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Recording piano fingering in live performance

Introduction

Piano fingering is an area in which much is known intuitively. But many questions remain unanswered, because they have so far escaped systematic scrutiny. What fingerings do pianists actually use in performance? Do teachers use the same fingerings as they teach? Do pianists consistently use certain kinds of fingering in sight-reading and other kinds in memorized performance? In sight-reading, how far ahead do pianists plan their fingerings? How consistent are pianists in their fingerings from one performance to the next? Does more consistent fingering produce more accurate performance? Does consistent fingering aid memorization? Are certain kinds of fingerings more technically reliable than others? Do certain fingerings really help pianists to achieve certain kinds of musical expression or aesthetic effect? What cognitive processes allow a pianist to choose one from the various possible fingerings for a given passage? What exactly are the musical rules and psychological or motor processes that underlie fingering choices?

A major obstacle to a deeper understanding of piano fingering is the current absence of a method of recording fingering information reliably and quickly during piano performance. In this paper, we describe two possible methods for the recording of piano fingering in performance, and discuss their various advantages and disadvantages. We begin with an overview of some of the issues that have motivated our research.

Background

A systematic study of piano fingering is intrinsically interdisciplinary, involving both music and psychology. From a musical viewpoint, fingering is an ever-present concern to pianists; good fingering is a crucial ingredient in the preparation of performances that are both technically reliable and appropriately expressive. The findings of a systematic study of fingering may thus have applications in piano teaching and performance. Psychologically, the process according to which pianists decide to put specific fingers on specific notes may be regarded as one of the most complex cognitive-motor skills. A better understanding of this process may lead to a better understanding of related cognitive-motor skills such as typing and computer use.

Knowledge about piano fingering is transmitted from teacher to student by word of mouth, by demonstration, and by annotation. In addition, there are the printed fingerings of composers and editors that appear in musical scores, and countless references to fingering in the literature on piano performance, including the examination requirements and recommendations of national musical institutions such as the Associated Board. Treatises on piano performance that address fingering generally do so from the point of view of only one pianist (the author); to our knowledge, no-one has ever collected and compared the fingerings of different pianists for particular

passages. In other words, it would appear that no truly objective study has ever been made of piano fingering.

In our view, an objective study of piano fingering should satisfy the following two criteria. First, it should be basēd on a systematic analysis of the fingerings of a number different pianists. Second, it should be based on the fingerings that pianists actually use in performance, rather than those that they say they use, or those that they plan to use. To our knowledge, no-one has ever attempted to satisfy the first of these criteria, although nothing would have prevented a researcher from simply asking a number of pianists for their preferred fingerings of a given passage. The second criterion never been satisfied either, because it has not been possible to record fingering easily or reliably during actual performance.

A body of objective fingering data will enable us to address the following issues. First, we aim to explore the various principles and constraints that determine fingerings. These may be broken down into anatomical constraints (maximum and minimum comfortable spans), motor constraints (agility and coordination of specific fingers and combinations of fingers), cognitive constraints (ease of mental organization and memory of fingering patterns and motor sequences), and interpretive constraints (involving the relationship between fingering and aspects of musical structure – phrasing, accents, articulation, and so on). Second, fingerings seem to vary according to the demands of the task in hand (sight-reading, rehearsed reading, memorized performance, improvisation), and according to the expertise of the performer; we intend to explore these dependencies. Of particular interest are the advance search strategies employed by pianists as they spontaneously decide on fingerings while sight reading. Third, when pianists memorize a piece of music, they memorize not only the musical structure at different levels of abstraction, but also the fingering; we wish to improve our understanding of how fingerings are integrated into a performer's cognitive representation of a musical piece. Finally, we would like to improve our understanding of the acquisition of knowledge about fingering, whether that knowledge is acquired over long time periods (e. g., oral traditions, treatises), short time periods (learning within a single piece of music, such as the use of similar fingerings for diatonic or chromatic transpositions, or for identical passages embedded in different contexts), or intermediate periods (trial and error by individual performers as they explore the literature).

Principles of fingering

Certain basic principles of piano fingering are familiar to all pianists who emerge from the institutionalized, traditional piano teaching programs available in most Western countries. The acquisition of a sizeable repertoire of fingerings for commonly occurring note patterns (such as scales and arpeggios) is an important ingredient in any pianist's training.

The most important of these well-known fingering patterns, and the rules upon which they are based, emerged gradually during the 18th century. Perhaps the clearest exposition of such rules, and one that remains relevant to modern pianists, is Türk's ›*Klavierschule*‹.[1] Türk's approach may be summarized as follows:

[1] Daniel Gottlob Türk (1789). *Klavierschule, oder Anweisung zum Klavierspielen.* Leipzig und

- Use different fingers on different keys.
- In stepwise movement, use successive fingers (next note, next finger), and in smaller leaps (3rd, 4th, 5th) let the distance between the fingers correspond to the diatonic span (e. g., play the rising interval C–F with 1–4 or 2–5, but not with 1–3 or 1–5). In certain contexts, this rule must be dropped (e. g., a rising C–D that is preceded by a high C and followed by low D may be played 1–5).[2]
- Avoid the thumb and the little finger on black keys.
- In ascending right-hand (RH) and descending LH passages, turn the thumb under finger 2, 3, or 4; and in descending RH and ascending LH passages, turn finger 2, 3, or 4 over the thumb.
- When turning the thumb, place it on a white key immediately before or after another finger on a black key.
- Change fingers on fast repeated notes.
- Make mute finger changes on sustained notes if necessary for finger legato.

These rules are primarily anatomical and motor in nature, and tend to ignore cognitive and interpretive constraints, although the idea that specific scales should always be played with the same fingering may be regarded as a strategy to reduce cognitive demand. Türk's rules are of interest to us because we believe that a thorough understanding of anatomical and motor constraints will be a prerequisite for a systematic exploration of cognitive and interpretive constraints.

In our systematic exploration of piano fingerings, we plan to test rules such as these, and on that basis to develop a style-specific rule system that accurately reflects modern practice. In a first pass at the problem, we have developed a model that is restricted to short melodic fragments to be performed by the right hand. The model includes the following stages. First, enumerate all possible fingerings of the fragment, taking into account the maximum possible stretch between each pair of fingers. Then estimate the difficulty associated with each fingering, by adding contributions from a number of sources: the use of weaker fingers (4, 5); stretches that approach the maximum possible stretch between a given pair of fingers; compressed hand positions in which the fingers are uncomfortably close to each other (including thumb turning); changes of hand position; 1 or 5 on black; 4 on black next to 3 on white; and turning 1 onto black. Finally, put the difficulty estimates into rank order; the fingerings estimated to be the easiest should correspond to those used by pianists. Both fingerings collected from actual performances and fingerings that pianists write on scores may be used as raw data against which to compare the predictions of the model.

Video method

The most straightforward way to record piano fingering in live performance is to record the performance on video and to transcribe the fingering while playing back in slow motion. We have found that the best position for the camera is vertically above the middle of the keyboard (bird's-eye view). It is important that strong lights be used (say, 1000 watt) to minimize the exposure time of each frame and hence blurring in high-

Halle. Facsimile, Kassel: Bärenreiter 1962.

[2] Here, fingers are numbered as in modern keyboard music, with 1 = thumb, 2 = index finger, 3 = middle finger, 4 = ring finger, and 5 = little finger.

speed playing. We have used a bright light mounted on a stand and placed at one end of the keyboard at a 45 degree angle; the shadows cast by such a light make it easier for the transcriber to see which keys are depressed at any moment.

The video method has the advantage that it is non-intrusive to the pianist, and that it preserves information about movement of the fingers and hands. The major disadvantages of the method are that it is sometimes difficult to see the thumb (occlusion problem), that the transcription process is strenuous and time-consuming, and that the transcriber may make errors.

We have tried to minimize the drawbacks of the video method in various ways. First, inspired by recent work in Florida,[3] we have attempted to create a user-friendly environment for transcription. The transcriber (herself a pianist and a university-level music student) views the video on a computer screen; the computer is equipped with video card and associated software. MIDI data from the performance are displayed on the screen alongside the video. A set of five keys on the computer keyboard, chosen to fall comfortably under the fingers of the transcriber, are redefined as numbers 1 to 5. The transcriber then simply mimics the finger movements of the pianist as seen on the video. At any time the transcriber can stop and see what fingerings have been entered into the file, and if necessary correct mistakes.

We use a video machine with a shuttle control that is capable of running at half speed (with sound down an octave) and at slower speeds (with no sound). An important feature of the video player that we use, and a feature that is not available on many commercially available units, is a pause facility that reverts after pausing to the previous tape speed, rather than automatically changing back to full speed. Even with this equipment, the task of transcription is strenuous, requiring uninterrupted concentration; for this reason we insist that our transcriber work for no longer than two hours at a time, with a break after one hour. To monitor any human error, we spot-check the reliability of the data by re-transcribing selected passages.

Fingering glove

An alternative to the above is to attempt to develop a more direct fingering recording method. We are currently working on a ›glove‹ that records fingering automatically as a pianist plays on a MIDI keyboard. Due to various technical problems, the glove is not yet operational. Here, we describe the main features of the glove as we currently envisage it.

Each fingertip bears a pressure-sensitive pad. The pads are held in place by tight plastic covers; for this purpose we have used the fingers cut from a surgical glove. Each pad currently consists of a small piece of piezo-electric film. The film bends slightly as the finger hits a key, producing a voltage that depends on the rate of bending. The piezo is connected by a wire running along the top of each finger to a small electronic circuit, which is mounted like a watch on the pianist's wrist. The voltage produced by the film at each key impact is converted from analog to digital, triggering a digital pulse when the analog signal passes a given threshold. The threshold must be adjusted individually

[3] Andreas C. Lehmann, R.H. Woody, & K.A. Ericsson: Capturing fingerings in piano performance: VIBAFIN (Video-based transcription of fingerings). *Computing in Musicology*, in press.

for each finger, and can only be adjusted once both the pad and the cover have been put on the fingertip.

The pulses are converted to MIDI signals by a commercially available device (York MIDI Creator). The MIDI signal from the two hands is combined with the MIDI output from the piano, again with a commercially available device (Philip Rees MIDI Merge Unit). The resultant MIDI file alternately contains note onsets and finger impacts. Finally, each finger impact is assigned to the note occurring closest to it in time, by means of a computer program.

Progress on the glove has been delayed by a number of problems. The main problem is that piezo film responds to bending rather than pressure. As a result, the film tends to respond when it should not (e. g., when the finger moves without striking a key), or not to respond when it should (e. g., when a key is depressed gently). It has not, so far, been possible to calibrate a piezo-equipped fingertip so that it reliably responds to key presses and nothing else. One solution may be to develop more sophisticated software which can distinguish key presses from other disturbances to the film, perhaps by eliminating apparent finger presses which do not coincide (within an appropriate time window) with a note being sent from the piano. We have begun to explore sensors that are directly sensitive to pressure (e. g., resistance proportional to pressure), but so far without success.

As conceived, the fingering glove would have the advantage of reliability; that is, it would not be susceptible to the kinds of human errors that can occur during video transcription. A major disadvantage of the method is that it may interfere with the performance itself. For the method to be useful, the glove should of course have no effect on a pianist's finger choices.

Outlook

At the time of writing, a first set of data have been collected using the video method, and analysis is in progress. We are investigating possible solutions to the various problems associated with the glove method.