Listeners rapidly adapt to timbre

Elise A. Piazza*[1,2,3], Frédéric E. Theunissen[4], David Wessel[5], & David Whitney[4]

[1]Princeton Neuroscience Institute; [2]Helen Wills Neuroscience Institute, UC Berkeley; [3]Vision Science Program, UC Berkeley;
[4]Department of Psychology, UC Berkeley; [5]Department of Music and Center for New Music and Audio Technologies, UC Berkeley

Timbre: an introduction

Timbre = the tone color, or unique quality, of a sound, which cannot be attributed to pitch, intensity, duration, or location

Is timbre just a collection of independent, low-level features?

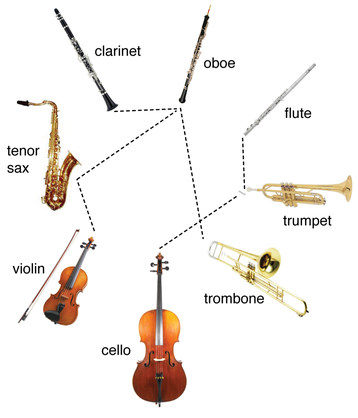
If timbre represents the holistic configuration of a sound, listeners should adapt to it, and this adaptation should generalize across changes in low-level features.

Design

In each trial, participants were repeatedly exposed to one of two adapters (see pairs below) and then judged the identity ("sound 1" or "sound 2") of a sound morph between those two adapters.

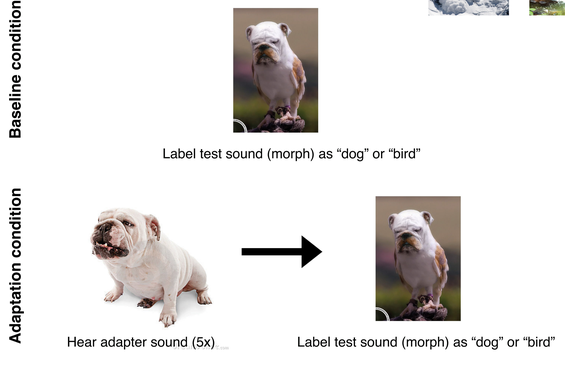
Each adapter pair and their resulting morphs were equated in pitch, loudness, and duration, so only timbre distinguished them.

Experiment 1: Musical Instruments

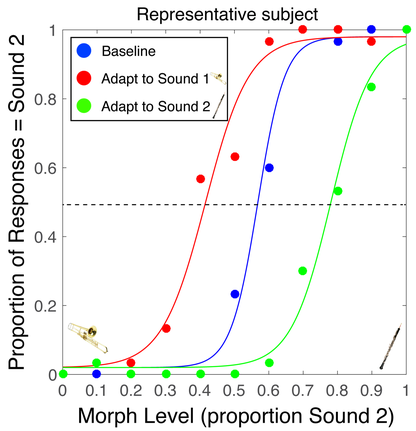


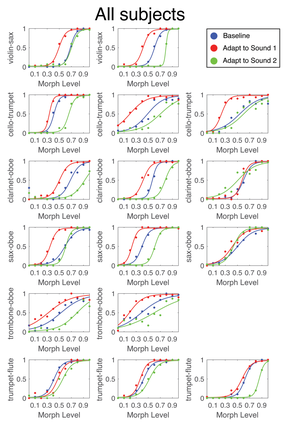
Experiment 2: Natural Sounds

Trial structure

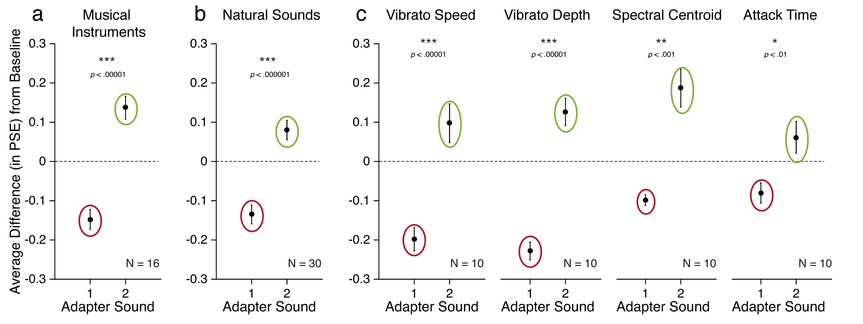


Results

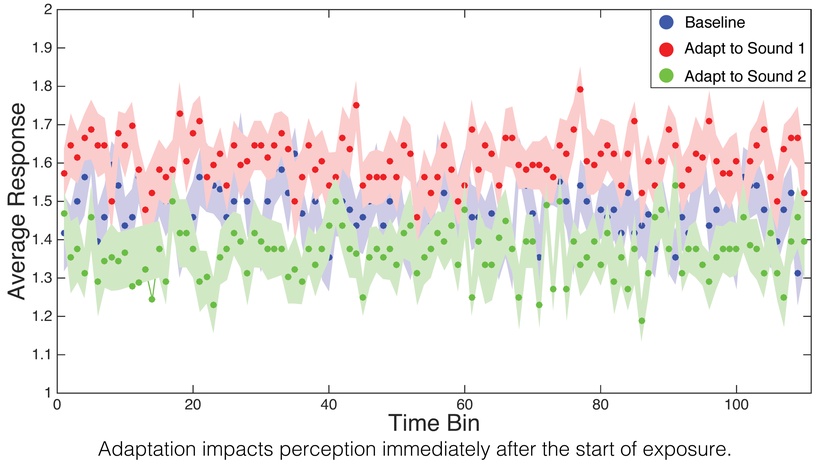




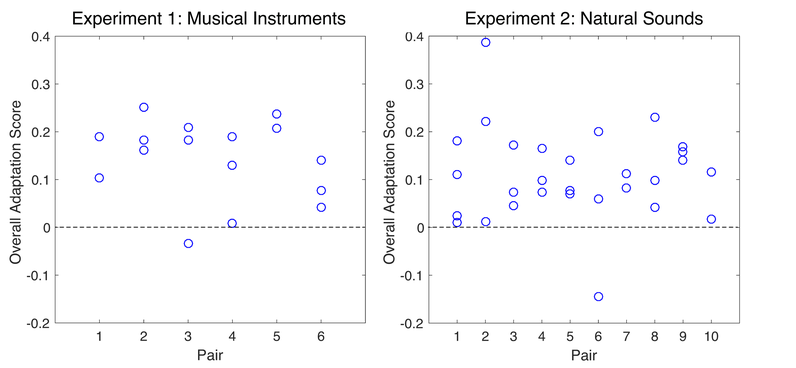
Repeated exposure to one of the adapters (e.g., "sound 1") alters the perception of morphs between sounds 1 and 2, making the morphs sound more like the other adapter.



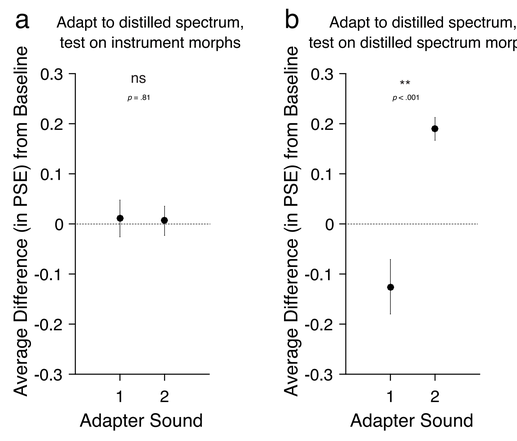
Listeners reliably adapt to the timbre of musical instruments, natural sounds, and a variety of individual dimensions of timbre. In a control experiment, we varied the pitch of the test morph and verified that timbre adaptation is robust to changes in this lower-level feature.



Adaptation impacts perception immediately after the start of exposure.



Adaptation effects were robust and consistent across instrument and natural sound pairs.



Exposure to synthetic sounds based on the distilled spectral centroid of instruments (but lacking their full combination of spectrotemporal features) failed to bias perception of the original instruments (a), indicating that natural timbre processing requires integrating multiple features into a holistic configuration. Importantly, these synthetic sounds were internally adaptable (b).

Conclusions and Implications

Adapting to timbre biases our perception of a variety of natural sounds.

Adaptation is robust to low-level changes that occur in the natural environment.

Composers likely exploit this phenomenon to enhance listeners' sensitivity to changes in musical texture, such as a new soloist in an orchestra or choir.

References

Elliott, T., Hamilton, L., & Theunissen, F. (2013). Acoustic structure of the five perceptual dimensions of timbre in orchestral instrument tones. *J Acoust Soc Am, 133*, 389-404. Grey, J. (1977). Multidimensional perceptual scaling of musical timbres. *J Acoust Soc Am, 61*, 1270. Opolko, F., & Wapnick, J. (2006). The McGill University Master Samples Collection on DVD (McGill University, Montreal). Webster, M., & MacLeod, D. (2011). Visual adaptation and face perception. *Philos T R Soc B, 366*, 1702-1725.

Acknowledgments

This work was supported by the Department of Defense through the National Defense Science and Engineering Graduate (NDSEG) Fellowship, 32 CFR 168a, awarded to E.A.P., the Princeton University C. V. Starr Fellowship, awarded to E.A.P., and NIH R01 EY018216, awarded to D.W. We thank Jacob Sheynin and Aaron Bloch for assistance with data collection.

*Corresponding author. Please contact Elise Piazza at elise.piazza@gmail.com.