

行政院國家科學委員會專題研究計畫 成果報告

觸知覺之大小腦神經互動機制-以射箭選手的感覺運動適應
為例

研究成果報告(精簡版)

計畫類別：個別型
計畫編號：NSC 100-2314-B-028-002-
執行期間：100年08月01日至101年07月31日
執行單位：國立臺灣體育運動大學競技運動系

計畫主持人：石佑翎
共同主持人：羅于倩
計畫參與人員：碩士班研究生-兼任助理人員：曾麗文

報告附件：出席國際會議研究心得報告及發表論文

公開資訊：本計畫涉及專利或其他智慧財產權，2年後可公開查詢

中華民國 101 年 10 月 02 日

中文摘要：感覺運動整合是人類與環境互動最主要的方式之一，協調動作的產生在於感覺與運動訊息是否得以完善地整合。一直以來，小腦皆被認為與動作協調有著直接的因果關係。在我們之前的研究中，以一般的健康受試者為研究對象，測量受試者在執行視聽時間區辨作業時的腦部血流變化，用以探討大小腦在處理感覺訊息時的神經互動機制。我們的研究結果支持了訊息可經由小腦分析整理之後傳送至大腦，以節省大腦訊息處理負擔的論點。本研究的目的是在於將先前的研究結果延伸至具有高度動作協調能力的運動員，研究徵召 47 名參與者，其中 16 名為射箭運動員，15 名田徑運動員，另外 16 名為一般的非運動員健康參與者。受試者分別執行主動的觸覺區辨作業與動作相同但不需觸覺區辨的作業，同時並接受功能性磁振造影掃描以記錄其腦部血流的變化。研究的主要結果發現，無論是非運動員或是田徑運動員參與者，其在小腦與體感覺聯合皮質的活化程度皆顯著較射箭運動員來得高。與小腦的感覺獲得理論相符合，小腦參與了感覺訊息區辨的歷程。本研究結果更進一步發現，相較於沒有豐富感覺區辨經驗的參與者(田徑選手與非運動員)，具有豐富感覺區辨經驗的參與者(射箭運動員)可使用較節省的大小腦神經訊息處理模式來完成作業，這樣的能量經濟模式推論是透過運動訓練所達成感覺運動適應過程。

中文關鍵詞：感覺運動整合、動作協調、功能性磁振造影、觸知覺、小腦

英文摘要：Sensorimotor integration is the foundation of movement coordination. The cerebellum has been long regarded as an essential brain organ for movement coordination. In our previous study of visual duration perception, findings from healthy participants suggest that cortical computation could be saved by receiving integrated sensory information from the cerebellum. The present study aims to extend our previous findings by examining the cerebrocerebellum interaction for tactile perception in archers, who are mastery of movement coordination. 47 participants, 16 archers, 15 middle and long distance runners and 16 novices, were recruited in the current study. Participants were instructed to passively sense or actively compare the tactile stimulation on their finger. Functional magnetic resonance imaging was used to investigate the difference of sensorimotor adaptation among these

three groups. It was found that the somatosensory associative cortex (BA7) and the cerebellum yielded significantly higher activations in both runners and novices than in archers. In accord with the predictions of sensory acquisition hypothesis of the cerebellum, the cerebellum plays an important role in tactile discrimination. In addition, through the process of the sports training, the expert brain adapts itself to a more economic mode for saving the neural processing loading in the related sensory areas, i.e. somatosensory associative cortex and the cerebellum.

英文關鍵詞： sensorimotor integration, movement coordination, fMRI, tactile perception, cerebellum

行政院國家科學委員會補助專題研究計畫 成果報告
 期中進度報告

Cerebrocerebellar Interaction for Tactile Perception--
Examining Sensorimotor Adaptation in Archers

計畫類別： 個別型計畫 整合型計畫

計畫編號：NSC 100-2314-B-028-002

執行期間：100 年 08 月 01 日至 101 年 07 月 31 日

執行機構及系所：國立臺灣體育運動大學競技運動學系

計畫主持人：石佑翎

共同主持人：羅于倩

計畫參與人員：曾麗文

成果報告類型(依經費核定清單規定繳交)： 精簡報告 完整報告

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中 華 民 國 101 年 10 月 31 日

研究計畫之背景文獻探討及目的

Sensorimotor integration is the most essential way to interact with the environment since the execution of a goal-directed, appropriate motor response is based on the sensory information perceived. Evidence for the role of the cerebellum in sensory processing is accumulating in recent years (Bushara et al., 2001; Grodd, Hulsmann, Lotze, Wildgruber, & Erb, 2001). Therefore, the cerebellum has been proposed that it acts as a sensory analyzer more than a motor coordinator (Bower, 1997). In our previous studies, it has been suggested that the cerebellum gives a great boost of cortical computation by providing coordinating sensory input (Shih, Yeh, Kuo, Tzeng, & Hsieh). In addition, the cerebellum is modulated only by task-relevant sensory information and it facilitates the integration of temporally correlated sensory inputs into a coherent perception (Shih et al., 2009). The present study aims to extend the previous findings from novices to expert athletes who are highly proficient at integrating sensory information in order to achieve the ultimate state of movement coordination. It has been argued that one of the crucial characteristics differentiating elite athletes from novices is the skill in filtering out the irrelevant sensory information (Milton, Solodkin, Hlustik, & Small, 2007). Hence, the mechanisms of sensory processing within the cerebellum and between the cerebellum and the cerebral cortex might be different in participants with different experience of sensorimotor coordination. Therefore, the purpose of the present study is to investigate how the cerebrocerebellar interaction differs between novices and expert archers for tasks with various demand of tactile perception, i.e. passive sensing and active discrimination, under different contexts of sensory relevance. Exploring the precise nature of the role of cerebellum for sensorimotor adaptation should be given precedence since it is fundamental for understanding the underlying neuromechanisms of movement coordination, which will in turn bolster the design of therapeutic interventions emphasizing sensory strategies for improving motor performance for

patients with movement coordination dysfunction.

研究方法

47 participants, 16 archers, 15 middle and long distance runners and 16 novices, were recruited in the current study. Participants were instructed to passively sense or actively compare the tactile stimulation on their finger. Functional magnetic resonance imaging was used to investigate the difference of sensorimotor adaptation among these three groups. Tactile stimulation is applied on the palmar side of right or left fingertips in different sessions in a counterbalanced order. Participants are instructed to sense the tactile stimulation on their index and middle finger passively in the low sensory demand condition (LD) whereas they are asked to discriminate actively if the tactile stimulation sensed on their index finger matches the one sensed on their middle finger in the high sensory demand condition (HD). For the effect of sensory relevance, only task-relevant tactile information is presented in the relevant-only condition (R) while both tactile and visual (task-irrelevant) stimulation is delivered in the irrelevant-presented condition (IR). These four conditions are presented in a counterbalanced order with resting periods every 8 minutes. Participants are advised to maintain eye fixation on the central fixation point throughout the entire experiment. It takes about 100 minutes to complete the experiment.

Brain images are acquired on a 3T Siemens MRI system (Siemens, USA). Subjects' heads are immobilized with a vacuum-beam pad in the scanner. The experiment is done in block design. A T2*-weighted gradient EPI sequence is used for functional data (slice thickness= 5 mm, inter-slice gap= 1 mm, TR= 2,400 ms, TE= 40 ms, flip angle= 90°, in-plane resolution= 3.59x 3.59 mm, matrix size= 64x 64, FOV= 230x 230 mm). Twenty-four axial slices are acquired for whole brain coverage. 200 scans are acquired for each condition at each hand with a two minutes rest in between. An additional five dummy scans are added at the beginning of each task to allow the MR signal to reach equilibrium, and are discarded from further

analysis. The anatomical images are collected using a high resolution T1-weighted, 3D gradient-echo pulse sequence (slice thickness= 1.5 mm, TR/ TE/ TI= 88.1/ 4.12/ 650 ms, in-plane resolution= 0.9x 0.9, matrix size= 256x 256, FOV= 230x 230 mm, 128 axial slices).

Preprocessing and statistical analysis of MR images are performed by the SPM2 (Statistical Parametric Mapping, Wellcome Department of Cognitive Neurology, London, UK). A voxel-by-voxel comparison according to the general linear model is used to calculate differences of activation between the experimental and control conditions. The model consisted of a boxcar function convolved with the hemodynamic response function (hrf) and the corresponding temporal derivative. For group analysis, the contrast images of single subject for each experimental condition against control condition are entered into a random effect model. The resulting contrast images are taken to the second-level analysis. A 2(demand)x2(relevancy)x3(group) ANOVA model is used to test the effect of sensorimotor adaptation. The threshold of the t-statistic is set to FWE $p < 0.05$, with spatial extent threshold at 10 voxels.

結果與討論

The results of the main effect of the three factors, i.e. demand, relevancy and group, were listed in Table 1. The activation foci of effect of those three factors were shown in Table 2-3. For the effect of demand, significantly higher activation in left primary somatosensory cortex (BA2), secondary motor cortex (BA6) and right posterior cerebellum when active discrimination was needed. This finding not only validates the experimental manipulation for tactile discrimination and supports the notion that cerebellum plays an important role for sensory discrimination. For the effect of relevancy, parahippocampal gyrus yielded significantly higher action when only relevant information was presented than when the irrelevant visual information was added. The role of parahippocampal gyrus for the relevant condition is not immediately clear.

It has been reported that parahippocampal gyrus is involved in support of episodic memory and in processing the spatial content of sensory information (Eichenbaum & Lipton, 2008). It is speculated that the differential activation in parahippocampal gyrus might be related to the memorization of task instruction or to the activation suppression by the task-irrelevant visual information.

As far as the group effect is concerned, significantly higher activations in higher order motor (BA6) and visual (BA19) cortex were found in archer group than in runner group and stronger activations in primary motor and somatosensory cortex were shown in archer group than in runner group. In contrast, it was found that the somatosensory associative cortex (BA7) and the cerebellum yielded significantly higher activations in both runners and novices than in archers. Therefore, the present findings suggest through the process of the sports training, the expert brain adapts itself to shift the effort from the cerebellum to cortical sensorimotor areas.

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Table 1: Main effect

Cortical region	Hemisphere	BA	Talairach Coordinates	Cluster-level Extent	Z
Main effect of group					
Precuneus	L	7	-10 -52 44	3739	Inf
Precuneus	L	19	-28 -78 42	274	6.91
Medial Frontal Gyrus_SMA	L	6	-12 2 66	81	6.34
Inferior Parietal Lobule	L	40	-38 -32 42	979	6.32
Middle Occipital Gyrus	L	18	-28 -92 -2	107	5.17
Inferior Parietal Lobule	R	40	40 -52 50	83	5.04
Medial Frontal Gyrus, SMA	L	6	-6 -16 58	21	4.99
Middle Frontal Gyrus	R	6	36 2 56	14	4.93
Lingual Gyrus	R	18	12 -82 -16	34	4.85
Superior Parietal Lobule	L	7	-40 -64 52	12	4.78
Cerebellum, Posterior lobe, Declive	L		-6 -76 -20	14	4.76
Inferior Frontal Gyrus	R	44	50 -2 20	16	4.68
Main Effect of Demand					
Postcentral Gyrus	L	2	-64 -22 30	18	4.83
Cerebellum, Posterior Lobe, Declive	R		4 -66 -30	46	4.77
Thalamus	L		-12 -22 -2	23	4.76
Main effect of relevancy					
Parahippocampal Gyrus	R	30	24 -56 2	11	4.51

Table 2 Effect of demand and relevancy

Cortical region	Hemisphere	BA	Talairach Coordinates	Cluster-level Extent	Z
Effect of demand (Active >Passive)					
Postcentral Gyrus	L	2	-64 -22 30	29	4.97
Cerebellum, Posterior Lobe, Declive	R		4 -66 -30	90	4.90
Thalamus	L		-12 -22 -2	43	4.90
Middle Frontal Gyrus	L	6	-28 -8 50	13	4.44
Effect of relevancy (Relevant >Irrelevant)					
Parahippocampal Gyrus	R	30	24 -56 2	11	4.51

Table 3 Effect of group

Cortical region	Hemisphere	BA	Talairach Coordinates	Cluster-level Extent	Z
Archery >Track					
Insula	R	13	34 22 10	158	6.73
Precuneus	L	19	-30 -78 42	72	6.07
Medial Frontal Gyrus, SMA	L	6	-8 -14 58	10	4.79
Archery > Control					
Precentral Gyrus	L	4	-20 -28 60	266	6.85
Postcentral Gyrus	R	2	52 -32 38	501	6.52
Superior Frontal Gyrus	R	10	32 54 18	15	4.96
Track>Archery					
Precuneus	L	7	-10 -52 44	4372	Inf
Cerebellum, Posterior Lobe, Declive	R		22 -64 -22	370	5.83
Cerebellum, Anterior Lobe, Culmen	L		-20 -50 -24	340	5.72
Middle Frontal Gyrus	R	6	36 2 56	46	5.36
Postcentral Gyrus	L	43	-64 -10 16	21	4.83
Cerebellum, Posterior Lobe, Declive	L		-4 -74 -18	27	4.74
Medial Frontal Gyrus	L	10	-4 60 14	29	4.72
Control >Archery					
Cerebellum, Anterior Lobe, Culmen	L		-16 -52 -20	848	7.43
Medial Frontal Gyrus	L	6	-12 2 66	115	6.54
Fusiform Gyrus	L	19	-40 -80 -18	815	6.06
Cerebellum, Posterior Lobe, Declive	R		22 -64 -22	204	5.72
Insula	R	13	42 -20 0	38	5.21
Precuneus	L	7	-8 -52 46	49	5.18
Cuneus	R	18	4 -88 22	25	5.09

國科會補助

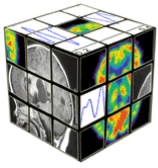
出席國際學術會議心得報告

日期：101 年 7 月 31 日

計畫編號	NSC 100-2314-B-028-002		
計畫名稱	觸知覺之大小腦神經互動機制-以射箭選手的感覺運動適應為例		
出國人員姓名	石佑翎	服務機構及職稱	國立臺灣體育運動大學競技運動學系 助理教授
會議時間	101 年 3 月 31 日 至 101 年 4 月 3 日	會議地點	芝加哥
會議名稱	(中文) 2012 年認知神經科學年會 (英文) CNS 2012 Annual Meeting		
發表論文題目	(中文) 排球選手之視聽時間知覺敏感度研究 (英文) Examining the Effect of Sound on the Sensitivity of Visual Time Perception in Volleyball Athletes		

與會心得：

如同每次參加國際研討會一樣，藉此可與相關領域之學者交流對研究的想法，也可尋找是否有跨國研究的可能性。不同以往，此次與會另一個主要的目的為訓練及培養研究生之國際研究視野，藉以提升未來國內優秀年輕研究者之研究潛能，而這可視為此次與會之最大收穫。



February 23, 2012

To Whom It May Concern:

This letter is to confirm that Yu-Ling Shih, Assistant Professor at the National Taiwan University of Physical Education and Sport, has a paper entitled “Examining the Effect of Sound on the Sensitivity of Visual Time Perception in Volleyball Athletes” that has been accepted for presentation at the 19th Annual Meeting for the Cognitive Neuroscience Society at the Palmer House Hilton Hotel, in Chicago, IL USA, March 31 – April 3, 2012.

This is an official letter of invitation for Yu-Ling Shih to present Poster H66, Tuesday, April 3, 8:00 – 10:00 am.

Since its founding in 1994, the Cognitive Neuroscience Society has been dedicated to bringing its 2,000 worldwide members the latest research and dialogues in order to facilitate public, professional and scientific discourse.

Our members, who are engaged in research focused on elucidating the biological underpinnings of mental processes, form a network of scientists and scholars working at the interface of mind, brain and behavior research. The findings of this research are presented at our member-supported annual scientific conference. The three-day program of plenary speakers, symposia, posters and special events covers all aspects of cognitive neuroscience research.

Should you require any further information, do not hesitate to call our office or email me directly at Renee@TaraMillerEvents.com.

Best regards,

Renée Smith, CMP
Registration Manager
CNS 2011 Meeting
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Examining the Effect of Sound on the Sensitivity of Visual Time Perception in Volleyball Athletes

Chiu-Chan Chou and Yu-Ling Shih*

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Introduction

- Auditory dominance of audiovisual time perception may be modulated by long-term training of sport highly emphasizing accurate time perception.
- Although sports like dancing and volleyball both stress accurate time perception for successful performance, the strategies used for time perception may differ.
- Therefore, we hypothesize that volleyball athletes would perform better on visual time perception, and would be affected more by the sound during visual time perception.

Methods

Participants

- Three groups of participants, 20 persons in each group, with different experience of time perception training, namely volleyball, dancing and novice, were recruited in one local university.
- Volleyball and dancing athletes were recruited from the university teams, and they trained more than 5 days per week (volleyball athletes: 5days/week; dancing athletes: 6 days/week) and had trained for more than 8 years (volleyball athletes: 8 years; dancing athletes: 10 years).

Apparatus and Stimuli

- The visual stimuli consisted of gray circles (6.5° of visual angle) presented against a black background, presented on a 19-in LCD monitor (60 Hz refresh rate) and were presented using the E-Prime programming software (E-Prime 1.1, Psychology Software Tools).
- The participants responded using a computer mouse and were instructed to press the left button when the second visual stimulus was “shorter” and the right button when it was “longer” than the first stimulus.

Design

- The effect of sound on the sensitivity of visual time perception was examined by presenting a discrete tone during visual duration judgment.
- Two gray circles were presented consecutively on the monitor with a 1000 ms interstimulus interval (ISI) in the visual duration judgment task.
- The first circle (the standard) was presented for 400 ms, while the second circle (the comparison) was presented for 300, 350, 375, 400, 425, 450 or 500 ms.
- During visual duration judgment, a discrete tone was either not presented or else was presented synchronously at the onset of the standard stimulus.
- There were 140 trials in each condition, and they were divided into ten blocks with self-decided duration of rest period among each experimental block.

Data Analysis

- The average RT and error rate were calculated across all the trials of each condition except the trials with the comparison duration of 400 ms.
- The RT and error rate were analyzed using separate models of analysis of variance (ANOVA) having one factor (sports training) with three levels (volleyball, dance and novice) in order to examine the effects of sports training on the visual time perception.

Results

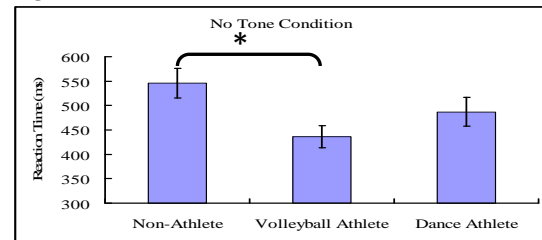
- The results of the measurements were summarized in Table 1.

Table 1 Mean (\pm standard error, S.E.) of the reaction time, error rate.

	Novices	Volleyball Athletes	Dancing Athletes	F values	P values
Reaction Time (ms)					
No Tone	546 (\pm 30)	436 (\pm 23)	487 (\pm 30)	3.89	0.03
Tone	531 (\pm 27)	455 (\pm 24)	482 (\pm 26)	2.31	0.11
Error Rate (%)					
No Tone	31 (\pm 1.6)	28 (\pm 1.3)	30 (\pm 1.1)	1.67	0.20
Tone	31 (\pm 1.3)	26 (\pm 1.1)	32 (\pm 1.7)	6.00	0.004

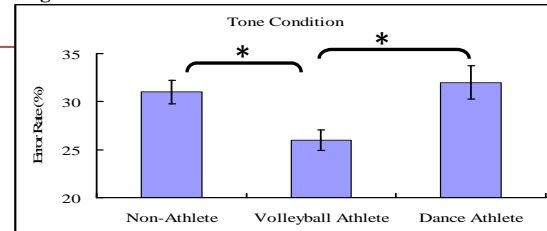
- Analysis of the RT data revealed a significant main effect for the no tone condition ($F(2, 59)=3.89, p=.03$), but not for the tone condition ($F(2, 59)=2.31, p=.11$).
- The RT of volleyball athletes was significantly shorter than that of novices ($p=.01$) whereas no significant differences of RT were found between novices and dancing athletes nor between volleyball and dancing athletes (Figure 1).

Figure 1



- The error rate analysis revealed a significant main effect for the tone condition ($F(2, 59)=6.00, p=.0004$), but not for the no tone condition ($F(2, 59)=1.67, p=.20$).
- The error rate of volleyball athletes was significantly lower than both novices ($p=.004$) and dancing athletes ($p=.004$).
- There were no significant differences of error rate between dancing athletes and novices (Figure 2).

Figure 2



Discussions and Conclusions

- The finding that faster response for visual time perception observed only in volleyball athletes suggests that they benefit more by sport-specific training in perceptual stage of visual information processing (Mann, Williams, Ward, & Janelle, 2007; Zwierko, Osinski, Lubinski, Czepita, & Florkiewicz, 2010).
- The sound facilitation effect, i.e. volleyball athletes perceive visual time more accurately by the presence of a tone, may result from the perceptual strategies developed from volleyball skill training (Kioumourtoglou, Kourtessis, Michalopoulou, & Derri, 1998; Kioumourtoglou, Michalopoulou, Tzetzis, & Kourtessis, 2000).

Key References

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國科會補助計畫衍生研發成果推廣資料表

日期:2012/08/08

國科會補助計畫	計畫名稱: 觸知覺之大小腦神經互動機制-以射箭選手的感覺運動適應為例
	計畫主持人: 石佑翎
	計畫編號: 100-2314-B-028-002- 學門領域: 復健科
無研發成果推廣資料	

100 年度專題研究計畫研究成果彙整表

計畫主持人：石佑翎		計畫編號：100-2314-B-028-002-					
計畫名稱：觸知覺之大小腦神經互動機制-以射箭選手的感覺運動適應為例							
成果項目		量化			單位	備註（質化說明：如數個計畫共同成果、成果列為該期刊之封面故事...等）	
		實際已達成數（被接受或已發表）	預期總達成數（含實際已達成數）	本計畫實際貢獻百分比			
國內	論文著作	期刊論文	0	0	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%		
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力 （本國籍）	碩士生	1	1	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		
國外	論文著作	期刊論文	0	2	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	0	0	100%		
		專書	0	0	100%	章/本	
	專利	申請中件數	0	0	100%	件	
		已獲得件數	0	0	100%		
	技術移轉	件數	0	0	100%	件	
		權利金	0	0	100%	千元	
	參與計畫人力 （外國籍）	碩士生	0	0	100%	人次	
		博士生	0	0	100%		
		博士後研究員	0	0	100%		
		專任助理	0	0	100%		

<p>其他成果 (無法以量化表達之成果如辦理學術活動、獲得獎項、重要國際合作、研究成果國際影響力及其他協助產業技術發展之具體效益事項等，請以文字敘述填列。)</p>	<p>無</p>
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	成果項目	量化	名稱或內容性質簡述
科 教 處 計 畫 加 填 項 目	測驗工具(含質性與量性)	0	
	課程/模組	0	
	電腦及網路系統或工具	0	
	教材	0	
	舉辦之活動/競賽	0	
	研討會/工作坊	0	
	電子報、網站	0	
	計畫成果推廣之參與(閱聽)人數	0	

國科會補助專題研究計畫成果報告自評表

請就研究內容與原計畫相符程度、達成預期目標情況、研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）、是否適合在學術期刊發表或申請專利、主要發現或其他有關價值等，作一綜合評估。

1. 請就研究內容與原計畫相符程度、達成預期目標情況作一綜合評估

達成目標

未達成目標（請說明，以 100 字為限）

實驗失敗

因故實驗中斷

其他原因

說明：

2. 研究成果在學術期刊發表或申請專利等情形：

論文： 已發表 未發表之文稿 撰寫中 無

專利： 已獲得 申請中 無

技轉： 已技轉 洽談中 無

其他：（以 100 字為限）

3. 請依學術成就、技術創新、社會影響等方面，評估研究成果之學術或應用價值（簡要敘述成果所代表之意義、價值、影響或進一步發展之可能性）（以 500 字為限）

由本研究之結果可得知，即使是長期接受運動訓練的運動選手，由於專項運動的特性不同，其對大腦可塑性的調控也有極大的差異。射箭選手在執行觸覺作業時，小腦的活化區域較少，但是小腦的節省伴隨著大腦區域活化的增加。此一結果可作為小腦感覺獲得與動作學習理論的支持證據。