行政院國家科學委員會專題研究計畫 期末報告

音符認讀過程中之音高與時長處理：事件誘發電位研究

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執 行 單 位 ： 中山醫學大學心理學系（所）（臨床組）

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中 華 民 國 101 年 11 月 22 日

中 文 摘 要 ： 為了研究音符認讀過程中音高與時長的處理關係，本研究要求 20 位非音樂家參加一個以音符刺激材料的類 Stroop 作業。此作業先呈現一個刺探物(probe)，它含有特定的音高及節拍訊息，然後再呈現目標物，目標物會以不同的顏色呈現，以表示此時需判斷的向度是音高或是節拍。參與者必須判斷目標物的內容是否與刺探物所指相同。本研究操弄目標物的不相關向度的相容性來探討不干擾向度的訊息(音高或時長)是否會影響目標向度的訊息(時長或音高)判斷，結果發現無論是反應時間或是錯誤個數都反映出不相關向度對相關向度的干擾效果。因此，單音符中音高與時長的訊息的處理具交互作用。

中文關鍵詞： Stroop 作業，交互作用，音高，時長，事件誘發電位

英 文 摘 要 ： To study the relation of pitch and duration processing in reading musical notation, a Stroop-like task was used by 20 nonmusicians. A probe display was presented before each target note. Participants were required to process the tonal and metric information of the probe and then to make a match or mismatch decision between probe and target. The target’s color informed participant which dimension (pitch or duration) required analysis. The congruity of the irrelevant dimension of the target was manipulated to examine the effect on the relevant dimension. The interference effect of the irrelevant dimension on the relevant dimension was obvious for number of errors and reaction times. This result was consistent with pitch and duration being processed interdependently and reconciled with the theory of dynamic attention.

英文關鍵詞： Stroop task, interaction effect, pitch, duration, ERP

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

音符認讀過程中之音高與時長處理

計畫類別：■ 個別型計畫　　□ 整合型計畫
計畫編號：NSC 100－2410－H－040－002－
執行期間：100 年 08 月 01 日至 101 年 010 月 31 日

計畫主持人：李宏鎰
共同主持人：(無)
計畫參與人員：鄭曼辰、李逑富、吳子丰

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■涉及專利或其他智慧財產權，■一年□二年後可公開查詢

執行單位：中山醫學大學心理系

中　華　民　國　一百零一　年　十一　月　十　日

音符認讀過程中之音高與時長處理

摘要

為了研究音符認讀過程中音高與時長的處理關係，本研究要求 20 位非音樂家參加一個以音符刺激材料的類 Stroop 作業。此作業先呈現一個刺探物(probe)，它含有特定的音高及節拍訊息，然後再呈現目標物，目標物會以不同的顏色呈現，以表示此時需判斷的向度是音高或是節拍。參與者必須判斷目標物的內容是否與刺探物所指相同。本研究操弄目標物的不相關向度的相容性來探討不干擾向度的訊息(音高或時長)是否會影響目標向度的訊息(時長或音高)判斷，結果發現無論是反應時間或是錯誤個數都反映出不相關向度對相關向度的干擾效果。因此，單音符中音高與時長的訊息的處理具交互作用。

關鍵詞：Stroop 作業，交互作用，音高，時長，事件誘發電位

INTERACTION OF PITCH AND DURATION PROCESSING BY NONMUSICIANS IN READING MUSIC NOTATION

Abstract

To study the relation of pitch and duration processing in reading musical notation, a Stroop-like task was used by 20 nonmusicians. A probe display was presented before each target note. Participants were required to process the tonal and metric information of the probe and then to make a match or mismatch decision between probe and target. The target's color informed participant which dimension (pitch or duration) required analysis. The congruity of the irrelevant dimension of the target was manipulated to examine the effect on the relevant dimension. The interference effect of the irrelevant dimension on the relevant dimension was obvious for number of errors and reaction times. This result was consistent with pitch and duration being processed interdependently and reconciled with the theory of dynamic attention.

KEYWORD: Stroop task, interaction effect, pitch, duration, ERP

INTRODUCTION

The music notation conveys information on pitch and timing as well as the structure of the music. In standard Western musical notation, the pitch information is expressed by the specific vertical position of a note on a staff position (a line or a space), a higher position indicating a higher pitch. The timing information of a note is expressed by the form of the note, depending on the flag, the stem, the head, and the dot after the note. Thus, in the visual modality, pitch and timing information are represented separately by different attributes. In this paper, the pitch and duration processing for reading musical notation were explored. The related literatures in the auditory domain were not discussed completely.

PURPOSE

In the present study nonmusicians were required to do a Stroop-like task similar to the one adopted by Schön & Besson(2002), in which variability on the irrelevant dimension was manipulated to examine the effect on the relevant dimension, to explore the relation of pitch and duration processing of single notation.

REVIEW OF DOCUMENTS

The neuropsychological literature contains many findings that support the independent processing of information about pitch and timing in music reading. For example, some patients, who had experienced damage to the left angular gyrus, had difficulty in reading rhythm but pitch-reading is preserved (Assal, 1973; Midorikawa, Kawamura, & Kezuka, 2003), while other patients with occipital damage had difficulty in pitch reading but not in rhythm reading (Brust, 1980; Fasanaro, Spitaleri, Valiani, & Grossi, 1990; Horikoshi, Asari, Watanabe, Nagaseki, Nukui, Sasaki, et al., 1997).

Using a group of young musicians as participants, Schön and Besson (2002) combined judgments of pitch and duration in a single-note reading task which was a Stroop-like paradigm. A probe display was presented before each target note. The participants were required to process the tonal and metric information of the probe, and then made decision for a match or a mismatch between the probe and target note. Researchers found that neither reaction time nor event-related potential (ERP) data showed an interference effect of the irrelevant dimension on the relevant, suggesting that pitch and duration may be processed independently. Recent research using functional magnetic resonance imaging (fMRI) with professional pianists playing notes has shown that processing of melody uses the dorsal visual stream, whereas processing of rhythm uses the ventral visual stream. This result may suggest dissociation between pitch and time processing in music reading (Bengtsson & Ullén, 2006). Thus, there seems to be, at least in the visual modality, agreement that pitch and rhythm processing are independent and use different cognitive capabilities. Pitch processing relies on visual spatial ability, whereas rhythm processing relies on object recognition.

However, some findings still suggest the possibility of an interaction between pitch and time processing in the visual modality. For example, MacKenzie, Vaneerd, Graham, Huron, and Wills (1986) showed that when skilled pianists sight read short segments of music, the pitch structure of a segment of music affected the rhythmic production of that music, indicating an interaction between pitch and time processing. Waters and Underwood (1999) regarded that, when performing a written recall task, pitch and rhythmic auditory distractors disrupted the recall of pitch, but rhythmic auditory distractors had no disrupting effect on the recall of time. These results suggest that, at least the pitch processing cannot occur independently from the time processing. In fact, the partial results of Schön and Besson (2002) still supported that pitch and duration information of single notes were processed interdependently. In their results, RTs to targets, which relevant dimension were incongruous, were faster when the irrelevant dimension of targets were also incongruous than when they were congruous. As yet, previous results have not settled the question of whether an interactive or independent relation of pitch and duration processing. In particular, there are still few empirical studies of music reading in the visual modality, and more evidence is needed. Additionally, Pitt and Monahan (1987) proposed that pitch and time may be processed independently at the early stages of information processing (such as perceptual judgments of pitch height or tempo), and then be integrated at later stages of processing (such as melodic completion or rhythmic similarity). However, it is still not entirely clear the percept is integrated at what stage in information processing. Most of the above mentioned studies concerned relatively late stages of processing and attended to global level of analysis of musical events. The present study concerned with processing mechanism at the earlier stages of music reading. The single note-reading task, which did not involve complex perceptual and expressive requirements, was used to explore pitch-time interaction at the visual perception stage of single notation.

On the other hand, Prince (2011) had revealed that musical training was not associated with any qualitative differences in the pattern of pitch-time integration at least in the auditory domain. Therefore, in the present study nonmusicians were required to do a Stroop-like task similar to the one adopted by Schön & Besson(2002), in which variability on the irrelevant dimension was manipulated to examine the effect on the relevant dimension, to explore the relation of pitch and duration processing of single notation. If pitch and duration are processed dependently, results should show the interference effect. That is, reaction times (RTs) or number of errors should be larger when the irrelevant dimension is incongruous with the relevant dimension than when the irrelevant dimension is congruous when the relevant dimension, as demonstrated in Stroop-like paradigm (MacLeod, 1991, for a review).

METHOD

Participants

University students (N = 24; 13 men and 11 women) whose mean age was 20.0 yr. (SD = 1.0) participated. Four male participants whose correct rate were below 70% were excluded. Thus, data were available from 9 men and 11 women (N = 20). All of the participants took an introductory psychology course and were motivated to participate in the experiment as partial fulfillment of a course requirement at Chung Shan Medical University in Taiwan. They were currently majoring in subjects other than music, and had never received any formal musical training, but had acquired a basic knowledge of Western music notation from music classes during their elementary and high school years in Taiwan. Their self-reported vision was normal or normal after correction.

Stimuli

Visual stimuli were presented at the center of a computer screen (17-in. NEC SVGA color monitor). Each trial began with a fixation cross presented for 200 msec, followed by a probe display for 500 msec. The probe comprised a solmization syllable (Do, Re, Mi, Fa, Sol, La, or Si) and a note value [(半拍 (1/2 beat), 一拍 (1 beat), 一拍半 (3/2 beat), 二拍 (2 beats), 三拍 (3 beats), or 四拍 (4 beats)] written in Chinese characters (see Fig. 1). After the presentation of a probe, the screen was blank for 1,000 msec. before a target display appeared for 1000 msec. The target display was a note in different vertical positions included from the line below the staff to the third line of the staff, and with different time values (i.e. eighth note, quarter note, dotted quarter note, half note, dotted half note, or whole note). A total of 82 target stimuli were composed (7 pitches × 6 duration × 2 colors). The solfage name and time value of a target note was defined by C major and 4/4 time, respectively, because this is the simplest context and suits nonmusicians. By presenting the probe, which supply the message of pitch and duration, participants were required to build a representation of both pitch and duration dimensions of the target note, and then they were required to judge only one dimension (pitch or duration) of the target note, that is, to make a decision to match or mismatch probe and the relevant dimension of target. The keyboard was pressed to indicate match (the "Z" key) or mismatch ("M"). The association between decisions and response keys was also counterbalanced across participants. After the presentation of a target, the screen was blank for 1,500 msec. and then a masking display (XXX) followed for 2000 msec.

In each task, four conditions were created according to the relation of probe and target (see Fig. 2): The target either matched the probe in both pitch and duration (Match condition) or differed from probe in pitch (Duration condition), duration (Pitch condition), both pitch and duration (Mismatch condition). Both match and mismatch conditions were further classified into the consistent condition, in which the irrelevant dimension relative to the relevant dimension was congruent. Both duration and pitch conditions were classified as the inconsistent condition, in which the irrelevant dimension relative to the relevant dimension was incongruent. If the interference effect occurs, then RTs and number of errors should be smaller in the consistent condition than that in the inconsistent condition.

The experiment was divided into pitch and duration tasks with different color (red or green) targets. According to the color of the target, participants were required to perform the pitch task or the duration task. This association between color and task was counterbalanced across participants. All participants performed 336 trials, a mixture of half pitch and half duration tasks. Pitch and duration tasks were presented in a random order. After 21 trials a short break was allowed.

E-Prime (Psychology Software Tools, Pittsburgh, PA) was used to control stimulus presentation and to record the behavioral responses. The data was analyzed using SPSS 13.0 to compute descriptive statistics and inferential statistics (two-way ANOVA).

insert Fig. 1 about here

Design

A within participants (2 × 2) design was chosen. The independent variable was the task (pitch vs duration) and the consistency (consistent vs inconsistent), whereas the dependent variables were mean reaction time and number of errors.

Procedure

Each participant was seated 50 cm from the computer monitor. All participants were asked to respond as soon as possible on each of 40 practice trials for each task to be familiar with the task before beginning the formal experiment. All participants performed the pitch and duration tasks in a random order.

insert Fig. 2 about here

RESULTS

Table 1 and Figure 3 showed the results. For RTs, a two-way repeated measure ANOVA (task × consistency) was conducted. There was no significant main effect of task ($F_{(1,19)}$ = 1.57, MSE = 7727.36, p = .23, η^2 = 0.08), but a main effect of consistency ($F_{(1, 19)}$ = 11.33, MSE = 15925.96, p < .01; η^2 = 0.37). That is, RTs were slower in the inconsistent condition (Fig. 3a). There was no significant interaction task and consistency ($F_{(1,19)}$ = 0.50, MSE = 642.70, p = .48; η^2 = 0.03).

For the mean number errors, a two-way repeated measure ANOVA was performed again. There was no significant main effect of task ($F_{(1,19)}$ = 3.30, MSE = 96.80, p = .08, η^2=0.15), that is, the mean number errors in the pitch and duration tasks were not significantly different. However, there was a significant main effect of consistency ($F_{(1, 19)}$ = 24.99, MSE = 2599.20, p < .001; η^2=0.57). There was no significant interaction of task and consistency (F = 0). The result showed that mean number errors were higher in the inconsistent condition (Fig. 3b).

insert Table 1 about here

insert Fig. 3 about here

DISCUSSION

In the present study, all of results showed that there were significant effects of consistency, that is, participants performed worse when congruity on the relevant dimension was not consistent with congruity on the irrelevant dimension. Thus, the irrelevant dimension had an impact on the relevant one. This suggested that pitch and duration information are processed interdependently, that contradicted the suggestions of Schön and Besson (2002).

In the auditory domain, in order to reconcile those divergent results involved independence versus interactive processing between pitch and duration dimension, Jones and colleagues had proposed the dynamic attending theory, which argued that both pitch and temporal patterning of a sequence drive listeners’ attention by producing dynamic expectancies for subsequent events in both dimensions (Jones, Moynihan, MacKenzie, & Puente, 2002; Jones, Johnston, & Puente, 2006). Such a model is built upon the notion that pith and time have an interactive relation, with attending one dimension affecting judgments on the other dimension. However, an asymmetric interaction between pitch and time was found in some studies (Jones et al., 2002; Prince, Thompson, & Schmuckler, 2009; Prince, Schmuckler, and Thompson, 2009). Prince (2011) proposed that if one dimension is more salient than another, asymmetric interactions occur, whereas if dimensions are equally salient, a more global interactions occur. That is, the relation between pitch and time were mostly independent when presented with a task that requires selective attention to one dimension in the stimulus, but more interactive when evaluating both dimensions (Prince, 2011).

In the present study, the probe drove participants to place equal attention on pitch and time dimension, and then found that pitch information influenced recognition of the time value in reading single musical notes (vice versa), which provided evidence for the dynamic attending theory. In the same way, the interference effect found in the results of Schön and Besson (2002) could also be reconciled with the theory of dynamic attention.

From another point of view, the source of the asymmetry is entirely experience-dependent in Stroop paradigm. That is, word naming is faster and interferes with color naming but not vice versa due to greater practice in the word naming than color naming (MacLeod, 1991, p. 182). Lovett (2005) suggested that task effectiveness mediates the effects of practice. Only when competing processes differ in task effectiveness, a distinct consequence occurs. The efficiency of color naming lowers than word reading in the standard Stroop task. Thus, the asymmetry was not observed in the present study duo to the equal processing efficiency of pitch and time task for nonmusicians. RTs and errors results showed no difference between pitch and duration processing for nonmusicians, which supported this viewpoint.

Finally, the present study adopted the naming paradigm in which the target stimulus was a single note, and still found the pitch-time interaction. It suggested that this interaction could occur at visual perceptual stage in music reading, in which features are extracted and recognized before organizing notes into melody.

Limitation

The present participants were nonmusicians who were different from those in many relevant studies (e.g., Bengtsson & Ullén, 2006; Schön & Besson, 2002; Waters & Underwood, 1999), Although, in the auditory domain, no significant qualitative differences in the pattern of pitch–time integration between musicians and nonmusicians were reported in several researches (Lebrun-Guillaud & Tillman, 2007; Prince, 2011; Tillman & Lebrun-Guillaud, 2006). However, Lee and Lei (2012) found that musicians might spend less resource on executing spatial attention than non-musicians do during pitch processing of note-reading. Wong and Gauthier (2010) found activity in the superior temporal sulcus (STS) when music-reading experts read musical notes. The STS is a key brain area for multisensory integration. Thus, music-reading training resulted in notes becoming multisensory objects and the auditory meaning of notes becoming easily accessed from visual presentation alone (Wong & Gauthier, 2010). It is still possible that the pattern of pitch-time relation varied with musical training in the visual domain. Future research could directly compare the music-reading performance of musicians and nonmusicians to examine the expertise effect on the interaction between pitch and time processing.

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Fig. 1. An example of a trial sequence in the pitch task or duration task which depends on the color of target notation.

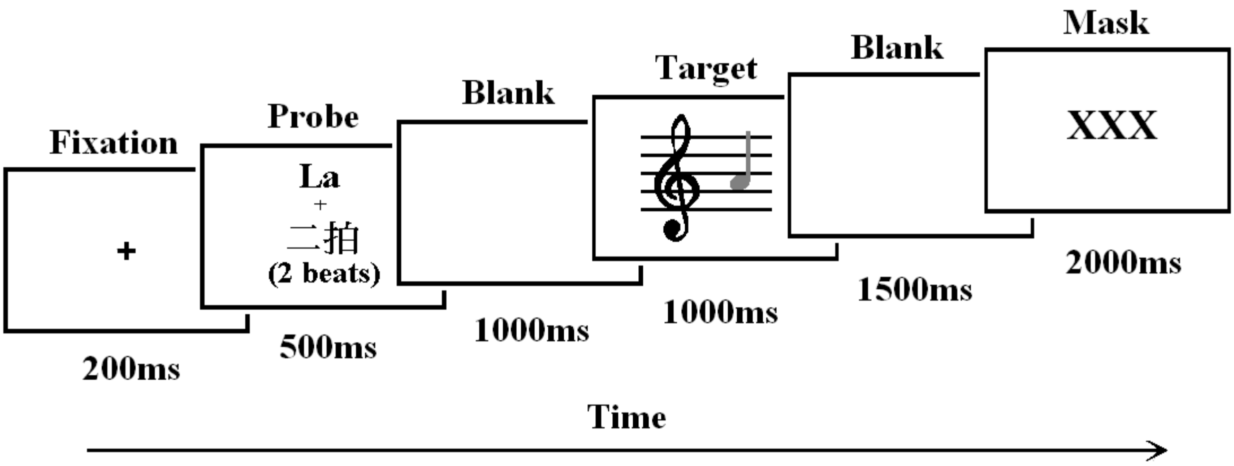


Fig. 2. Examples of the four experimental conditions. The probe display indicated the solfage name "La" and time value "2 beats". (1) The target note (a half note on the second space of the staff) matched with the pitch and duration information indicated by the probe. This was the match condition. (2) In the pitch condition, the target note was a quarter note on the second space that matched with the pitch indicated by the probe, but not with duration. (3) In the duration condition, the target note was a half note on the third line that matched with the duration indicated by the probe, but not with pitch. (4) In the mismatch condition, the target note was a quarter note on the third line that mismatched with the duration and pitch indicated by the probe.

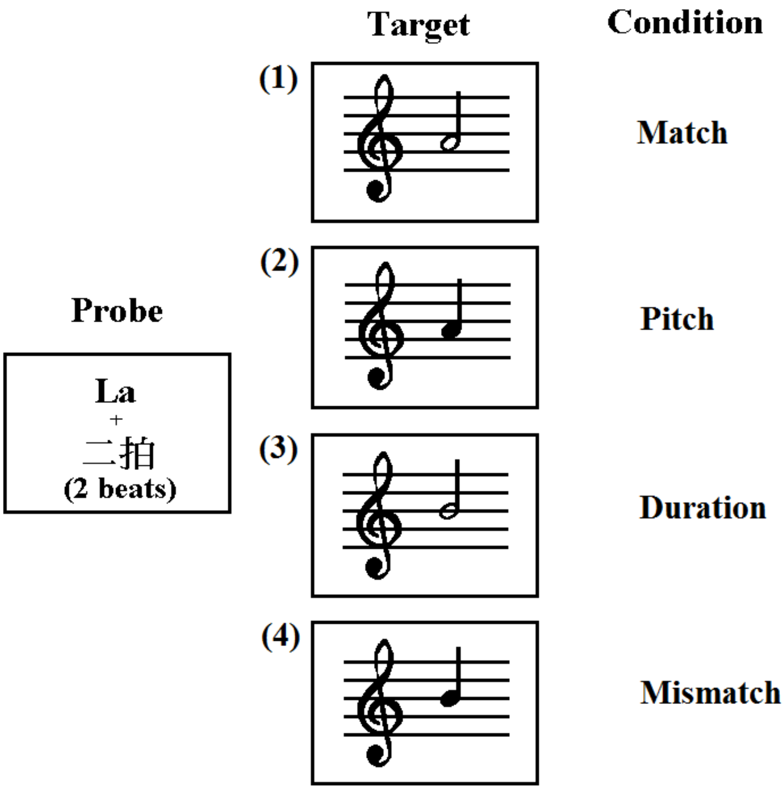


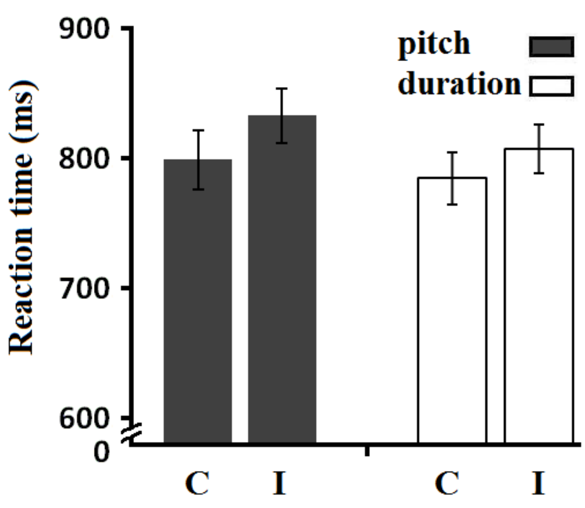
TABLE 1

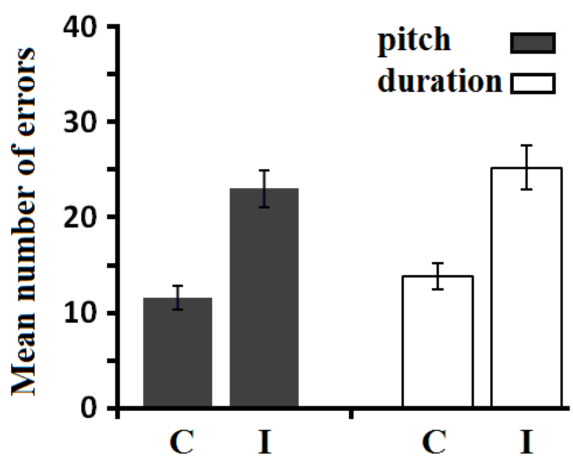
MEANS AND STANDARD DEVIATIONS OF REACTION TIMES (RT) AND NUMBER OF ERRORS FOR PITCH AND DURATION TASKS

	Consistent	Inconsistent
RT (msec.)		
Pitch	798.9(99.9)	832.8(92.4) *
Duration	785.0(89.8)	807.5(84.5)*
Error (No.)†		
Pitch	11.6(5.7)	23.0(8.5)*
Duration	13.8(6.0)	25.2(10.4)*

NOTE: *$p < .01$; †A total of 168 trials were presented in each condition, with 84 trials in the pitch and 84 trials in the duration task.

Fig. 3. The average RT (1) and mean number of errors (2) plus/minus one standard error for the two conditions in each task. (C = consistent; I = inconsistent)





成果補充

本研究首先提出 ERP 的證據。如下圖 a，當相關向度一致的情況下，不相關向度的相容與否造成很大腦波差異。當相關向度不一致的情況下，不相關向度的相容與否所造成腦波差異較不明顯(如圖 b 所示)。限於研究成果的篇幅，腦波部分的成果將另外整理發表。

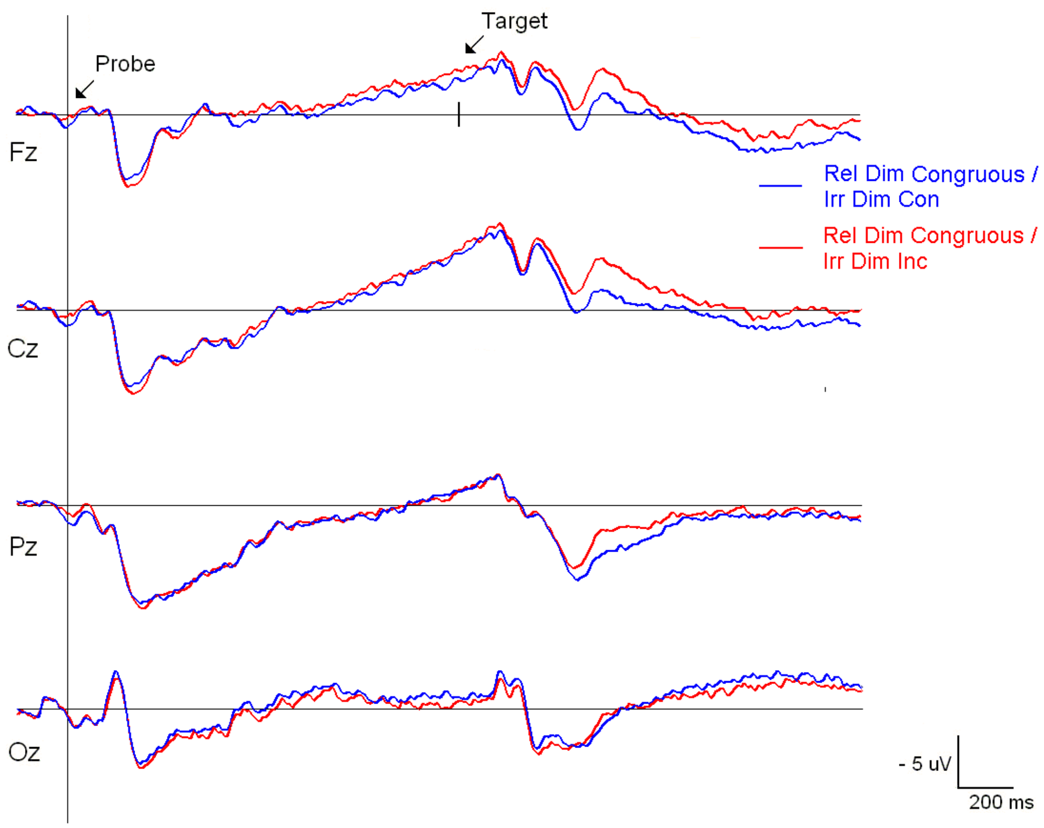


圖 a　當相關向度一致的情況下，不相關向度的相容與否造成很大腦波差異。

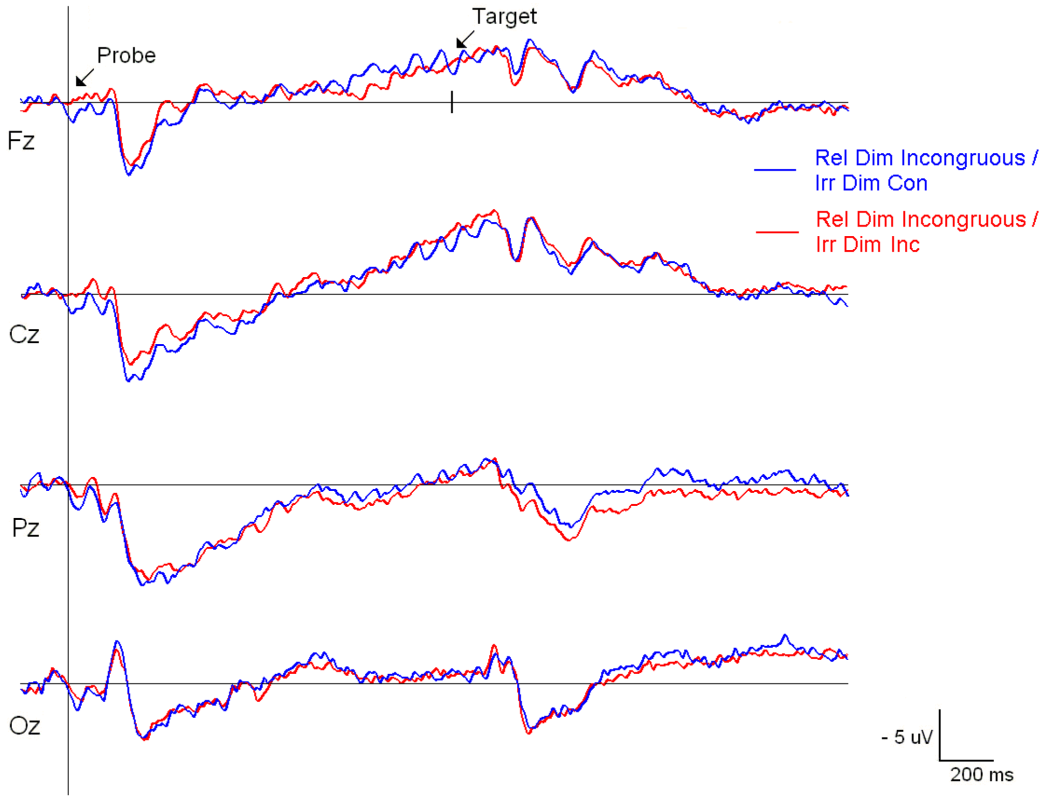


圖 b　當相關向度不一致的情況下，不相關向度的相容與否所造成腦波差異較不明顯。

國科會補助專題研究計畫出席國際學術會議心得報告

日期：101 年 11 月 13 日

計畫編號	NSC100－2410－H－040－002－		
計畫名稱	**音符認讀過程中之音高與時長處理：事件誘發電位研究**		
出國人員姓名	李宏鎰	服務機構及職稱	中山醫學大學心理系教授兼系主任
會議時間	101 年 7 月 22 日至 101 年 7 月 27 日	會議地點	南非開普敦
會議名稱	(中文)國際心理學會 (英文) International Congress of Psychology		
發表題目	Lee, H. -Y. (2012). The interaction between pitch and duration processing in music notation reading. *Poster presented at 2012 International Congress of Psychology (ICP),* Cape Town, South Africa. 國科會補助：NSC 100-2410-H-040-002-。 Lee, H. -Y. (2012). Exploring the association between visual perception abilities and musical notation reading. *Poster presented at 2012 International Congress of Psychology (ICP),* Cape Town, South Africa. 國科會補助：NSC 98-2410-H-040-001。		

一、參加會議經過

International Congress of Psychology (ICP)是由 International Union of Psychological Science (IUPsyS)贊助並指導的研討會。ICP 的歷史非常悠久，從 1889 年在巴黎舉辦第一屆，往後每隔約 4 年舉辦一次。研討會內容涵蓋心理學各個領域，包括生理、社會、知覺、諮商、臨床等。此研討會邀請超過 100 個演講者，及超過 200 個 symposia。此外，還有多個口頭及海報場次，目不暇給。我個人共待在會場三個天半。參觀我的專長：音樂心理學及過動症的相關研究。

二、與會心得

由於研討會資訊繁多，我挑選與我研究高相關的場次進行瞭解。加拿大的學者 Peretz, Isabelle 獲邀口頭演講題目 The nature of music。在音樂心理學領域，她是相關知名的學者，所以可以講這麼大的題目。首先，她為了一般非音樂研究領域的大部

分學生說明音樂的基本特性，如音樂如同語言是所有人類都擁有的共同特質。在人類發展史上不同的文化下的人們都創作及享受音樂。然而，儘管音樂無所不在，音樂能力很少被當作是生理功能來研究，音樂基本上被視為是文化的產物。在此次演講中，Peretz 提出了許多音樂的生理證據，包括腦側化的情形、音樂天賦的問題、音樂是否具特化性等。將音樂目前研究出來的特質介紹了一遍。最後，Peretz 認為音樂的研究應該包括基因、發展及跨文化比較等的研究，甚至音樂學(musicology)。

聽完之後，覺得個人目前的研究方向亦在 Peretz 所建議的軸線上。最近，個人發表的一篇論文(Musical training effect on reading musical notation: evidence from event-related potentials. *Perceptual and Motor Skill*, *115(1)*, 7-17.)正是提出閱譜的生理證據，而且獲得很大的回響。法國知名學者 Besson 特別撰寫文章(MUSIC READING AS A CROSS-MODAL PROCESS: MORE TO EXPLORE)評論我的論文。希望國內更多人投入這部分的研究。

三、發表論文全文或摘要

THE INTERACTION BETWEEN PITCH AND DURATION PROCESSING IN MUSIC NOTATION READING

HORNG-YIH LEE
School of Psychology, Chung Shan Medical University
Department of Psychiatry, Chung Shan Medical University Hospital

Abstract
The aim of the present study was to study the relationship between pitch and duration processing in reading musical notation. This paper used Stroop-like task to demonstrate the effect. A probe display was presented before each target note. The participants were required to process the tonal and metrical information of the probe, and then made a match or mismatch decision between probe and target. The color of target informed participant which dimension (pitch or duration) need be analyzed. The congruity of the irrelevant dimension of target was manipulated to examine the effect on the relevant dimension. 20 university students, non-musicians, participated in the experiment and demonstrated the obvious interference effect of the irrelevant dimension on the relevant dimension for Error-counts results. These results supported that pitch and duration processed interdependently.

EXPLORING THE ASSOCIATION BETWEEN VISUAL PERCEPTION ABILITIES AND READING OF MUSICAL NOTATION

HORNG-YIH LEE
School of Psychology, Chung Shan Medical University
Department of Psychiatry, Chung Shan Medical University Hospital

Abstract

In the reading of music, the acquisition of pitch information depends primarily upon the spatial position of notes as well as upon an individual's spatial processing ability. This study investigated the relationship between the ability to read single notes and visual-spatial ability. Participants with high and low single-note reading abilities were differentiated based upon differences in musical notation-reading abilities and their spatial processing; object recognition abilities were then assessed. It was found that the group with lower note-reading abilities made more errors than did the group with a higher note-reading abilities in the mental rotation task. In contrast, there was no apparent significant difference between the two groups in the object recognition task. These results suggest that note-reading may be related to visual spatial processing abilities, and not to an individual's ability with object recognition.

四、建議

希望國科會可以提供充裕的經費給予優秀學者出國發表論文，宣揚國內學者的研究成果。本次或許因為本人申請較晚只獲得機票的補助，不過101學年度的補助就很充裕了。

五、攜回資料名稱及內容

摘要集

六、其他

無

國科會補助計畫衍生研發成果推廣資料表

日期:2012/11/08

國科會補助計畫	計畫名稱: 音符認讀過程中之音高與時長處理:事件誘發電位研究
	計畫主持人: 李宏鎰
	計畫編號: 100-2410-H-040-002- 學門領域: 教育及教學心理學

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：李宏鎰	計畫編號：100-2410-H-040-002-
計畫名稱：音符認讀過程中之音高與時長處理：事件誘發電位研究	

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	1	1	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	2	2	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	1	2	100%	篇	
		研究報告/技術報告	0	0	100%		
		研討會論文	2	2	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%		

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。)	無

	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：

本研究內容完全依照原計畫進行，然而台中教育大學音樂系學生參與研究的意願不高，目前沒有音樂系的資料。由一般大學生所獲得的資料已經整理完成且投稿，目前在二審中。此外，所得閱譜困難者僅 8 人，研究結果可能較不穩定。因此，本人主持之研究室將持續蒐集音樂系及閱譜困難的學生，增加人數，以利統計分析。

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)

由一般大學生所獲得的資料已經整理完成且投稿，目前在二審中。

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）

本研究說明閱譜歷程中音高與節拍的交互作用，發現兩者互相干擾，與最近的研究相符。然而，本研究首先提出支持音高與節拍具交互作用的 ERP 證據，當相關向度一致的情況下，不相關向度的相容與否造成很大腦波差異，此部分具有相當大的學術價值。此外，本研究以一般非音樂家為研究對象，不同於以往以音樂家為對象的研究。創立以非音樂家為對象時，音樂刺激材料的設計典範。以樂音為刺激材料時(聲音領域)，許多研究並沒有發現音樂專家與非音樂專家的音高-節拍交互作用有所不同(Lebrun-Guillaud & Tillman, 2007；Prince, 2011； Tillman & Lebrun-Guillaud, 2006)。然而，在音符閱讀的領域(視覺領域)，Lee 和 Lei (2012) 發現音樂專家花費較少的資源在執行音高閱讀作業上。所以，在音符閱讀時，很有可能音樂專家與非音樂專家的音高-節拍交互作用是有所不同。期待本研究後續相關資料的完成，可進一步了解音樂訓練的成效及閱譜困難者的音高及節拍處理歷程。