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Axel Berndt, Tilo Hähnel Chapter 5

Studying Music Performance and Perception via Interaction

Abstract Musicians achieve expression in their performance to a large part by using holistic concepts. Likewise, many aspects of expression are perceived unconsciously by listeners. For performance research and the development of models for synthetic music performance the challenge lies in uncovering the underlying principles of a widely undiscovered interplay between several parameters like timing, dynamics, and articulation. Inégalité is a typical example for this. Simply put, the impression of inégalité in musical pulse refers to an unequal playing of notes of equal value. This involves the full range of performance aspects and complex interdependencies between them. Novel interactive techniques for performance synthesis open up new possibilities to study these performance aspects and interdependencies more effectively. We demonstrate this by a study that addresses inégalité, in which experts and non-experts interactively adjusted the performance of a short musical phrase. The results give insight into the relationships of different performance parameters and they give rise to discussing the role of expertise and skill. With this chapter, we exemplify and hope to inspire music-related research methods that are driven by new interactive music techniques.

5.1 Introduction

Conveying the impression of liveliness in a synthetic music performance requires a vital work with performance features, such as timing, dynamics, and articulation. Techniques for the synthesis of expressive music performances have been developed for several decades now and they had a first peak in the 1980s

when Todd (1985) presented his "Model of Expressive Timing in Tonal Music". Computer-based expressive performance techniques are based on machine learning techniques (Widmer, Flossmann & Grachten 2009), mathematical models (Todd 1985, 1989, Mazzola, Göller & Müller 2002), and rule systems (Friberg, Bresin & Sundberg 2006). An introduction and overview of the subject is given by Widmer & Goebl (2004) and also Hähnel (2013) and Berndt (2011*b*). One aim of performance research in this context is the search for appropriate models and parameterizations to describe performance features, detect typicalities in human performances, and be able to synthesize human-like performances. This may then lead to better tools for computer-based music production.

However, the parameter space that is spanned by musical performance features is high-dimensional. An analysis by measuring human recordings (Gabrielsson 1999) is usually confronted with an ambiguous interplay of several layers of features of which a single one is hard to isolate. Instead, listener studies can be performed in the following way. Based on deliberately produced musical material, listeners judge performances and, thus, provide clues for the underlying research question (Gabrielsson 1985). But even this approach is limited, since human musicians intuitively perform many features, over which they have only limited control. It is extremely hard, if not impossible, for most musicians to consciously form, e.g. a linear and an exponential ritardando. With synthesized musical material it is much easier to vary such parameters with finest nuances, as fine as the research question and stimulus design for a study demands. The number of stimuli and the length of such a study are, however, limited for practical reasons.

At this point interactive music techniques come into play. Participants can interactively explore the parameter space and adjust certain performance features according to a given task. In contrast to a mere listening study the participants are now actively involved. They decide about the necessity and degree of settings and their gradual refinement. Thereby, a much wider parameter space can be covered. In the study described below we could effectively cover a three-dimensional parameter space, 21 grades per parameter, in sum 9,261 different stimuli. This exemplary study addresses a performance phenomenon called "Inégalité".

The succeeding section provides an introduction to this phenomenon and related research. The technical background and methodology are described in Section 5.4. Interdependencies between different parameters are uncovered in Section 5.5. It turned out that the ability of identifying the performance parameters is an important aspect and has an effect on the responses. Section 5.6 in-

This is a reading sample!

5.3 Hypotheses

From the foregoing considerations we assume that in notes inégales, onset timing, loudness, and tone duration are used to emphasize a tone. If each of the parameters has an effect on the perceived degree of inégalité, this effect should be increased when all parameters are used simultaneously. To avoid an overemphasis, the intense use of one parameter should imply a rather moderate use of the others. These considerations led to the following hypotheses.

1. When controlled separately, the parameters of loudness, timing, and duration are used to a larger extent than in combination.
2. Assuming an interdependency between and somehow interchangeability of the parameters, there should be a negative correlation between all parameters when used in combination.
3. The results are more distinct, if not only significant for participants who are experts. Experts should also be more correct in identifying a parameter by listening.

Following Gabrielsson (1985) a further question was whether specialized performers or listeners prefer a different degree of inégalité than non-specialists.

There are two contradictory hypotheses regarding expertise. Experts may prefer a higher degree of inégalité, because they are used to it, as Gabrielsson (1985) showed for inequality of beat length in the Viennese Waltz. On the other hand, it is also possible that non-experts intuitively prefer a degree of inégalité of a similar intensity, because the macro timing is not affected and the inequality of eighths notes is used in a wide range of styles, right up to Jazz music's swinging eighth notes. As a consequence of these contradictory hypotheses, the investigation of expertise is rather exploratory than hypothesis-driven.

5.4 Methodology

The analysis-by-synthesis approach that this study is based on reaches back to Metfessel (1926) and Seashore (1932). It was detailed by Bengtsson & Gabrielsson (1977). Various stimuli are presented to listeners, who were then asked to judge them. These stimuli comprized synthetic performances that differed in the characteristic of some particular performance parameters. For the present study

this approach has been modified for the following reason. The total amount of stimuli depends largely on the number of grades a parameter is subdivided into. A combination of three parameters of 21 grades each, as in this study, results in $21^3 = 9,261$ stimuli, which are practically impossible to be all presented to the listeners. The problem was to provide all stimuli but at the same time reduce them to a minimum. This was solved by letting the participants manipulate these three parameters independently and interactively until they approved the parameter combination they preferred. The whole procedure, the participants and the technical setup are described in the following sections.

5.4.1 Participants

In order to analyze the expertise of the participants, diverse skills were captured in more detail. It was important to test musicians with advanced skills and knowledge about the Baroque performance of notes inégales. Hence, the test included musicologists, musicians, music teachers, and professional musicians specialized in Historically Informed Performance.

The participants were 36 western socialized adults (21 female, 15 male). To ascertain their expertise they were asked for how many years they were playing an instrument, whether they had a degree in music, musicology, music education, or similar subjects, how much they liked classical and Baroque music, and whether they were working as professional musicians. The answers were used in the later analysis to test which expertise influenced particular results most.

10 participants were professional musicians, 16 had a degree in music, 20 played an instrument for more than 10 years, 14 of which for more than 20 years. 25 stated to like classical music or Baroque music in particular. 22 were acquainted with the term Historically Informed Performance.

5.4.2 Stimulus Design

The stimulus comprised the first four bars of a Polonoise composed by Georg Philipp Telemann, shown in figure 5.1. Two tests were carried out, first a *separate parameter test* and then a *combined parameter test*. In the first test the participants were asked to modify the performance of the eighth notes of the stimulus, which was presented in a playback loop. Either timing (esp. rubato), dynamics (esp. metrical accentuation), or articulation (focussing on tone duration changes) were modified (refer to section 5.4.3 in this book for further details of the parameters and their implementation), i.e., only one parameter was set modifiable at

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The crucial aspect of motor planning and motor control is known at least since Clynes & Walker (1982) and Shaffer (1981). In their view, a motor program allows storing a single movement which consists of temporal and spatial parameters. Applied on an instrument, these movements cause certain effects on timing, loudness, and articulation. In a similar way these parameters seem to be perceived as a whole rather than as a combination of different parameters. Only the group of professional musicians, which assumedly have internal representations of the movements simulated in the stimuli, as well as a broad declarative knowledge, were very close to identifying the parameters better than the other participants at a significance level of $\alpha = 0.05$.

The gender difference observed can hardly be explained. The most probable explanation would be the constitution of the participants. Separately analyzed, women did not significantly differ from men with respect to a degree in music, profession, or the time span they were playing an instrument. But they were to a larger degree represented in several expertise groups. In sum, this might have had an effect in this particular case.

5.7 Summary

Listeners prefer eighth notes to be played inégal by different means. Surely, loudness, onset timing and tone duration are among these means. They are not independent from each other. In particular, loudness and timing are negatively correlated.

Participants with expert knowledge in Historically Informed Performance did not differ significantly from non-experts. But the data of participants who were able to identify the parameters by listening, showed a decreased variance. The difference in parameter identification between professional musicians and non-experts was, however, non-significant in most cases. But that the difference was near significance raises further questions that should be answered in future tests. Above all, the observation that professional musicians might differ from musicologists and skilled but nonprofessional performers led to the (still rather speculative) assumption, that expert knowledge comprises both, declarative knowledge and motor skill.

The technical challenge for this study was that the participants had to manipulate three parameters independently and interactively. By the use of an interactive tool, participants could adjust these three means in a four bar phrase taken

from a piece of Baroque music. Besides the purely technical challenge, it was difficult for the participants to handle three parameters independently, especially for non-experts. A reason for this might be that humans tend to perceive—and as well produce—different performance parameters as one entirety of a musical movement.

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