Macrotimbre: Contribution of Attack and Steady State

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Abstract: Recorded and synthesized musical instrument tones (oboe and English horn) are used to explore how listeners learn to identify musical instruments. Results show that impoverished forms of musical tones (static steady states), poorly identified in isolation can be well identified in multiple note presentations. This shows that the 'timbre' of an instrument is the composition of multiple timbral qualities occurring across the instrument's pitch range.

INTRODUCTION

Because a musical instrument has different qualities across its pitch range, it is unlikely that its characteristic aural signature, or timbre, is learned from a single performed note. Such a characteristic signature is more likely to be distributed over a series of timbres over different pitches. The features that listeners absorb from such varied input that enables them to identify what they are hearing can be referred to as an instrument's "macrotimbre."

A previous study (1,2) showed that comparing timbres of different performed notes of an instrument helps listeners generalize knowledge and identify instruments from novel presentations. Subjects were posed the task of learning the timbre of two confusable instruments (oboe and English horn) by learning to distinguish them over five common pitches in one of two conditions: either in a manner facilitating comparison of timbre among the five pitches (M-listeners), or impeding such comparisons (S-listeners). Listeners were then tested on notes from a pitch register remote from the training register (novel notes). Whereas S-listeners were substantially worse at the novel notes, M-listeners showed the same performance across familiar and novel notes. This suggests that something about the instrument's timbre is learned over several notes which cannot be learned from notes in isolation.

Two issues of interest are: (1) presumably the listener acquires a more accurate representation with a larger number of presented notes, and (2) attack and steady state portions of tones may contribute in different ways or degrees to acquiring macrotimbre.

EXPERIMENT

Listeners were trained to identify oboes and English horns in a natural context by listening to 25 passages of recorded performances by well-known virtuosi (Thomas Stacy, Carolyn Hove, and Alexandra Pohran). They were then tested on tones of the same instruments (in the range c4 to g5, common to both) taken from the McGill University Master Samples and Prosonus compact disks. On each trial, listeners heard an oboe (OB) presentation immediately followed by the same presentation on the English horn (EH), or in the opposite order. They then identified them by sorting the items from this pair into their choice of OB and EH category (a graphical computer interface was used in which subject moved unmarked sound-icon buttons to bins marked "oboe" and "English horn"). Each trial consisted of one note plus 0, 2, or 4 additional chromatically-contiguous context tones. For example, the note f#4 would be presented as f4-f#4-g4 in 3-note presentations and e4-f4-f#4-g4-g#4 in 5-notes presentations. There were also three tone types: (1) natural recording (standardized to a common length by truncation), (2) a static steady state tone synthesized from a spectrum analysis of the note's sustained portion, and (3) the attack portion of the natural tone smoothly joined into the static steady state described in (2).

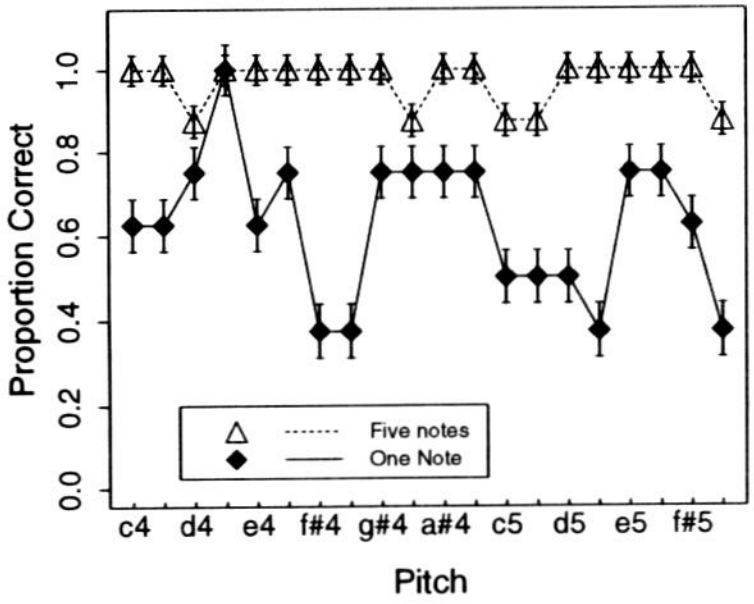

Figure 1: Results for 1 subject (means and standard errors for 8 replications), tone type 3 (static steady states).

Figure 1 gives detailed results showing the effect of number of tones for tone type 3. Here we see many scores for one-note presentations improving from near chance levels to nearly perfect for five-note presentations. Figure 2 shows more general results for tone types 1 and 3, over one-, three- and five-note presentations. Static steady state tones, poorly recognized with one note, are recognized with five notes with better accuracy than natural tones. The steep improvement with number of notes shows that listeners can combine information from steady states across different notes.

Recent research in timbre (3) has suggested that previous research (4, for example) may have overestimated the importance of the attack in the identification of musical instruments, and that greater amounts of information may be carried in the steady state than previously assumed. Results here show that while single tones in steady state form are impoverished, multiple pitches carry information that can make the identity more vivid.

REFERENCES

1. Sandell, G.J. and Chronopoulos, M. (1996). "Identifying musical instruments from multiple versus single notes" (abstract). *Journal of the Acoustical Society of America* **100**, 2752, 1996.

2. Sandell, G.J. and Chronopoulos, M. (1997). "Perceptual constancy of musical instrument timbres; generalizing timbre knowledge across registers" (M. Chronopoulos, 2nd author). In A. Gabrielsson, (Ed.), *Third Triennial ESCOM Conference Proceedings*, 222-227. Department of Psychology, Uppsala University, Sweden.

3. Hajda, J. (1996). "A new model for segmenting the envelope of musical signals: The relative silence of steady state versus attack, revisited." *Audio Engineering Society Reprint* 4391.

4. Saldanha, E.L. and Corso, J.F. (1964). "Timbre cues and the identification of musical instruments." *Journal of the Acoustical Society of America* **36**, 2021-2026.

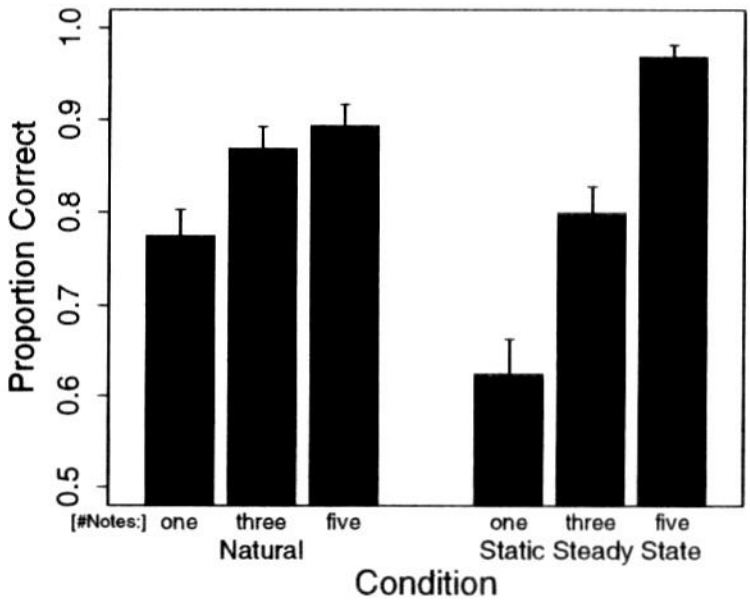

Figure 2: Results for 1 subject (mans and standard errors for 8 replications, collapsed over the 20 notes c4 to g5), for tone types 1 and 3 (natural and static steady states).

Session 4aMU

Musical Acoustics: Timbre of Musical Sound I

James W. Beauchamp, Chair
University of Illinois, 2136 Music Building, 1114 West Nevada, Urbana, Illinois 61801

Invited Papers

8:25

4aMU2. Macrotimbre: Contribution of attack, steady state, and verbal attributes. Gregory J. Sandell (Parmly Hearing Inst., Loyola Univ., 6525 N. Sheridan, Chicago, IL 60626, sandell@sparky.parmly.luc.edu)

The timbre attributes of a source that are contained across variations in pitch, dynamic, and articulation can be referred to as its "macrotimbre." The timbre of a musical instrument changes across pitch, and thus learning its macrotimbre can be dependent upon the ability to make comparisons among individual pitches. Using 20 pitches shared by two easily confused instruments ($C4$ to $G5$, oboe and English horn), listeners performed better at categorizing novel notes (from a pitch range different from those heard in training) when training facilitated comparison of notes (versus isolated presentations) [Sandell and Chronopoulos, Proc. Third ESCOM Conf., Uppsala, Sweden, 222–227 (1997)]. This indicated that information contained across pitches was useful in generalizing timbre knowledge to previously unheard notes. The present study used (1) multiple versions of the tones (natural, shortened, attack + synthetic steady-state, synthetic steady-state alone), (2) a sorting task under conditions where comparisons were facilitated or hindered, and (3) ratings of verbal attributes (nasal, breathy, muffled, etc.) to isolate the relevant across-pitch timbre properties, and appraise the relative contributions of the attack and steady state.

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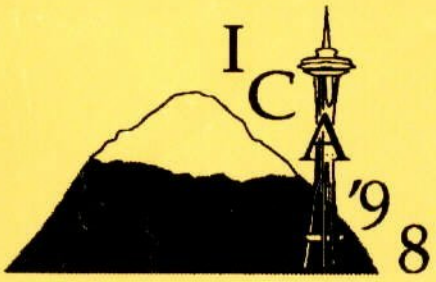

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