DOI: 10.6497/BSEPT2014.1402.05

Bulletin of Sport and Exercise Psychology of Taiwan
Society for Sport and Exercise Psychology of Taiwan
Volume 14, Number 2, pp. 67-81 (2014)
臺灣運動心理學報
臺灣運動心理學會
第 14 卷第 2 期，67-81 頁 (2014)

The variability in the hands of pianists

Shih-Chiung Lai [1] Ru-Lin Lai [2]

[1] Department of Exercise and Health Science, National Taipei University of Nursing and Health Sciences

[2] Department of Music, National Taiwan University of Arts

Abstract

By utilizing the Pullman spiral analysis (Pullman, 1998), the purpose of the study was to examine the degree of severity (DOS), movement smoothness, irregularity, and tightness of highly skilled piano players, using finger tremors as the index of movement variability. Twenty piano major college-aged students (21.75 ± 0.65 years old) with right dominant hands participated in the study. They were asked to hold an electronic pen and draw several spirals in a natural position, with both hands performing the task 10 times. Two-hour-long piano practice sessions with a relatively fast tempo occurred between the pretests and posttests. The before/after piano playing sessions and the right/left hands were used as the two independent variables in the experiment. The major dependent variables included the DOS, movement smoothness, irregularity, and tightness. The two-way repeated measure ANOVA was applied to examine the effect of the piano playing and hands on the dependent variables. The results determined that: (1) No significant DOS differences exist in before/after piano playing, nor in the interchange between right/left hands; and (2) the right hands appear to generate smoother movements than the left hands, $F(1, 19) = 59.68$, $p < .001$, $\eta^2 = .76$. However, the left hands displayed more regular movement features than the right ones, $F(1, 19) = 24.37$, $p < .001$, $\eta^2 = .56$. The conclusion of the study was that, although no apparent practice effect appears in the piano players' hands, their right hands displayed a relatively higher irregularity, but with smoother playing. The pianists' left hands, however, assumingly trained more often in a chord-playing manner, displaying relatively more regularity with less smooth playing. The results of the study are useful in broadening the knowledge and understanding of the prolific perceptions of music, particularly in the arena of piano playing.

Key Words: coordination, perception, motor control, motor performance, tremor

主要聯絡者：賴世烱　國立臺北護理健康大學運動保健系
聯絡地址：112 臺北市北投區明德路 365 號
E-mail：lsc2kpsu@yahoo.com.tw

DOI: 10.6497/BSEPT2014.1402.05

Introduction

Among the human motor functions, finger movement is a basic but simultaneously highly specialized motor skill. Every movement performed by the human hands, from the hierarchical viewpoint of the degrees of freedom (DOF) in neurons, muscles, or joints, proposed by Bernstein (1967), is composed of delicate yet complex mechanisms. In the hand articular DOF alone, for example, apart from the wrist joint, there are five finger knuckles connected to the palm, each palm-knuckle able to move in flexion and extension, as well as abduction and adduction directions. One can thus identify 10 DOFs (5 knuckles $\times$ 2 planes) in the palm-finger joint connection. In addition, there are 9 flexion/extension DOFs from the thumb's one and other 4 fingers' eight knuckles (the thumb has only one finger knuckle, while the index, middle, ring, and little fingers have 2 knuckles, respectively), amounting to 19 DOFs in the joints' aspect in a single hand. This means that the amount of DOFs can equal up to 38 for a normal person controlling or performing a bimanual movement. It is therefore a complex process for the movement of joints, not to mention for the muscles and neurons involved.

The tools and resources available have become rapidly more plentiful due to the work conducted by human hands with five flexible fingers. This specialized biological evolution makes human beings the most dominant species in the planet. Piano playing is a highly specialized skill occurring as a result of the many specific hand movements that exist. In fact, playing a meaningful tune requires fine coordination of the sensory system, motor system, neuron transmitters, and muscle contractions.

Among the classifications of motor skills, piano playing is identified with the fine, serial, and closed motor skill (Magill, 2013). The neurons located in the primary motor cortex play a central role in delicate finger movement of this nature (Schieber & Hibbard, 1993; Kandel, Schwartz, & Jessell, 2000). The supplementary and pre-supplementary motor areas (Karni et al., 1995), in particular, relay impulses to the fingers, conducting the sequential keyboard-pressing actions with various coordinated and precise tempos and strengths. The pianists face a stationary instrument, playing the piano with their hands and occasionally adjusting the tone using the piano pedals with the soles of the feet. The somatic nervous system regulates the control of the spatial position of the extremities. Furthermore, highly skilled pianists do not use their visual faculty; instead, their playing is affected by the proprioceptors (for example, Golgi tendon organ) in the musculoskeletal organs and joint capsules (Gardner, Martin, & Jessell, 2000).

In the case of highly skilled pianists, an automatic movement pattern of piano playing may occur with an internal brain plan before they play a specific set of chords (Rosenbaum, 1991). Although the striking of the piano keys occurs as a series of automated movements, certain movement variability can be undoubtedly observed continuously. From the perspective of the dynamical system, this variability is the cause of the striking movement to possess characteristics of flexibility and adaptation. However, an automated movement should theoretically indicate less variability, which is a similar feature to the so-called stereotyped movements (Newell, Gao, & Sprague, 1995) that relatively show smaller amounts of motion or stiff characteristic. To identify a stereotype as a repetitive movement sequence, more specifically, the movement variability should be low and the movement sequence should be invariant (Newell & Slifkin, 1998).

Dimensionality is one of the measures used to examine the structure of movement variability (Newell, 1996). Based on the idea of dimensionality in different time scales (Mayer-Kress, 1986), scientists have tested the dimensionality of the finger tremor as a function of normal and tardive dyskinetic (TD) groups. Surprisingly, it was found that the dimensionality of the finger tremor is lower in TD groups than in normal groups (Newell et al., 1995; van Emmerik, Sprague, & Newell, 1993). Instead of investigating the dimensionality issue in a system, however, here conjures an interesting question: If relatively lower movement variability can be observed in both the automated and stereotyped movements, could the highly skilled piano striking movements be considered akin to stereotyped ones?

The current study utilizes the Pullman spiral analysis (Pullman, 1998) to focus on a preliminary analysis, and tests the practice effect of a highly skilled piano playing on the degree of severity (DOS) and movement variability of the pianists' hands. In the research arenas of neuroscience and motor disorders, the Pullman spiral analysis is a useful tool for investigating the tremor occurring in Parkinson's disease (PD), the essential tremor (ET), Bradykinesia, and Dystonia (Cohen, Pullman,

DOI: 10.6497/BSEPT2014.1402.05

Jurewicz, Watner, & Louis, 2003; Elble et al., 2006; Louis, Yu, Floyd, Moskowitz, & Pullman, 2006; Saunders-Pullman et al., 2007; Wang et al., 2008). The theory involves measuring the integration of pressure, distance, velocity, and acceleration generated from the spiral-drawing tasks. The hands' stability indices recorded include the DOS, smoothness, irregularity, and movement tightness.

Instead of the usage of traditional variability index (e.g. the standard deviation), the study applied an alternative approach to infer the variability in a system and investigated the relationship between the low variability and the automatic feature of high skill pianists, which is an important variability issue in motor control. The alternative approach, by means of the nonlinear Pullman spiral analysis (Pullman, 1998), was used to investigate the practice effect of high skill pianists on the tremor indices, including the degrees of severity, smoothness, irregularity, and tightness from the spiral drawing tasks.

Although clinical evidence was found and a noteworthy theory established via the Pullman spiral analysis on the neuropathology of the motor disorders mentioned, few studies have been concerned with the possibility that highly skilled movement performers may present relatively lower movement variability (Newell, 1996). Since the practice effect in essence might result in the changes in motor learning and control, the current study focused on highly skilled pianists and investigated their movement variability via the observation of the degree of severity (DOS), movement smoothness, irregularity, and tightness before and after practicing their piano-playing.

Beside the before/after piano playing, the right/left hand is the second independent variable for the consideration of the handedness problem in the current experiment. The major dependent variables include the DOS, movement smoothness, movement irregularity, and movement tightness. Apart from the overall evaluation of a spiral inferred from the DOS, the Pullman spiral analysis also provides three important indices, in which first order smoothness characterizes the movement imperfection (that is, smoothness in a reversed expression), first order zero crossing rate determines the movement irregularity, and tightness measures the spacing between consecutive loops across the spiral (Saunders-Pullman et al., 2007). In sum, the variables mentioned above provide alternative indices to infer movement variability in the area of motor learning and control, rather than using the traditional standard deviation to indicate the variability in a system. But due to a limited length of the text, and to focus on the research topic, this study can only express the general but not very details regarding the algorithms of the indices (see details in Pullman, 1998).

Essentially, the algorithm of the degree of severity (DOS) combines the kinematic and kinetic parameters measured from the spiral-drawing movement on a 6 x 11 Wacom Intuos3 (Model PTZ-631W) graphics tablet. These measurements include the spiral frequency and triaxial dimensions X, Y, and pressure, followed by the simple linear and second-order polynomial regressions relating to the indices of the movement irregularity. The DOS and the related parameters do not only provide useful information regarding motor control in the arms and fingers, but also characterize motor dysfunction in clinical diseases (Saunders-Pullman et al., 2007; Pullman, 1998). The output of the DOS of handwritten spirals is determined according to a clinically relevant score between 0 and 4, where 0-1 = normal; 1-2 = mildly; 2-3 = moderately; and 3-4 = severely abnormal spirals. The equation is denoted as follows (Pullman, 1998, p. 87):

Degree of Severity (DOS) =

$$0.4615 \times I_1 + 0.0544 \times I_5 - 0.2331 \times I_1^{\,2} - 0.0726 \times I_2^{\,2} - 0.001 \times I_5^{\,2} + 0.2539 \times I_1 \times I_2 + 1.3668$$

where I_1 = first order smoothness, I_2 = second order smoothness, and I_5 = second order zero crossing.

When it comes to movement variability, the traditional way to infer was using the indices such as the standard deviation (SD), absolute error (AE), constant error (CE), or variable error (VE). The current study changed the inference method to the indices developed by Pullman (Saunders-Pullman et al., 2007; Pullman, 1998). Scientific research always investigates the unknown from the known. It is rational and worthy to give it shot to study the same subject, i.e. the movement variability in this case, from different research approaches (e.g. the traditional SD or the variability indices derived from Pullman).

Method

Participants

Twenty piano major college-aged students (21.75 ± 0.65 years old) with right dominant hands and normal vision participated in the study. They had over 5 years of experience in piano-playing. The relevant demographic data of the participants included the sex, age, height, weight, and the length and width of their palms. The palm length was measured as the distance from the distal middle finger to the proximal wrist, and the width as the widest horizontal distance with the five fingers extended and pushed together. The distance from the thumb to the little finger was also measured while all five fingers were stretched out as far apart as possible to determine the palm's stretching interval, indicating the maximum distance a hand can stretch when playing. Each of the participants gave informed consent to the experimental procedures, which were approved in compliance with the policy of the university participants' Institutional Review Board. The participants also received gift certificates at the end of the experiment.

Apparatus

The apparatus included the following: (a) A 6 x 11 in. WACOM INTUOS 3 (Model PTZ-631W) graphics tablet, with a sampling frequency of 200 Hz and a resolution of 50 lines per inch; (b) a 13-gram 151 x 13 mm Intuos Pen (Model ZP-130-00DA); (c) a portable personal computer with a 14 in. video monitor (Lenovo X200s); (d) a YAMAHA acoustic piano (#2, YAMAHA); and (e) Matlab version 6.5 (Mathworks, Inc., Natick, MA). The pixels on the monitor were set at 1280 x 800 pixels. The image of the apparatus setup is shown in Figure 1.

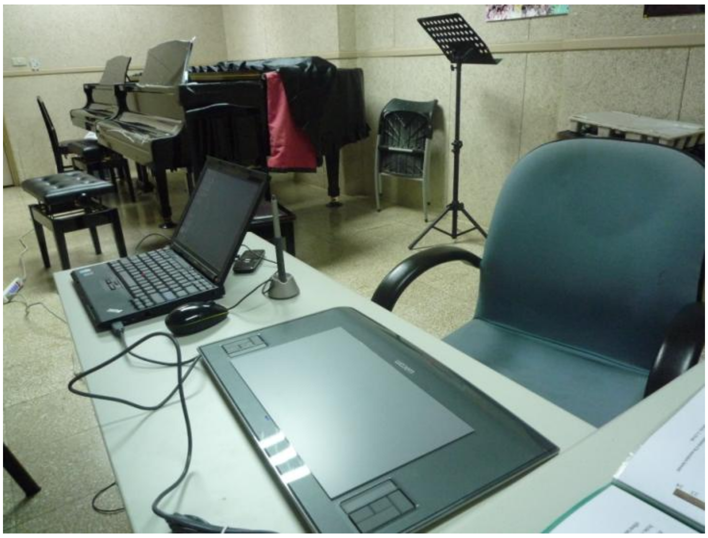

Figure 1. The setup of apparatus used in the experiment.

Procedures

Prior to the experiment, the participants were required not to play the piano for at least eight hours before the experiment. During the experiment, each participant sat on a chair of standard height, approximately 40 cm away from the graphics tablet. They were asked to hold an electronic pen and draw several spirals in a natural position under the dimension of 10 x 10 cm square size, both hands performing the task 10 times. Since the spiral-drawing task is a one-draw task (no need to tracking any target), the participants were simply drawing several spirals in a comfortable way without other restrictions. Figure 2 illustrated three example pictures of spiral loops from a single participant.

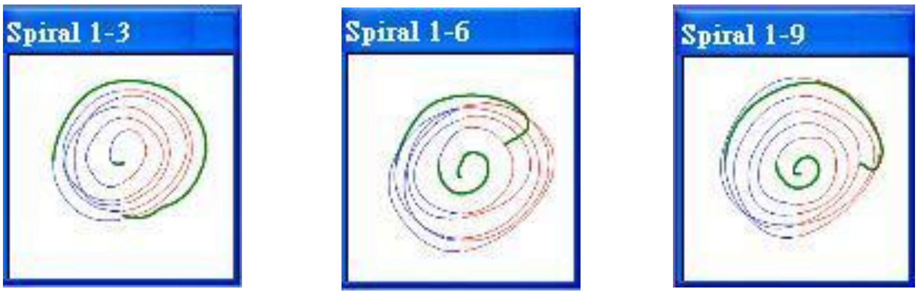

Figure 2. Three example pictures of spiral loops. The green boldface lines (or simply black boldface lines if printed in black-white type) indicated the beginning and ending of a single draw with relatively stronger pen wielding. The lines with other colors (or thin lines) were the default lines in the software, representing the drawing trajectory in left and/or right half sides.

The task was not a laborious one so that the rest interval between successive trials was 30-60 seconds depending on each person. As to the sequences for the usage of 2 hands, the odd number participants performed first in left hand while the even number ones performed first in their right hands. Two-hour-long piano practices with a reasonably fast tempo occurred between the pretests and posttests.

Data analysis

The before/after piano playing and the right/left hands were the two independent variables of the experiment. The major dependent variables included the degree of severity (DOS), movement smoothness, movement irregularity, and movement tightness. The basic ideas of the algorithm used for these variables could be seen in the introduction section or originally inferring to Pullman’s (1998) spiral data analysis. The two-way repeated measure ANOVA was applied to examine the effect of the piano playing and hands on the dependent variables above at the significant level $\alpha = .05$.

Results

Background variables

The basic demographic data were collected at the beginning of the experiment, including sex, age, height, weight, palm length, palm width, and palm stretch (data in Table 1).

Table 1. *The demographic data of the participants.*

No.	Sex	Age (yrs)	Height (cm)	Weight (kg)	Left Palm (cm)			Right Palm (cm)		
					Length	Width	Stretch	Length	Width	Stretch
1	F	22.7	160	42	16	8.5	18.5	16	8.5	18
2	F	21.6	157	49	15.4	8.3	19	15	8.2	18.4
3	F	22.0	168	50	16.4	8.8	20.1	16.8	8.7	19.5
4	F	21.9	168	50	18.5	9.5	21.1	18.3	9.5	20.2
5	F	23.4	163	50	17.6	8.2	19.4	17.6	8.4	20
6	F	21.9	161	46	17	9	21.9	17.3	9	20.6
7	M	20.5	170	67	18.5	10	20.9	18.4	9.9	21
8	F	21.8	157	52	15.9	9.3	20	16	9	19.4
9	M	22.1	181	81	19.2	10.5	23.9	19.2	10.5	23.2
10	M	22.0	170	55	17.2	10	21	17.2	9.8	21.3
11	F	21.8	166	58	18	10	21.9	18.6	9.6	20.9
12	F	21.5	157	48	17.5	7.9	21.9	18.1	7.9	20.9
13	F	22.5	158	57	16	8.4	18.8	15.8	8.4	17.9
14	M	20.7	179	71	19.3	10.8	23.9	19.8	10.9	24
15	F	21.1	156	53	16	8.8	20	16	8.8	20
16	F	21.4	168	65	18.5	9.2	22.3	17.9	8.8	21.6
17	F	21.2	163	64	17.8	9	21	17.2	9	21
18	M	21.5	173	73	18.6	9.9	21.3	18.6	9.9	21.4
19	F	21.8	166	48	17.2	8.5	22	18	9	21.5
20	M	21.6	181	60	19.1	9.5	23	19.1	9.8	23
Mean		21.75	166.10	56.95	17.49	9.21	21.10	17.55	9.18	20.69
SD		0.65	7.94	10.30	1.23	0.81	1.56	1.30	0.79	1.62

Degrees of severity in the piano-playing of pianists

No significant differences in the degrees of severity (DOS) were found in the piano playing, $F(1, 19) = 2.15$, $p > .05$, nor in the right/left hands, $F(1, 19) = 2.00$, $p > .05$. This means that neither the piano playing nor the individual hands significantly changed the values of the DOS. These values, in fact, were relatively low according to

 DOI: 10.6497/BSEPT2014.1402.05

the original explanations relating to the DOS. The means and standard deviations of the before practice/right hand, before practice/left hand, after practice/right hand, and after practice/left hand groups were 0.76 ± 0.50, 0.84 ± 0.51, 0.84 ± 0.55, and 0.94 ± 0.58, respectively. According to the defined normal DOS scores ranging from 0-1, the results also indicated that the piano players are normal persons, not displaying signs of the movement disorders characterized by tremors. Table 2 shows the results of the two-way ANOVAs for the dependent variables.

Table 2. *Two-way ANOVAs for the dependent variables.*

Dependent variables	Interaction	Piano playing effect	Right/left hands effect
Degrees of Severity (DOS)	F (1, 19) = 0.18	F (1, 19) = 2.15	F (1, 19) = 2.00
Smoothness (Imperfection)	F (1, 19) = 0.94	F (1, 19) = 0.05	F (1, 19) = 59.68* (RH < LH)
Irregularity	F (1, 19) = 2.19	F (1, 19) = 0.09	F (1, 19) = 24.37* (RH > LH)
Tightness	F (1, 19) = 0.01	F (1, 19) = 0.01	F (1, 19) = 34.08* (RH > LH)

Note 1: * p < 0.001.

Note 2: ( ) after * indicates the post hoc results; RH means right hand and LH means left hand.

Smoothness, irregularity, and tightness of the hand movements

Three important indices based on the Pullman's technique were analyzed to determine the smoothness, irregularity, and tightness of the piano players' hand movements. Concerning the smoothness and irregularity of the hand movements, the right hands appeared to move more smoothly than the left hands, $F(1, 19) = 59.68$, $p < .001$, $\eta^2 = .76$. However, the left hands displayed more regular movement features than the right ones, $F(1, 19) = 24.37$, $p < .001$, $\eta^2 = .56$. The raw data of smoothness, irregularity, and tightness were shown in Table 3.

DOI: 10.6497/BSEPT2014.1402.05

Table 3. *The raw data of smoothness, irregularity, and tightness (numbers in parentheses are standard deviation).*

	Smoothness	Irregularity	Tightness
Before practice			
Left hand	0.68 (0.63)	31.85 (10.8)	1.15 (.64)
Right hand	1.43 (0.46)	24.16 (8.89)	1.73 (.81)
After practice			
Left hand	0.75 (0.58)	25.04 (7.93)	1.15 (.55)
Right hand	1.4 (0.59)	30.03 (9.71)	1.74 (.93)

To indicate the significance of the data concerning tightness and as defined in Pullman's (1998) article, the tightness is a relative measure, with a value of 1 denoting a spiral with five perfect loops in the 10 x 10 cm box. Spirals with more than five loops in the 10 x 10 cm square have tightness values larger than 1, and fewer than five loops have values less than 1. The 2-way ANOVA of the tightness of the hands' movements revealed that the right hands drew relatively more loops with smaller spaces between consecutive loops across the spiral, $F(1, 19) = 34.08$, $p < .001$, $\eta^2 = .64$.

Discussion

Based on the idea that automated and stereotyped movements may produce relatively lower variability, this study investigated the variability in the hands of pianists using the Pullman spiral analysis (Pullman, 1998). Due to the low values of the degrees of severity (DOS) obtained, no clear practice effect seemingly exists on the tremor index with the manipulations of before/after playing and right/left hands. This result also indicates that highly skilled pianists play in an almost automated manner. The other variability indices, however, provided further information regarding the smoothness, irregularity, and tightness of hand movements. Since tightness was measured from the spacing between loops the participants drew in a certain 2-dimension space, it was inferred that, with relatively higher tightness values, one can play the piano with higher dexterity and better motor control in the fingers.

The relationship between smoothness and irregularity, however, is not as simple as the trade-off phenomenon between speed and accuracy (Fitts, 1954). According to previous research, synchronicity exists in the nature of smoothness and irregularity (Jung, 1955/1985), meaning that the two events relate to each other and synchronize simultaneously. Based on this idea, this empirical study showed that the dominant right hands can move in relatively smoother but more irregular ways compared to the left hands. The pianists' left hands, however, are possibly trained more often in a chord-playing manner, and represented relatively lower irregularity with less smooth playing.

Significantly, the more irregular but smoother hand movements indicate that the pianists' hands can move simultaneously in flexible and controlled ways. The variability in the dominant hand (the right hand in this study) should be considered as a benefit or advantage rather than an inferiority or insufficiency. Incorporated with the lower level of irregularity and smoothness into the left hands, the consonant accompaniment can render a tune more pleasant, harmonious, or sentimental. Evidence for this phenomenon can be observed, for instance, in most of the fast-hand movements in W. A. Mozart's Piano Sonatas and F. F. Chopin's Nocturnes. In these repertoires, the right hand is usually engaged in more technically demanding tunes, and is responsible for the melodic line, which is extremely active and irregular. Conversely, the left hand is required to provide accompanying chords or chordal figures, of which the movement is usually significantly more regular than that of the right hand. Although this may not necessarily be technically demanding, the primary task of the left hand is to control the volume and fluid action of the accompanying figures located in the relatively lower registers. Nevertheless, this conclusion could only be appropriate for the right handed population and the extending inference should be expressed conservatively.

The reason for the effect of the piano practicing being indistinct may be due to the short period of practice time (only two hours), which the practice amount, comparing to the daily routine piano playing, seemed not reaching the critical point for the changes in a biological system. The finding indicating the differences of smoothness and irregularity between piano players' two hands is highly significant in

DOI: 10.6497/BSEPT2014.1402.05

the arena of education concerning piano playing specifically. In summation, the present study can broaden the knowledge and understanding of the prolific perceptions concerning music, particularly in the arena of piano playing.

References

Bernstein, N. A. (1967). *The co-ordination and regulation of movements*. Oxford: Pergamon Press.

Cohen, O., Pullman, S. L., Jurewicz, E., Watner, D., & Louis, E. D. (2003). Rest tremor in patients with essential tremor. *Archives of Neurology, 60*, 405-410.

Elble, R. J., Pullman, S. L., Matsumoto, J. Y., Raethjen, J., Deuschl, G., & Tintner, R. (2006). Tremor amplitude is logarithmically related to 4- and 5-point tremor rating scales. *Brain*, *129*, 2660-2666.

Fitts, P. M. (1954). The information capacity of the human motor system in controlling the amplitude of movement. *Journal of Experimental Psychology, 47*, 381-391.

Gardner, E. P., Martin, J. H., & Jessell, T. M. (2000). The bodily senses. In E. R. Kandel, J. H. Schwartz, & T. M. Jessell (Eds.), *Principle of neural science* (4th ed., pp. 430-450). New York: McGraw-Hill.

Jung, C. G. (1985). *Synchronicity: An acausal connecting principle* (R. F. C. Hull, Trans.). London: ARK Paperbacks. (Original work published 1955).

Kandel, E. R., Schwartz, J. H., & Jessell, T. M. (Eds.). (2000). *Principle of neural science* (4th ed.). New York: McGraw-Hill.

Karni, A., Meyer, G., Jezzard, P., Adams, M. M., Turner, R., & Ungerlieder, L. G. (1995). Functional MRI evidence for adult motor cortex plasticity during motor skill learning. *Nature, 377*, 155-158.

Louis, E. D., Yu, Q., Floyd, A. G., Moskowitz, C., & Pullman, S. L. (2006). Axis is a feature of handwritten spirals in essential tremor. *Movement Disorders, 21*, 1294-1295.

Magill, R. A. (2013). *Motor learning and control: Concepts and applications* (10th ed.). New York: McGraw-Hill.

Mayer-Kress, G. (Ed.). (1986). *Dimensions and entropies in chaotic systems*. New York: Springer-Verlag.

Newell, K. M. (1996). The dynamics of stereotypic behaviors: Movement variance and invariance in the classification of movement disorders. In R. L. Sprague & K. M. Newell (Eds.), *Stereotyped movements: Brain and behavior relationships* (pp. 115-138). Washington, DC: American Psychological Association.

Newell, K. M., & Slifkin, A. B. (1998). The nature of movement variability. In J. P. Piek (Ed.), *Motor behavior and human skill: A multidisciplinary approach* (pp. 143-160). Champaign, IL: Human Kinetics.

Newell, K. M., Gao, F., & Sprague, R. L. (1995). The dynamics of finger tremor in tardive dyskinesia. *Chaos, 5*, 43-47.

Pullman, S. L. (1998). Spiral analysis: A new technique for measuring tremor with digitizing tablet. *Movement Disorders, 13* (supplement 3), 85-89.

Rosenbaum, D. A. (1991). *Human motor control*. San Diego, CA: Academic Press.

Saunders-Pullman, R., Derby, C., Stanley, K., Floyd, A. G., Bressman, S., Lipton, R. B., ... Pullman, S. L. (2007). Validity of spiral analysis in early Parkinson's disease. *Movement Disorders*, *23*, 531-537.

Schieber, M. H., & Hibbard, L. S. (1993). How somatotopic is the motor cortex hand area? *Science*, *261*, 489-492.

van Emmerik, R. E. A., Sprague, R. L., & Newell, K. M. (1993). Finger tremor and tardive dyskinesia. *Experimental and Clinical Psychopharmacology, 1*, 259-268.

Wang, H., Yu, Q., Kurtis, M. M., Floyd, A. G., Smith, W. A., & Pullman, S. L. (2008). Spiral analysis- Improved clinical utility with center detection. *Journal of Neuroscience Methods, 171*, 264-270.

臺灣運動心理學報 DOI: 10.6497/BSEPT2014.1402.05
第 14 卷第 2 期，67-81 頁 (2014) Pianists variability

鋼琴彈奏者之手部變異性

賴世烱 [1]　賴如琳 [2]

[1] 國立臺北護理健康大學運動保健系

[2] 國立臺灣藝術大學音樂學系

摘要

本研究使用普爾曼螺旋分析 (Pullman spiral analysis) (Pullman, 1998) 以探討高技能鋼琴彈奏者之手部變異性，此動作變異性之指標爲手指震顫，包括震顫嚴重程度、動作流暢度、不規則性及緊張度等變項。實驗參加者爲 20 位主修鋼琴且慣用手爲右手之大學生 (平均年齡爲 21.75 ± 0.65 歲)，實驗要求其分別以左手和右手自然地握住一電子感應筆來畫數個螺旋形狀，左右手之試作次數各爲 10 次；在前測與後測之間，參加者皆練習二個小時較快節奏之鋼琴彈奏練習。本研究以重覆量數二因子變異數分析，檢驗畫螺旋形狀之前後測與左右手交替使用在以下四個依變項之效果：手部動作之震顫嚴重程度、動作流暢度、不規則性及緊張度。主要研究結果爲 (1) 上述二個自變項皆未在練習彈奏快節奏鋼琴二個小時後對震顫嚴重程度有所影響，及 (2) 右手動作較左手流暢，但左手則較右手顯現出較高之規律性。本研究提出以下結論：雖然鋼琴彈奏者之手部震顫程度並不顯著，研究發現以右手爲慣用手之鋼琴彈奏者的右手表現出較不規律、但卻較爲流暢之手部動作型態，相反地，其左手則表現出較爲規律卻較不流暢之動作結果，究其原因可能與鋼琴彈奏者常以左手練習較爲穩定之和弦彈奏有關。本研究發現有助於瞭解音樂知覺之相關知識，尤其是在鋼琴彈奏方面之音樂知識領域。

關鍵詞：協調、知覺、動作控制、動作表現、震顫