Strategies for the exploration of ornament performance

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Abstract

Performing music is a creative process, even if notated music is performed. It is creative in the sense that performers have to establish and refine an interpretation of the music, given the under-specification of western notation and the aesthetic demands to provide an individual, but coherent, interpretation. Part of the practice is to explore interpretations and refine a chosen interpretation. Focusing in on this process, we asked student pianists to explore different ways of performing a musical ornament in order to improve their ability to imitate example performances of the ornaments, which was tested before and after the exploration training. Within the exploration training, participants showed a variety of strategies to explore ornament performance, varying the time-steal characteristics, the accenting pattern or the time inserted to add an ornament. Principle-component-analysis was used to define these strategies and loadings on the factors of exploration were used to define trajectories of exploration. This procedure highlighted strong differences between the tendencies of participants to explore the performance space defined by a factor. While some participants explored the entire factor, the performances of other participants remained within a specific area of interpretation. Wide exploration and jumps in interpretation were generally associated. Nevertheless, some participants combined small inter-trial changes with wide exploration, suggesting exploration through refinements. The results of the study are limited to the interpretation of a specific musical element. Nevertheless, parallel strategies seem to exist in music performance in general, opening educational possibilities for training these skills as well as providing direction for wider investigation of creative strategies in performance.

Keywords: music performance; creativity; cognitive strategy; ornament timing.

Introduction

Creativity in performance of western classical music is related to the interpretation of music as it is notated in a score. Although music notation restricts the potential creativity of musicians compared to the creative possibilities in, for example, improvised music, performing music from a score nevertheless provides musicians considerable expressive freedom. Although the performed notes may be the same, the timing of simultaneous and sequential events is varied, as well as the intensity of events, the duration, and, for most instruments, the intonation of events. Taken together the combinatorial possibilities for expression are endless.

To some extent, performers tend to explore only a particular area of the hypothetically possible performances. This is suggested by found performance rules (e.g. Sundberg, Askenfelt, Frydén, 1983; Todd, 1985; 1992; Repp, 1992a; 1992b). These performance rules define "styles of thought" or conceptual spaces, in the terminology of Boden (2004), that can in themselves be explored. Moreover, over the decades, performance styles change considerably (e.g. Philip, 1992) and even on an individual level, performers can markedly be innovative, indicating in Boden's terms "transformations of the conceptual space".

A special instance of performance expression relates to the interpretation of musical elements whose notation is underspecified. This concerns music notation in general, however it concerns ornamental notes in particular. Ornaments are notated by symbols that indicate the kind of ornament, but do not contain an explicit rhythmic prescription that is otherwise used in music notation.

Several conventions have been established by musicians related to the performance of ornaments. For example, it is common in performance treatises to distinguish between ornaments that are 1) accented and long, and conventionally performed "on the beat", and 2) unaccented and short, and often performed "before the beat" (Neumann 1986; Donington, 1989). Indeed, recently, we showed that the timing of one-note ornaments (grace notes) clusters into two categories, even for the same musical fragment, that show distinct temporal positioning of the grace note and distinct durations of the grace note (Desain & Timmers, 2008).

Having established an interpretation of the music, performers show amazing consistency over repeated

performances, which may even approach the limits of motor control and just-noticeable differences in perception (Desain & Timmers, 2008). However before establishing an interpretation, performers often explore different possibilities. Although performers seem to have a default interpretation of familiar music that they use for example when sight-reading, advanced performers do spend considerable time defining, shaping, and refining an interpretation, especially when preparing for a concert performance (Chaffin, Imreh Lemieux, & Chen, 2003). This process often includes the exploration of alternatives (see also Davidson & King, 2004).

Note that "divergent thinking" is combined with a process of "evaluation", in this case within the same person rather than between a person and a field (Csikszentmihalyi, 1988; Gardner, 1993). It is the process of exploring, shaping and refining that is creative, and which demands considerable resources of concentration, goal-setting, self-evaluation and problem-solving ability (Chaffin & Lemieux, 2004). Assuming that the performer is not satisfied with a default manner of performance, he/she has to find and refine a new way that is satisfactory.

In the study, we asked student pianists to explore different ways of performing a musical fragment containing a grace note in order to refine their ability to imitate examples of grace note timing. They had 36 trials to explore and refine grace note performance. Participants performed on a MIDI grand piano, which allowed us to precisely record the timing and key-velocity of individual notes. Key-velocity is an indication of the intensity of a note. It refers to the velocity with which the key hits the string. Focusing on the timing and dynamics of the grace note in the context of surrounding notes, variations in performing and interpreting the grace note can be captured using a relatively small number of performance features (11 in total, see method section). Both the recording of the second to second development of the exploratory process and the exhaustive definition of the performance features provides a unique possibility of investigating cognitive strategies for exploration in real-time without interference from an experimenter or the interference of self-report.

Little is known about exploratory strategies in music performance, and therefore we had limited prior expectations besides the following. It may be that different performers show varying preferences for the variation of particular parameters, e.g. varying dynamics rather than timing (Sloboda, 1983), or that performers differ in style of exploration, being either mostly consistent or explorative (as in Timmers, Ashley, Desain, & Heijink, 2000). Performers may switch between different interpretations, as predicted by the clustering observed in natural performances of these musical excerpts (Desain & Timmers, 2008) rather than trying out a range of interpretations in between. In other words, they may respect the established conceptual spaces, or break the rules. Although the musical framework establishes a number of constraints, the ornament may nevertheless afford exploration, when participants try to find the limits of what is still feasible.

Method

Participants

24 piano students participated in the study (13 females and 11 males, average age: 25.5 years old). They were all students of the Royal Conservatoire of The Hague. Most of them were very advanced with 17.4 years of piano training on average (std 5.2 years).

Material

The participants performed two musical excerpts taken from the theme of Beethoven's Paisiello Variations from musical notation in a moderate tempo (dotted 8th note is 60 BPM). Scores of the excerpts are shown in Figure 1.

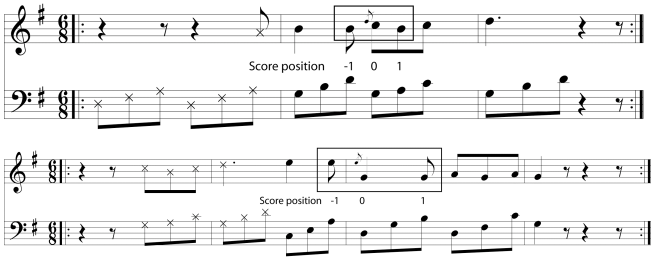

Figure 1: Scores of Excerpt 1 and 2. The first six 8th notes (illustrated as cross notes) are performed by a computer to indicate the tempo, where after the participant continues the performance. The timing of the notes within the square is varied and visualized in the feedback.

In the pre-test and post-test (see procedure), nine computer-generated performances of each fragment were used that only differed in the timing of the grace note and its surrounding notes. The different renditions were a sampling of interpretations of these ornaments by professional pianists collected and modeled in a previous study (Timmers, Ashley, Desain, Honing, & Windsor, 2002).

Procedure

Each participant performed both excerpts, where the order of excerpts was counter-balanced. The procedure for both excerpts was identical and included 1) the performance of the excerpt without the grace note, 2) a pre-test imitation of nine computer-generated performances; participants heard the fragment with a particular rendition of the grace note and had one trial to imitate it, 3) an exploration training consisting of 36 trials, and 4) a post-test imitation of the nine computer-generated performances. In all instances, participants continued the performance of the excerpt after a computer-generated introduction that indicated the tempo of performance (see Figure 1).

Half of the group of participants received visual feedback during the exploration training, which visualized the timing

of the grace note and its surrounding melody notes (examples with explanation are given in Figure 2).

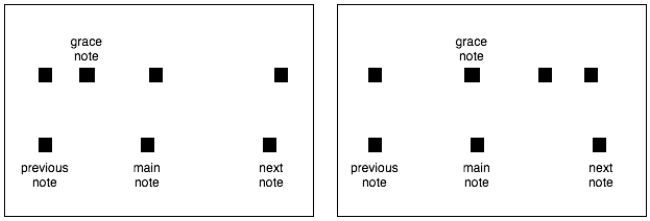

Figure 2. Examples of the visual feedback as used in the instruction to the experiment. Timing of the melody notes is shown with the grace note (top) compared to the without grace note timing (bottom).

Feature analysis

The analysis focuses on the characterization of the performances in the exploration training only. It does not consider the effect of visual feedback, nor the relation between the training and the imitation performances in the post-test compared to the pre-test, which are the subject of a follow-up study.

To characterize the grace note timing strategies in the exploration training, a previously defined model of grace note timing was adapted and elaborated. This model used the grace note duration (Grace IOI or inter-onset-interval between the onset of the grace note and the onset of the subsequent main note, Equation 1) and the changes in the onset timing or inter-onset-intervals of the surrounding melody notes (see Timmers et al 2002).

The timing of the grace notes was modeled as "time-shift" or "time-stealing", capturing the adaptations of the timing of the surrounding notes to add the ornament by either inserting time and shifting all subsequent notes, or by taking time and shortening intervals between surrounding notes. These changes in timing are then expressed as proportions of the grace duration (Grace IOI), highlighting which part of the length of the grace note is acquired by stealing time or by shifting notes in time.

In the original model, the timing of notes in performances with a grace note is directly compared to the timing of notes in performances without a grace note, assuming a performance context in which tempo differences between performances are minimal. However, while exploring grace note timing, participants took the freedom to slow down or speed up the overall tempo if found necessary, and tempo differences between trials were considerable. Therefore two alternative definitions of timing of the grace note and time-steal and time-insert measures were formulated. The first definition compares the actual timing of melody notes with a grace note to the predicted timing of the melody notes without a grace note, if participants would have continued performing the music in the respective initial tempo. The difference in time is divided by the grace IOI (Equation 1) to get the proportion of the grace duration that is taken from the previous IOI (Equation 2) or main IOI (Equation 3) or acquired through shifting the next note (Equation 4).

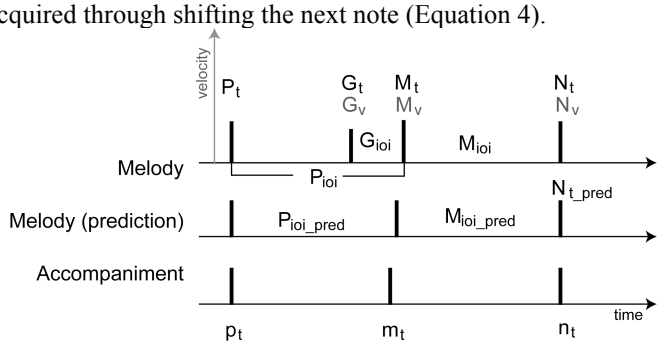

Figure 3. Schematic of the feature parameters. The black letters refer to timing parameters, while the gray letters in the melody plot (top) refer to velocity parameters.

In these equations, a capital letter refers to the timing of a melody note, while a lower case letter refers to the timing of an accompaniment note (Equations 5-7). P is the previous note (score position -1), G is the grace note (score position 0), M is the main note (score position 0), and N is the next note (score position 1). See Figure 3 for an illustration of the parameters used for the features.

$$G_{ioi} = M_t - G_t \quad (1)$$

$$pG = \frac{P_{ioi\_pred} - P_{ioi} - G_{ioi}}{G_{ioi}} \quad (2)$$

$$pM = \frac{M_{ioi\_pred} - M_{ioi}}{G_{ioi}} \quad (3)$$

$$pN = \frac{N_{t\_pred} - N_t}{G_{ioi}} \quad (4)$$

The second definition uses the displacement or asynchrony between the melody and accompaniment notes, using the tendency for the accompaniment notes to be timed metrically. If the grace note is timed in time of the previous IOI, it anticipates the main accompaniment (Equation 5). If the main or next notes are delayed, they follow the timing of their respective accompaniment notes (Equations 6 and 7). These asynchronies are divided by the grace IOI, to get the proportion of the grace duration that is performed in time of the previous or main note, or that is acquired through shifting the next note.

$$aG = \frac{G_t - m_t}{G_{ioi}} \quad (5)$$

$$aM = \frac{M_t - m_t}{G_{ioi}} \quad (6)$$

$$aN = \frac{N_t - n_t}{G_{ioi}} \quad (7)$$

Additionally, four dynamics features were defined that take the key-velocity of the grace note, main note and next note relative to the average key-velocity of the first melody notes (Equations 8-10), and the difference in key-velocity between the grace note and main note (Equation 11). These measures give an indication of the relative accenting of the respective notes.

$$avvG = G_v - Av_v \quad (8)$$
$$avvM = M_v - Av_v \quad (9)$$
$$avvN = N_v - Av_v \quad (10)$$
$$G_{vi} = G_v - M_v \quad (11)$$

Results

Participants often performed all or close to all 36 trials of the exploration training without any mistake in performance. However, if there was a mistake in notes or order of notes as found through a matching procedure, the trial was deleted. This resulted in the deletion of 4.7% of the trials for Excerpt 1 and 6.8% of the trials for Excerpt 2.

Factor Analysis

To assess the independent or coordinated variation of the 11 performance features over the training trials and participants, a principle component analysis was run followed by a varimax rotation including the four factors that had an eigenvalue greater than 1. This analysis was done for the performances of Excerpt 1 and Excerpt 2 separately.

The main results of the factor analyses are given in Tables 1 and 2, which report the correlation between each feature and each factor as well as the cumulative explained variance. The results for the two excerpts are highly comparable. The first factor is for both excerpts most strongly correlated with the timing of the grace note and main note with respect to the accompaniment main note (aG and aM). Additionally, for Excerpt 1, Factor 1 is correlated with the grace note timing with respect to its predicted position (pG), while, for Excerpt 2, Factor 1 is correlated with the asynchrony between the next melody and accompaniment note (aN) (an interpretation of these results is given below). Factor 2 is most strongly correlated with the key-velocity of the grace note (avvG), the difference in key-velocity between the grace and main note (Grace VI) and the duration of the grace note (Grace IOI). Factor 3 correlates most strongly with the timing features that use the predicted temporal position of the main note and next note (pM and pN) for Excerpt 1, and of the grace note, main note, and next note (pG, pM, and pN) for Excerpt 2. Factor 4, finally, correlates most strongly with the key-velocity of the main note and next note relative to the average velocity (avvM and avvN).

These four factors can be interpreted as representing different strategies to vary the performance of the grace note. Factor 1 represents the variation of the temporal position of the grace note, through stealing time from the surrounding notes, while keeping the time inserted constant. In particular, the grace note is placed at varying positions before or after the accompaniment main note, leaving the next note unaffected for Excerpt 1, but also influencing the asynchrony of the next note for Excerpt 2. Factor 3 represents, on the other hand, a strategy to vary the timing by actually inserting (or subtracting) time. In this case, the asynchronies with the accompaniment notes are unaffected, while the positions relative to the predicted onset times are affected. For Excerpt 1, the time insertion concerns primarily the main and next note, while, for Excerpt 2, it concerns all three notes, suggesting that the insertion precedes the grace note rather than follows it. With more time insertion (pN increases), the time stolen from the previous and main note (pG and pM) decreases.

Factor 2 and Factor 4 rather represent variations in accenting and lengthening the grace note (Factor 2) or accenting the main note (Factor 4). Apparently, there is no strong covariance between accenting pattern and temporal placement of the grace note. Instead onset-timing and accenting are varied separately.

Table 1: Pair-wise correlations (N = 823) between features and factors for performances of Excerpt 1. Cumulative explained variance is given in the bottom row.

Feature	Factor 1	Factor 2	Factor 3	Factor 4
Grace IOI	-.09	.71	.00	-.14
pG	.78	.03	-.31	-.03
pM	-.29	.00	-.89	.05
pN	-.37	-.02	.90	-.02
aG	.94	-.15	.13	.03
aM	-.94	.15	-.13	-.03
aN	-.35	.39	.20	-.24
avvG	-.04	.81	.01	.48
avvM	.05	-.20	.13	.85
avvN	.00	.00	-.16	.76
Grace VI	-.07	.87	-.09	-.23
Cum. %	25	45	61	76

Table 2: Pair-wise correlations (N = 805) between features and factors for performances of Excerpt 2. Cumulative explained variance is given in the bottom row.

Feature	Factor 1	Factor 2	Factor 3	Factor 4
Grace IOI	.16	.64	-.07	-.09
pG	-.09	-.03	-.86	.03
pM	.47	.07	-.71	-.08
pN	-.28	-.03	.96	.03
aG	-.97	-.11	.15	.06
aM	.97	.11	-.15	-.06
aN	.78	.03	-.06	-.02
avvG	-.01	.87	.08	.33
avvM	-.07	-.19	.11	.88
avvN	-.03	.06	-.06	.76
Grace VI	.05	.85	-.02	-.43
Cum. %	26	44	64	79

Exploration of factorial dimensions

To characterize the manner in which participants explored the different dimensions highlighted by the factor analysis, each factor was subdivided into 8 zones of equal data distribution (a subdivision in "octiles"): Zone 1 of Factor 1 contains the 12.5% of the data with the lowest scores on Factor 1, while Zone 8 contains the 12.5% of the data with the highest scores on Factor 1, etcetera. We use these subdivisions of the factors to assess the areas of the four-dimensional space that participants are exploring: whether participants stay within the same zone, jump between different zones, explore widely or explore neighboring zones. The reason to define these zones rather than using the continuous scale of the factor loadings is that the data distribution for all factors tends to deviate considerably from a normal distribution, having long tails on both sides as well as a peaky distribution in the middle.

Figure 4 shows the relative frequencies of data points within each zone per participant for Factor 1 of Excerpt 2. As can be seen, the data of some participants almost exclusively fall within one zone, indicating a preference for a particular interpretation, while the data of other participants distribute almost equally over all eight zones, suggesting wide exploration of the performance space. If we quantify the unevenness of distributions as the relative size of a zone compared to the next-smaller zone, participants who are conservative in exploration show an unevenness in distribution as large as 1.7 to 2.8, depending on the factor and excerpt. This indicates that the frequency of occurrence of frequent zones is on average almost twice or three times as large as the frequency of occurrence of the next-frequent zone. In contrast, the unevenness in distribution for explorative participants may be as small as 1.1 to 1.2, depending on the factor and excerpt, approaching an almost perfectly even distribution of 1.

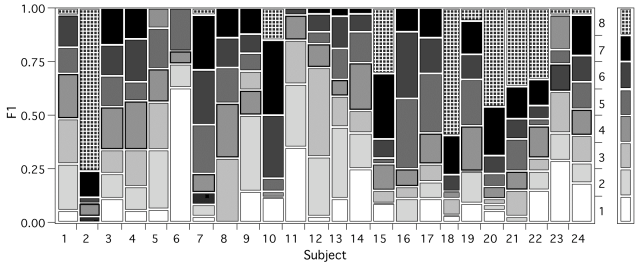

Figure 4: Relative frequencies of data points of individual participants performing Excerpt 2 that fall within zones 1 to 8 of Factor 1.

Figure 5 shows a similar distribution plot for the difference between zones of data of subsequent trials. In other words, it characterizes the trial-to-trial behavior. As clearly apparent in Figure 5, the most frequent difference in zones between subsequent trials is a difference of 1, followed by no difference (delta is 0). In contrast, the tendency to jump to a zone far apart is very small.

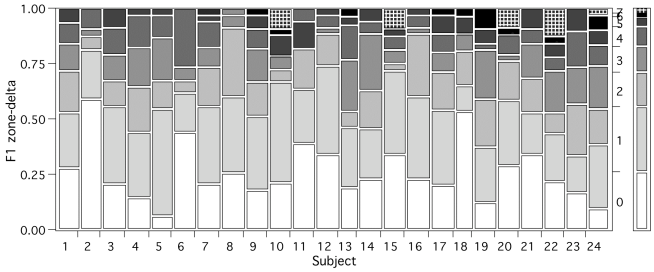

Figure 5: Relative frequencies of differences in zones of Factor 1 between subsequent trials of individual participants performing Excerpt 2.

Nevertheless, the tendency to repeat or change interpretations in subsequent trials varies considerably over participants. Participants who maximally jump between interpretations show an average weighted zone difference of 3.6 to 4.5 on a scale from 1-8, depending on the factor and excerpt (weighted according to the frequency of occurrence). In contrast, participants who maximally repeat show an average weighted zone difference of only 1.8 to 2.4, depending on the factor and excerpt, showing a very limited tendency to change interpretation.

Interestingly, for all factors of both excerpts, there are always some participants who show both a relatively strong tendency to repeat characteristics, being among the eight participants with the lowest scores for average weighted zone difference, as well as a strong tendency to explore, being also among the eight participants with the lowest scores for unevenness in distribution. Apparently, these participants combine a strategy to refine and explore.

Discussion and Conclusion

The results of this study show that the tendency of student pianists to explore grace note performance varies widely. Some students explored interpretations widely and finely, while others were more conservative in exploration. Nevertheless, this preliminary investigation is not sufficient to claim that some performers were more successful in exploration than others. For example, some participants might have compromised a number of constraints in order to be more explorative than others. In particular, participants may have shown a speed-accuracy tradeoff (Fitts, 1954; Fitts, & Peterson, 1967): compromising speed in order to time more finely, or, vice versa, keeping the speed, but being less differentiated in performance.

Another issue is the availability of feedback that visualizes the characteristics of the performed notes. It is likely that visual information may have influenced the explorations, functioning both as a source of information (affording ideas for exploration) and a form of feedback. Because the feedback highlights certain performance aspects, we actually expect more focused exploration within the participant group receiving visual feedback. In a continuation of this study, we will investigate the effect of visual feedback as well as the possible transfer of

exploration training to the ability to imitate the target performances within the "post-test".

The results have highlighted part of the dynamics of exploration (Thelen & Smith, 1994): how the performances of some participants fluctuate around "attractor" zones within the performance space, and how the performances of other participants show less stability and vary more freely in characteristics. It emphasized personal (p-creativity) rather than historical creativity (h-creativity; Boden, 2004). Nevertheless, to explore widely, participants abandoned regular performance constraints. They explored the options that were available: the relative positioning, the relative intensities and durations, and the insertion of pauses.

Although these exploratory dimensions may seem particular for ornament timing, they are actually expressive strategies that can be used in performance more generally; giving length to notes without losing tempo (tempo rubato; Donington, 1989; Hudson, 1994), inserting a micropause (Sundberg et al, 1989) or accenting using duration or intensity (Sloboda, 1983).

For educational purposes, it might be very important to explicitly refer to these kinds of strategies and be more aware of their applicability. Training them in a well-defined setting such as ornament performance might be a way of enhancing their usability. Building on research on music performance of ornaments as well as larger musical structures (Desain & Honing, 1994; Timmers, 2002), an automatic evaluation and feedback system is now within reach that assists music students in enhancing their technical skills as well as hopefully motivating their exploratory tendencies.

Acknowledgments

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