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Effects of musical texture, performer's preparation, interpretative goals, and musical competence on error patterns in organ performance

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This study compared the influence of musical texture (homophony versus contrapuntal writing), conditions of preparation (sight-reading versus prepared), interpretative goals, and level of competence (results in organ performance competitions) on the type and number of errors that are committed in organ performance. In the sight-reading condition, eight professional organists recorded different interpretations of two short Baroque organ pieces of contrasting texture. In the prepared condition, 16 organists made two recordings of J.S. Bach's organ fugue in D minor (BWV 538). Results show that musical texture has a strong effect on the type of errors: substitutions and intrusions tend to be more contextually appropriate when the musical setting is mostly homophonic than when it is contrapuntal. Interpretative goals also affect the distribution of errors: organists make fewer errors for the notes belonging to the voice that they are trying to emphasize. In addition, the error rate is higher for notes belonging to inner voices and is positively correlated with onset density. Finally, although musical competence had no significant effect on error rate in sight-reading conditions, the prize-winning performers made significantly fewer errors in the prepared condition.

Keywords: organ performance; performance errors; musical structure; interpretation; musical

The analysis of performance errors is a powerful tool that provides valuable data which can be used to build plausible models of the performer's mental representation of a musical score (Palmer and Van de Sande 1993, 1995; Repp

1996). Such an analysis allows us to study the effects of musical texture, interpretative goals, and musical competence on this representation. The present study sought to compare the influence of musical texture (homophony versus contrapuntal writing), conditions of preparation (sight-reading versus well-prepared piece), interpretation (emphasizing a given voice, mechanical versus expressive performance), and level of competence (as assessed by results in organ performance competitions) on the type and amount of errors that are committed in organ performance.

METHOD

Participants

All participants were professional organists from the Montreal area, or organ students at McGill University in Montreal. Table 1 summarizes the relevant information about the participants.

Materials

Three pieces were selected for this study. In the sight-reading condition, organists recorded a short French Baroque contrapuntal piece (*Premier Agnus* by Nicolas de Grigny) and a short German Baroque homophonic piece (a chorale harmonization of *Wachet auf, ruft uns die Stimme* by Samuel Scheidt). In the prepared condition, two recordings of the *Organ Fugue in D minor* BWV 538 (also known as the "Dorian" fugue) by J. S. Bach were made.

The performances were recorded on the Casavant organ of the Church of St-Andrew and St-Paul in Montreal, Canada. This five-manual organ (five keyboards and a pedal-board) was built in 1931. The console was restored in 2000, at which time a MIDI system was installed by Solid State Logic.

Procedure

In the sight-reading condition, the score was given to the organists 20 minutes before the recording session began, in order to give them time to practice on the organ. For the contrapuntal piece (*Premier Agnus*), three different interpretations were recorded. In one interpretation, the organists were told to emphasize the soprano part, in another, the alto part, and in a third one, the tenor part. Two recordings were made for each interpretation. The order of the instructions was randomized according to a Latin square design. For the homophonic piece (*Wachet auf*), two different interpretations were recorded. In one interpretation, the organists played the piece in an expressive way, while in the second they were asked to play a mechanical, or

Table 1. Information on participants**.** F=female; M=male. The age range is indicated in years in parentheses. Prize-winners refers to the number of organists who have won prizes at national or international competitions.

Piece	*Participants*	*Mean age*	*Prize-winners*
Wachet auf (sight, homophonic)	8 (2F, 6M)	27 (23-30)	3
Premier Angus (sight, contrapuntal)	8 (2F, 6M)	26 (19-30)	3
Dorian fugue (prepared)	16 (2F, 14 M)	37 (24-59)	9

expressionless, performance. For both interpretations, two recordings were made. Organists always played the expressive version first, and then the mechanical one. In the prepared condition (Dorian fugue), organists were given 20 minutes to practice, after which they made two recordings of the piece.

The audio signal was recorded through two omnidirectional Boehringer ECM 8000 microphones. The audio and MIDI signals were sent to a PC computer through a MOTU audio interface, recorded using Cakewalk's SONAR software, and stored on a hard disk. Using the MIDI data, performance notes were matched to score notes using an algorithm written in MATLAB by the first author.

RESULTS

Contextual effects on error rate

It has been observed that more attention is given to outer voices than to inner ones, both when listening (Huron 1989) and while performing (Palmer and Van de Sande 1993). This study corroborates earlier results: in all three pieces the error rate for a given score note was significantly higher for notes belonging to an inner voice than for notes belonging to an outer voice (Table 2).

One could also expect that, since notes belonging to a theme or important motive are presumably given more attention, both on the part of the performer and of the listener, the error rate for these notes would be lower than for non-motivic notes. This hypothesis was tested on the performances of the Dorian fugue, which was the only piece of substantial length under study here. Since this piece is a fugue, motives are present in all the voices; however, most motives occur in outer voices, presumably because the composer wants to make them stand out perceptually. The position of a note (inner/outer voice) was thus also taken into account in order to avoid any

Table 2. Comparison of error rates per score note in outer and inner voices**.** The total number of score notes belonging to each category is given in parentheses. The significance of the χ^2 value was assessed using a one-tailed Fisher exact test (* $p<0.05$, ** $p<0.01$, *** $p<0.001$). The frequency count (total number of notes analyzed for all performances of a given piece) is given in square brackets.

Piece	*Outer voices*	*Inner voices*	*χ^2 value (df=1)*
Wachet auf	1.46% (176)	3.61% (193)	54.36*** [11808]
Premier Agnus	1.16% (136)	1.49% (184)	3.07* [15360]
Dorian fugue	0.33% (1547)	1.01% (1154)	161.56*** [86432]

Table 3. Effect of musical texture on the contextual appropriateness of substitutions and intrusions**.** An error was defined as contextually appropriate if its pitch was equivalent (via octave transposition) to that of another score note belonging to the same chord. Percentages are given in parentheses.

Substitutions and intrusions	*Homophonic (Wachet auf)*	*Contrapuntal (Premier Agnus)*
Contextually appropriate	47 (34.3%)	16 (18.8%)
Contextually inappropriate	90 (65.7%)	69 (81.2%)

confounding effect. A maximum likelihood analysis of variance showed that both factors (outer/inner and motivic/non-motivic) had a significant impact on the error rate per score note [outer/inner: $\chi^2(1)=122.74$, $p<0.001$; motivic/non-motivic: $\chi^2(1)=12.49$, $p<0.001$], with no significant interaction.

Among the other factors affecting the error rate, it seems likely that the number of score notes played simultaneously (or *onset density*) would have an effect, with higher rates of error for score events correlated with a higher onset density. For all three pieces, the average error rate per score note was positively correlated with onset density, with correlations of 0.24 (df=143, $p<0.01$), 0.16 (df=146, $p<0.05$), and 0.08 (df=1382, $p<0.01$) for *Wachet auf*, *Premier Agnus,* and the Dorian fugue, respectively.

Palmer and Van de Sande (1993) had previously shown that musical texture has an effect on the type of errors committed in performance. In this study, we analyzed the effect of musical texture on two types of pitch errors, namely substitutions (replacing a score note by a note with the wrong pitch) and intrusions (playing additional notes not indicated in the score), by comparing the type of errors found in sight-reading performances of a mostly homophonic piece (Scheidt's *Wachet auf*) and a contrapuntal piece (Grigny's

Premier Agnus). These two pieces have approximately the same number of score notes (369 and 320, respectively), with a mostly four-voice texture throughout (average number of active voices per score event=3.98 for both pieces), thus providing an adequate basis for comparison. Table 3 shows that substitutions and intrusions tend to be more contextually appropriate when the musical setting is mostly homophonic and less contextually relevant in a contrapuntal setting [$\chi^2(1)=6.18$, $p<0.05$].

Interpretative goals and performer's intentions

This study also sought to examine whether the intentions of the performer affected the error rate. This was tested by comparing the mean error rate per score note for each voice in all three interpretations of the *Premier Agnus*, in which performers were instructed to emphasize the soprano, alto, or tenor part. Results show that the interpretative goal affects the distribution of errors: although the overall mean error rate does not vary significantly, organists make fewer errors for the notes belonging to the voice that they are trying to emphasize (Figure 1). A repeated-measures analysis of variance on the mean error rate, with instruction and voice as within-subject factors, showed no significant effect of instruction or voice, but a significant interaction between instruction and voice on the error rate [$F(6,42)=2.36$, $p<0.05$, Huynh-Feldt epsilon=1.05].

Musical competence

Repeated-measures analyses of variance were conducted on the total number of errors per performance with musical competence (prize-winner or non-

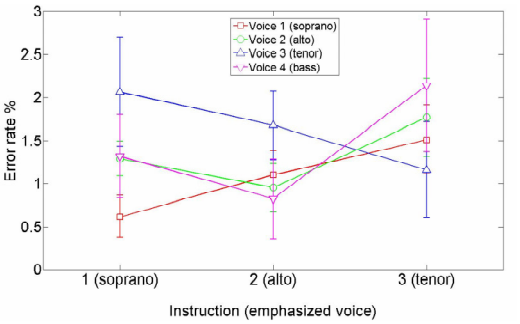

Figure 1. Effect of interpretative goals on error rate. Mean error rate for all voice combinations, averaged across performers. Error bars represent standard errors of the mean. (See full color version at www.performancescience.org.)

prize winner) as a between-subjects factor, for all three pieces. Although musical competence had no significant effect on error rate in sight-reading conditions [$F(1,6)=0.43$, $p>0.5$ for *Wachet auf*; $F(1,6)=0.54$, $p>0.1$ for *Premier Agnus*], the prize-winners made significantly fewer errors in the prepared condition [$F(1,14)=5.43$, $p<0.05$ for the Dorian fugue].

DISCUSSION

The pattern of performance errors is affected by both local musical context and global musical texture, suggesting that musical structure modulates the mental representation of the score at several levels. The effect of the interpretative goal on the pattern of performance errors implies that performers pay more attention to the voice they are emphasizing.

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