Handedness in Percussion Sight-Reading

Benjamin Bacon[†]
IDMIL
CIRMMT
McGill University
bjaminbacon@gmail.com

Marcelo M. Wanderley[‡]
IDMIL
CIRMMT
McGill University
marcelo.wanderley@mcgill.ca

Fabrice Marandola[§]
CIRMMT
McGill University
fabrice.marandola@mcgill.ca

ABSTRACT

This paper presents the findings of a study investigating the effects of handedness on percussionists. Handedness, which is a subcategory of the field of laterality, has a number of wide-ranging effects on human movement. Previous research has shown that more attention is diverted to the preferred-hand when the level of difficulty is increased in a given task. Furthermore, the preferred hand is relied upon to initiate a timing schedule for bimanual tapping tasks. Given the strong connection between performance-based tapping tasks and percussion performance, this study sought to test the aforementioned findings in the context of instrumental performance. In the current literature, little to no research exists on the subject of handedness in percussive performance.

With the assistance of 7 right-handed and 2 left-handed participants, the effects of handedness were observed in a motion capture facility. The participants performed a single-page sight-reading exercise. Each participant had at least one year of undergraduate training in percussion performance. The tasks were performed on a 29-inch timpani drum.

The sight-reading exercise was written to specifically challenge the participants with regards to handedness. Here, the exercise gradually changed in rhythmic complexity, using irregular and syncopated rhythm structures to complicate the participant's internal timing.

The findings of this study revealed a sharp shift in the use of the preferred and non-preferred hands in relation to beat structure. Larger beat structures, such as down-beats, commanded 84.1% usage of the preferred-hand while 16th-note subdivisions reported just 32.0%. Further observations and analysis show that the obfuscation of the down-beat with irregular rhythms disrupt the participant's timing causing a series of multi-strokes with the preferred-hand.

[†]M.A. Candidate McGill University

[‡]CIRMMT, IDMIL Director

[§]Professor of Percussion at Schulich School of Music

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Categories and Subject Descriptors

H.5.5 [**Information Interfaces And Presentation (e.g. HCI)**]: Sound an Music Computing

General Terms

Handedness, Laterality, Down-beat, Subdivision

Keywords

Sight-Reading, Handedness, Percussion, Motion Capture

1. INTRODUCTION

In a seemingly endless number of ways, we are affected in some degree by *lateralisation*. This is generally defined as the preference of one side of the body for a particular function [2]. The field of laterality is multidisciplinary in nature, stemming from studies in psychology and neuroscience [10], and further applied to reviews of its effects in the arts and culture [5]. Common sub-categories of laterality include studies in handedness, footedness, and the hemispheres of the brain.

With such widespread influence over our bodies, one can easily begin to wonder how laterality affects our movement strategies. The subcategory of handedness is one of the most popular points of inquiry, and has included studies attempting to understand some of the most basic questions regarding the human mind and body, including how prenatal movement can predict traits later on in life [8]. Among these questions lies the search for the cause of human hand-preference. It is generally agreed upon that we live in a right-hand dominated world. Thus, when we classify ourselves in terms of handedness, we employ a dichotomy: those who exhibit sinistral (left-handed) preferences, or dextral (right-handed) preferences.

2. THE NATURE OF HANDEDNESS

While it is a widely known fact that the majority of humans tend to prefer their right hand when performing a manual task, most are unaware that this phenomenon is considered to be unique among humans [4]. The distribution of handedness in humans fits along a bell curve which, if it were shifted to the left, would match the distribution curve of other mammals (where the center of the curve is located over 50%). Therefore, our handedness distribution is shifted to the right in relation to other species. In addition, other extensive studies suggest that handedness itself is congenital and exists not as a dichotomy, but as a continuum [4] [9]. Every individual exhibits a unique mixture of preferences for the right- and left-hands.

2.1 Classifying Handedness

For many years, inventory-based questionnaires were the most popular tool for handedness classification [26]. Such questionnaires are inexpensive to reproduce, quick to perform, and easy to distribute. However, these methods are often poor indicators [18]. Choosing tasks to inquire about is difficult partially due to cultural influences. While inquiring about which hand a person writes with seems like a simple indication of hand-preference, those living in East Asia for instance, [16] are likely to experience cultural pressure to use the right hand over the left. Furthermore, questionnaires task the researcher with issuing a level of importance to each task when assessing the metrics of handedness' effects.

Issues inherent with questionnaire classification have given rise to performance-based classification methods. These tests are more time consuming than the questionnaires, and require controlled conditions and detailed analyses. Although, performance-based tests still hold the advantage because they do not rely on the participant's recollection or personal opinion on which hand they prefer; the behavior of the participant can be observed [18].

2.2 Tapping-based Tasks

Despite the lack of evidence suggesting an individual's proclivity towards superior musical abilities, handedness has been shown to have a strong effect on the movement strategies of performers. In this case, a great deal of research has been focused on the use of performance-based tapping to observe these effects. As a bimanual task, tapping has been used to observe the effects of handedness in tapping consistency [14] [13], phase wandering [17], and the effects of attention on handedness performance [3]. In addition, other studies have shown that the non-preferred hand performs better when it is fully automated [25], suggesting that when the attention is shifted away from the preferred-hand, the performance of each hand suffers. Recent findings have suggested that although the preferred hand generally receives most of the attention when a task's difficulty is increased, the overall speed of the given action can have an overriding effect. Thus, an individual will move their attention towards the hand that performs the faster task. Regarding the timing of events in a bimanual task, there is evidence of a centralized timing schedule which is commonly initiated by the preferred hand [24].

3. HANDEDNESS IN MUSIC

When considering handedness research, the wide-ranging influence of its effects have given way to a large number of studies in many different disciplines. Due to the intrinsic nature of the hands in instrumental performance, music has been an area of intense focus. In the literature, it is generally concluded that an individual's handedness does not provide one with any inherent advantages or disadvantages with regards to musical ability [20]. Further studies have investigated the influence of handedness in reaction times of musicians [23], showing that the musicians' have more balanced bilateral attentiveness than non-musicians. The previously mentioned studies involving tapping included a focus on the differences between expert drummers and non-drummers, displaying the advanced movement strategies used by percussionists [13] [14].

3.1 Sight-Reading and Handedness

Sight-reading is considered to be one of the most basic and crucial musical skill sets. The ability to read unrehearsed music demonstrates numerous mental processes involving active-memory, visual decoding, and fine motor skills [22]. Literature on the matter is diverse, with studies seeking to validate certain mental encoding functions, understand how experience effects reading abilities, and determining how skills are used with increasing difficulty. In relation to handedness, current studies show that sinistral performers may have an inherent advantage over their dextral counterparts in sight-reading [21]. Other research in musical sight-reading has shown that as the complexity in sight-reading music increases, the necessary skills required from the performer move from an emphasis on general instrumental expertise to the psychomotor movement and information processing [19].

4. STUDY IN PERCUSSION SIGHT-READING

Although there have been many studies regarding the effects of handedness in tapping tasks, literature is virtually nonexistent when approaching the effects of handedness in percussion performance. Given the similarities between tapping and percussion performance, it seems appropriate to apply these findings in an investigation of handedness in a percussion performance setting.

4.1 Methodology

In a motion capture laboratory, 9 percussionists with at least a single year of university-level training were asked to perform a series of tasks on a single 29-inch timpani. The participants were recorded with motion capture cameras which were synchronized by an external clock with audio and video footage. A sight-reading task was performed consisting of no dynamic or articulation markings. A metronome of 90 beats per minute was used to count in the performers, and was switched off after the 4th measure. To analyze the performances, video footage of each performer was extensively reviewed in order to compile statistics on left and right hand strokes, identify errors in the performer's playing, and search for other unforeseen effects of handedness. To establish an even pace for each performer, a click track counted-in, and aided the participants for the first four measures. These first measures included very simple quarter-note rhythms in order to allow for the participants' establishment of a steady tempo foundation and counting strategy.

4.1.1 Marker Placement

The motion capture system required the use of passive markers, which were placed on each participant. A total of 65 markers were used. The Vicon Plug-in-Gait Model was used for this study [1]. This marker placement strategy takes advantage of the most stable locations on the body in order to prevent noise in the marker data caused by loose body tissue. Each participant performed with the same pair of timpani mallets, which were fitted with passive markers.

Table 1: Distribution of Rhythmic Elements

Element	Frequency	Function
Down-Beat	20.59%	Demarcates measures
Weak-Beat	20.59%	Basic beat marker
8th Note	26.47%	Introduces syncopation
16th Note	25.49%	Enhances metered complexity
Irregular	6.86%	Obscures metering

4.2 Sight-Reading Score

The score used for the sight-reading task in this experiment was designed specifically with handedness in mind. The timpani and sight-reading score do not contain any inherent bias towards the left or right sides. In addition, while remaining a challenge to read, the sight-reading score could easily be performed with simple alternating strokes by both left- and right-handed participants. Given the wide-ranging effects of handedness, it was hypothesized that the performers will not use alternating strokes in performance.

In an attempt to employ previous findings regarding handedness and timing, the overall structure of the sight-reading task consisted of several sections which gradually increased in levels of syncopation and rhythmic complexity. The rhythmic content which comprised the notation was broken down into four major categories based on beat function. This categorization includes: large beats, off-beats, subdivisions, and irregular rhythms.

The following descriptions will use the *1-e-and-a* beat counting strategy to describe their beat function. Large beats are quarter note rhythms, the largest beat found in the sight-reading study. This category contained a subcategory, weak beats. Large beats are considered those which fall on beats 1 and 3, while weak beats (or back beats) fall on 2 and 4. The off-beat category consisted of 8th-notes falling in-between the quarter-note values. This consists of rhythms on the *and* beat. The subdivision category contained sixteenth-note beats which fell in-between the 8th-note and quarter-note rhythms. The final category, irregular rhythms (also known as *tuplets*), are rhythmic structures which fall outside of the beat matrix dictated by the time signature. This includes quintuplet and triplet figures (e.g. 5:2, 3:4 patterns). The frequency and function of each rhythmic element can be seen in Table 1.

The sight-reading study structure consisted of four main sections which progressed from an emphasis on down-beats and weak-beats, to areas of rhythmic complexity featuring off-beats (8th-notes) and subdivisions (16th-notes), to the use of advanced syncopation and irregular rhythms. The structure also employed the use of three different time signatures (4/4, 3/4, and 2/4). With a simple introduction leading to areas of advanced rhythmic complexity, the sight-reading study was designed to challenge the plasticity of the performer's internal timing and to draw attention away from any expressive gestures.

Given that sight-reading demands the immediate attention of the performer, it was hypothesized that the preferred-hand would perform a majority of the down-beats, weak-beats, and irregular beats, while the non-preferred hand would share responsibility with the preferred-hand when performing off-beats and subdivision beats.

Overall, the sight-reading score consists of 7 time-signature changes, 21 measures, and 103 playable notes. With regards to ordering of the performed-hand, the term *sticking* will be used. This is the proper term percussionists use when referring to the process of choosing a stick (*i.e.* the left or right) to perform a given note.

5. RESULTS

The sight-reading study produced many interesting observations on each player's hand preferences. Despite the sight-reading task's neutrality towards the left and right sides, observations from this study produced strong evidence of the effect of handedness on percussion performance.

The general performance quality from each participant was very high. Given the complexity of the sight-reading task, the participants maintained a professional level of concentration. While only a few errors were produced, the sound quality and overall musicality of each performers' reading was excellent. No major variations in tempo or dynamics were apparent in any of the performances.

When assessed from a performer's perspective, the variation in musical quality between each participant's performance was not substantial. The overall lack of egregious errors, coupled with a consistency of tempo in each performance allowed for direct comparisons focusing in the effects of handedness. While each individual exhibited their own unique performance gesture, strong and clear similarities unite each of the performers with regards to the general use of the preferred-hand. A close look at local sections of the musical score reveal interesting divisions between the left- and right-handed performers.

5.1 Gestural Form and Function

The form and function of a participant's technical approach are two advantageous and insightful methods for analyzing a given performance. The form, in this case, refers to the *gestural profile* (*i.e.* trajectory) of a given performer, while the function refers to when a particular hand is used. In the context of the sight-reading task, using the preferred-hand more on down-beats is a result of handedness with regards to function. The trajectory of the hand is the form. Therefore, it is possible for two participants to perform a task similarly with regards to function (using the same hand to perform), while the form of their technique can vary greatly. An example of this can be seen in Figure 1, in beats 23-29. Participant B (left-handed) and G (right-handed) executed the segment of the sight-reading study with the exact same hand ordering. In fact, most participants in this segment relied upon their preferred-hand in a similar fashion. Yet, when we take a larger look at the form of technique of participant's B and G technique, we see that they are very different. Not only do the participants' technical approaches differ greatly, but each hand differs greatly as well. This can be seen in Figure 2. The differences in form seen here offer just one look at the many possible different gestural profiles found in each performer, which reinforces findings previously discussed by the work of [11] and [6].

5.2 Functional Roles of the Hands

Among some of the most interesting findings of this study include the fact that the preferred-hand was used a majority of the time when encountering strokes with the lowest time-subdivision (*i.e.* the largest time value). Down-beats

Figure 1: This is a normalized beat matrix depicting the sticking choices from the corresponding notation below. Red/grey boxes indicate the use of the preferred hand. Black indicates the use of the non-preferred hand. Players A and B are left-handed. Empty spaces are notes omitted by the participant. Gradient boxes are performed errors. Block 1 displays relative uniformity in hand choice. Block 2 displays the onset of extreme multi-strokes in players B, E, and F. Block 3 displays a return to uniform use of the hands in stick choice after reestablishment of the timing structure.

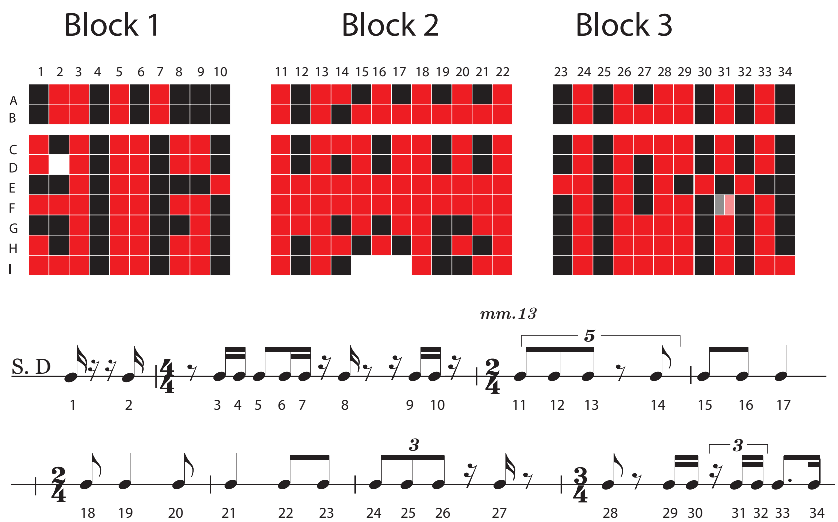
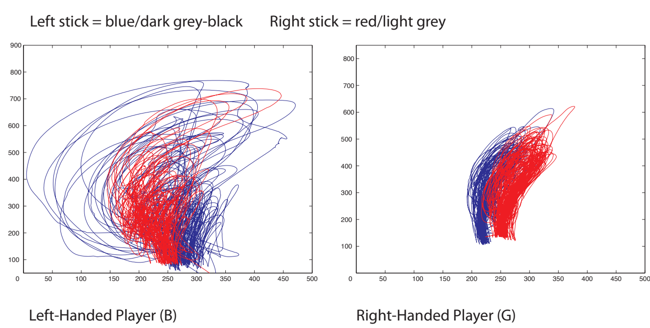


Figure 2: Represented here is the cumulative tracing of both left and right sticks of Player B and Player G, viewed from the sagittal plane. The axes are shown are in mm.



received the largest percentage of strikes from the preferred-hand at 84.1%.

The weak-beat also drew a large majority of preferred-hand strikes from each participant, but at a less frequent rate. With 68.2% of weak-beats played by the preferred-hand, we see that the non-preferred hand receives more of the work-load. Irregular beats, which require different time-keeping strategies for performance, received 55.6% of strikes from the preferred-hand.

With regards to the non-preferred hand, the findings suggest that it receives secondary timing responsibilities, as the 8th-note and 16th-note subdivisions received 57.2% and 32.0% striking percentage from the preferred-hand, respectively. In Figure 3, one can observe how the structural role of each rhythmic element affected the performers' use of the preferred-hand. As the beat-value moves from larger to smaller divisions, the preferred-hand's performance frequency decreased.

5.3 Comparisons Between Sinistral and Dextral Participants

In Figure 4, a beat matrix containing the sticking choices for all down-beats and 16th-note subdivisions provides a useful tool for examining the macro and micro functional trends of the hands in the sight-reading task. A clear shift towards the use of the non-preferred hand can be seen. Most of the time, the use of the preferred-hand in the left- and right-handed players is similar, as the context of the down-beats and 16th-note subdivisions generally elicits similar responses from both groups. Nevertheless, there arise several instances where the left- (A and B) and right-handed (C-I) performers differ. In Block 2 of both the down-beat and 16th-note beat matrices, the sticking choice of players A and B is identical. Block 2 of the 16th-note segment represents the entire middle section of the sight-reading material, where the highest density of 16th-note subdivisions reside. Based on the designed beat-hierarchy, where down-beats fall on the largest beat indicator, it appears that participants A and B exhibited a higher level of alternate use of the hands in the middle section of the sight-reading task. Upon closer examination, a slight shift towards alternate (even) sticking choice can be recognized. For the entire sight-reading exercise, performers A and B used their preferred (left) hand 58.65% and 61.54% of the time respectively. In the center segment of the study, which includes the notes found in Block 2 of the Figure 4 beat-matrix, the average for players A and B is 56.09% and 58.53%.

5.4 Multi-Strokes

Sequences of consecutive strokes (multi-strokes) were observed throughout the study, and were predominantly performed by the preferred-hand. A multi-stroke in percussion performance is generally defined as a series of 3 or more consecutive strokes performed with one hand.

Viewing Figure 1 reveals many instances of multi-stickings

Figure 3: Participant use of the preferred-hand for each participant. The x-axis displays the 4 beat structure elements, moving from the largest to smallest functional time division. The y-axis displays the % of times the preferred-hand was used to perform.

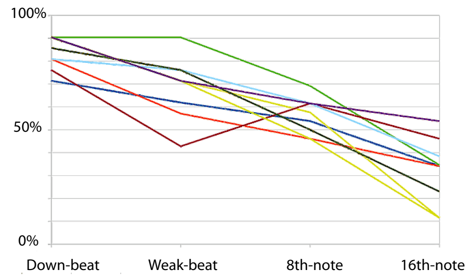
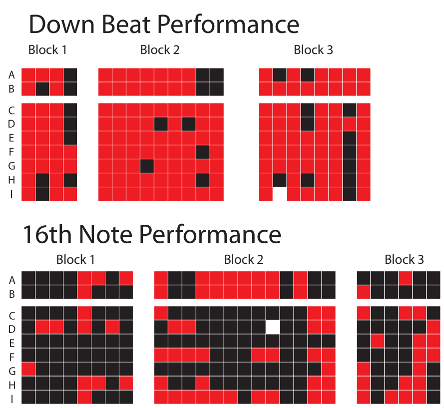


Figure 4: This is a normalized beat matrix depicting the sticking choices of all down-beats and 16th-note subdivisions of the study. Red/grey boxes indicate the use of the preferred hand. Black indicate the use of the non-preferred hand. Players A and B are left-handed. Blocks 1 and 3 in both matrices show unique sticking between all participants. Blocks 2 show identical sinistral performer sticking.



with each hand, ranging from double-strokes to a series of 15. While multi-stickings can be observed in each hand, they are predominantly found in the preferred-hand.

Three of the longest series of multi-strokes (8, 12, and 15) directly followed the irregular rhythm found in Figure 1. In Block 2 of the Figure, participants B, E, and F can be observed performing their multi-strokes. In the corresponding score beneath the beat matrix, the right-handed performers E and F initialize beat 11 with their preferred-hand. Beat 11 was strategically placed to obfuscate the down-beat which many performers rely on to perform rhythms accurately. In the notes following the quintuplet, the downbeat reappears on beat 15, and moves into a simple syncopated rhythm. The quick changes between the 4/4, 5/2, and syncopated 2/4 meters offers an explanation towards the extreme multi-stickings of participants E, F, and B. In the case of B, who is a left-handed player, multi-sticking happens after the quintuplet, beginning on beat 15. The extreme multi-stickings could perhaps be interpreted as a manifestation of the participants attempting to reestablish (find) the down-beat.

In Block 3, a majority of the performers (all excluding participant E), tended to follow the same sticking pattern. In the notation, beats 23-29 cover the transition from duple to triple meters, where an irregular rhythm was used to obscure the transition. Most performers in Block 3, performed three or four of beats 26-29 with their preferred-hand. Those particular beats contain the back-end of a triplet and a variety of 8th- and 16th-note rests and rhythms. These notes require an expert sense of musical time to perform accurately. Most participants relied upon their preferred-hand to play this segment correctly.

6. DISCUSSION

Although the findings show a clear trend towards the use of the preferred-hand in relation to the elements of rhythmic structure, the effects of handedness are far-reaching and deeply complex in nature. Each of the participants had at least one year of university-level percussion training, and many had performed professionally in the past. In percussion pedagogy, the influence of handedness is generally assumed [12], and in many method books, students are instructed to work on the left-hand (an example of right-handed bias) much more than the right. Further instruction on the matter is seldom discussed in detail. In relation to the sound and gesture, some methods encourage a display of *evenness* [15] [7], which hints at the sense of symmetry in both the form and function of each hand.

Another topic of interest regarding handedness may lie within the realm of dynamic variation. In this study, the sight-reading score contained no dynamic changes, leaving the participants free to perform without any necessary changes in gait. Studies regarding the motion of the human body describe a distinct jump from one locomotive strategy to another (*e.x.* walking and running) when the necessary force for a given task is increased. This change in locomotive *phase* has also been shown in the hands [17]. Given the extent of handedness' roots in human physiological development, it would be logical to extend this study to include dynamic variation in the score.

6.1 Functional Roles of the Hands

This overwhelming statistic of 84.1% use of the preferred-hand on down-beats indicates that rhythmic structure plays a clear role with regards to hand-preference. Beat structures which either begin or mark the halfway point of a measure are heavily relied upon by the preferred-hand. With regards to 16th-note subdivisions, which were he lowest beat-structure, the preferred-hand was used only 32.0% of the time. The smaller the rhythmic element, the less likely it was to fall on a major subdivision. This suggests that these notes played a less critical role in the timekeeping strategies used by the performer. Furthermore, the fact that the preferred-hand was favored so strongly supports the idea that handedness plays an integral part in timekeeping, which is closely linked to beat-structure. This notion is represented in Figure 3, with greater details seen in the amalgamated beat matrix Figure 4. Figure 4 also displays interesting departures from the left-handed performers (A and B) in Blocks 2, yet a continuation of this study with more left-handed participants is necessary for any conclusive findings.

6.2 Multi-Strokes

As seen throughout the beat matrix in Figure 1, one can find examples of multi-stickings. Results show that the preferred-hand performed multi-stickings more frequently, and with much longer extremes. Given that the beat matrix shown in Figure 1 coincides with the most challenging rhythms of the entire study, a deduced link between the obfuscation of a clear down-beat and multi-stickings of the preferred hand can be made.

A possible explanation for the observed multi-stickings in Figure 1 could be that the obfuscation of the *1-e-and-a* beat counting strategy by the irregular rhythms (beats 11-14, 24-26, and 31-32) disrupted the performer's timekeeping, thus requiring the preferred-hand to work harder in order to restart the centralized-timing schedule.

Technically speaking, percussionists are often trained to perform double-strokes (two consecutive strokes) as way to execute fast passages, initiate rolls, and place special emphasis on notes, with multi-strokes serving more advanced and extended technical passages. The sight-reading score, at 90 beats per minute, is hardly fast enough at its most rapid segments to challenge a university-level performer beyond the point where simply alternating the sticks would not be practical. In most cases, the performer can rehearse, identify the strengths and weaknesses in their hands, and choose the most advantageous sticking order. Sticking is an important skill to develop as a player, and while many seek to achieve a level of technical proficiency where sticking may become irrelevant, the effect of handedness is usually too strong to overcome entirely.

7. CONCLUSION

Despite the awareness on the issue of handedness by percussionists and the neutrality towards lateralisation of the presented sight-reading task, the compulsion to rely on the preferred-hand in critical time-keeping strategies seems reside deeply within each performer. High levels of training have not neutralized the effects of handedness regarding the form of each players technique. Although, it could be argued that the observed shift in function from the preferred-hand/down-beat to the non-preferred hand/subdivision relationship signals the possible influence of percussion training.

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