann 9 area, and 0.5319 may cover Broca's area of 44 and 45 areas. For different types of innovation tasks, the wavelet coherent rise

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index of group channel 7 is significantly different (t=-7.80, p<0.01), and the wavelet coherent rise index of general tasks in the domain (M=-0.20, SD=0.02) is lower than that of special tasks in the domain (M=-0.04, SD=0.03).

4. Conclusion and discussion

This study used fNIRS technology to study different domain tasks in interdisciplinary collaboration to verify previous hypotheses accordingly.

First, it can be verified from the team performance that different types of innovative tasks lead to significant differences in team fluency and team originality, but the research results show that the team fluency and team originality of general domain tasks are higher than those of domain-specific tasks, contrary to the hypothesis. Analyzing the possible reasons, the general tasks in the field are more basic and less professional than the special tasks in the field, and it is easier to communicate without threshold. In addition, the general tasks in the field are more situational, closer to life and easy to diverge and communicate, thereby improving fluency and originality.

Second, from the perspective of individual performance, it can be verified that subjects of different majors have different individual fluency and individual originality in different types of innovative tasks, and there are significant differences in individual fluency. The results of the study show that although the individual originality of design majors is higher than that of non-design majors, the individual fluency of non-design majors is even significantly higher than that of design majors in the field-specific tasks that meet design majors, contrary to the hypothesis. Analyzing the possible reasons, it is inferred that the problems of special tasks in the field contain factors of social hot issues of common concern in addition to design, and relatively older non-design majors except design majors have a certain basis of related topics and perform better. In addition, from the speculative prospect that the design major has a higher individual originality, the combination of individual originality and individual fluency of different professionals is different, and the individual originality and individual fluency of the same major are similar.

Third, from the brain blood oxygen data, it can be verified that the WTC index of different innovative task types is significantly different, and the wavelet coherence rising index of group channel 7 is significantly different. The WTC rise value (IBS increment) of channel 7 was higher than that of general tasks in the field, which verified the inference of this study.

To sum up, this study found significant differences in team originality, team fluency, and individual fluency under different task types. Among them, the WTC index of domain-specific tasks was found to be higher than that of domain-general tasks on the cerebral blood oxygen data, which verified the inference of Mayseless et al.

At the same time, there are still some deficiencies in the experiments of this study, which need to be adjusted and optimized in the future. First of all, due to irresistible factors, the number of subjects in this experiment is small, it is difficult to better rule out the influence of chance factors, and the difference analysis of small sample data is not significant. Secondly, as a field-specific design innovation task content, the professionalism is not strong enough, resulting in small performance differences between design majors and non-design majors. Finally, due to the limitations of fNIRS technology itself, it is difficult to map WTC with small sample data. It can be expected that in the future, the experiment will increase the number of subjects, improve the professionalism of special tasks in the field, and improve the interpretation and application of proper nouns. For future exploration in this field, representatives of the "industry, university, research and user" of the product's full life cycle can be used as subjects to simulate the communication status at each key stage, collect and analyze super-scanning data, and further explore the neural group decision-making mechanism in the field of design innovation. Evidence is provided for the performance advantages of interdisciplinary teamwork.

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5. Foundations

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References

[1] Yang, L.,Qian, T.,& Wu, Z.(2014).Analysis of the influencing factors and operating mechanism of interdisciplinary research organization collaborative innovation Beijing Education (Higher Education) (03), 25-27.

[2] Li Z.,& Liang, C.(2012). Analysis on the operation mechanism of collaborative innovation - based on the perspective of university innovation subject China Higher Education Research (07), 81-84. doi: 10.16298/j.cnki.1004-3667.2012.07.019.

[3] Lu, K., Qiao, X., Yun, Q., & Hao, N. (2021). Educational diversity and group creativity: Evidence from fNIRS hyperscanning. NeuroImage, 243, 118564.

[4] Lu, K., Gao, Z., Wang, X., Qiao, X., He, Y., Zhang, Y., & Hao, N. (2022). The hyper-brain neural couplings distinguishing high-creative group dynamics: an fNIRS hyperscanning study. Cerebral Cortex..

[5] Said-Metwaly, S., Fernández-Castilla, B., Kyndt, E., & Van den Noortgate, W. (2020). Testing conditions and creative performance: Meta-analyses of the impact of time limits and instructions. Psychology of Aesthetics, Creativity, and the Arts, 14(1), 15..

[6] Teng, J., Wang, X., Lu, K., Qiao, X., & Hao, N. (2022). Domain-specific and Domain-general Creativity Differences between Expert and Novice Designers. Creativity Research Journal, 34(1), 55-67.

[7] Torrence, C., Compo, G.P., 1998. A practical guide to wavelet analysis. Bull. Am. Meteorol.

[8] Xue, H., Lu, K., & Hao, N. (2018). Cooperation makes two less-creative individuals turn into a highly-creative pair. Neuroimage, 172, 527-537.

[9] Mayseless, N., Hawthorne, G., & Reiss, A. L. (2019). Real-life creative problem solving in teams: fNIRS based hyperscanning study. NeuroImage, 203, 116161. Article in a conference proceedings.