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# Individuality of movements in music – Finger and body movements during playing of the flute

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ABSTRACT

The achievement of mastery in playing a composition by means of a musical instrument typically requires numerous repetitions and corrections according to the keys and notations of the music piece. Nevertheless, differences in the interpretation of the same music piece by highly skilled musicians seem to be recognizable. The present study investigated differences within and between skilled flute players in their finger and body movements playing the same piece several times on the same and on different days. Six semiprofessional and four professional musicians played an excerpt of Mozart's Flute Concerto No. 2 several times on three different days. Finger and body movements were recorded by 3D motion capture and analyzed by linear and nonlinear classification approaches. The findings showed that the discrete and continuous movement timing data correctly identified individuals up to 100% by means of their finger movements and up to 94% by means of their body movements. These robust examples of identifying individual movement patterns contradict the prevailing models of small, economic finger movements that are favored in the didactic literature for woodwind players and question traditional recommendations for teaching the learning of motor skills.



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## 1. Introduction

Most often the acquisition and learning of a movement in sports, music or activities of everyday life is realized by orienting on a model template, especially in learning specific movement techniques in traditional sports. In contrast, children during their first 2 years of life mostly find by their self the task goal through trial and error new and potentially with an optimal movement solution for a task goal. And subsequently, with increasing age, the educational system takes over the control of learning on the basis of prescribing the possible solutions to their learners predominantly by learning through imitation. These generalizations reflect some of the major theoretical stances on learning strategies for the acquisition of skill.

It is against the background of this context that practicing sports or a musical instrument has to cope with similar challenges or environmental influences in the approach to instruction. Typically, during the early acquisition phase all learners are treated in a similar way by requiring them to copy a template or prototype that is oriented on the best athletes or musicians in their disciplines. Once a certain level of performance is achieved then individual adaptations and modifications are considered. This approach, however, does not take into account the striking historical evidence for individuality in movement patterns. Quantitative evidence for the individuality of movements was provided in an article (Otago Daily Times, 1893) about the individuality of typewriting (see also Crown, 1969). Individual movement patterns have also been shown for the signing of documents (Zheng, Li, & Doermann, 2004), acoustic speech (Weismer, Kent, Hodge, & Martin, 1988) and gait (Nixon, Tan, & Chellappa, 2006; Schöllhorn, Nigg, Stefanyshyn, & Liu, 2002; Troje, 2002; Troje, Westhoff, & Lavrov, 2005; Westhoff & Troje, 2007) as well as their situated dependence on emotions (Janssen et al., 2008) and fatigue (Janssen et al., 2011). The identification of top athletes on the basis of their movement kinematics or dynamics (Schöllhorn & Bauer, 1998), despite several common features in their techniques already, led to an alternative approach to the champion's template model in motor learning.

An analogous situation exists in learning to play an instrument or learning to sing a song. Despite the common features that are given by the compositions and form of the model that have to be copied ample different interpretations of the same piece can be heard in concerts. Meanwhile individual movement patterns of finger movements could be recognized in piano playing where the instrument is fixed and the finger, arms and trunk can freely move, whereas the lower extremities including the hips are restrained because of the seat.

Individual differences in movement kinematics and muscular activities across pianists have been addressed in several behavioral studies (Dalla Bella & Palmer, 2011; Furuya, Aoki, Nakahara, & Kinoshita, 2012). The kinematics of the finger tip movements of 4 pianists, playing 2 melodies consisting of 13 notes formed the basis of the individual recognition by Dalla Bella and Palmer (2011). Thereby, the original data were reduced by means of a PCA. The 5 main components formed the input variables for a two layer Neural Network with a back propagation algorithm. In 18 skilled pianists, the variations of velocities at the shoulder, elbow, wrist and finger joints in relation to loudness and tempo during repetitive keystrokes were categorized into 3 groups according to distinct joint coordination and on the basis of regression coefficients (Furuya et al., 2012).

Furuya and Altenmüller (2013) compared classification approaches by investigating data of index middle and ring fingers after reducing the data by means of PCA and comparing the classification results by means of Fisher's linear discriminant analysis (LDA), naive Bayesian Classifier (NBA) and Support Vector Machines (SVM) for each of the index, middle and ring fingers. All classification results of single fingers revealed best classification by means of Support Vector Machines (91–98%) and worst by means of LDA (65–81%). At least 17 pianists were classified according to the presence or absence of dystonic symptoms. Evidence on the influence of circadian rhythms on individual finger movements of pianists has been given by Van Vugt, Treutler, Altenmüller, and Jabusch (2013).

However, in difference to piano playing other music instruments and, especially wind instruments, have to be carried/supported by the arm–hand movement complex. Thereby, the dynamics of the finger movements can no more be supported by elbow and shoulder movement (Furuya et al., 2012). The finger movements during playing of a flute that are the main focus of the present study are subject to the biomechanical and sequential limitations that are relevant for pianists as well as for many of the