Exploring the Effects of "Sound Shape" on Consumer Preference

Participants in this study of amplitude envelope indicated not only a preferred product but also how much more they would be willing to pay for it.

By Michael Schutz & Jeanine K. Stefanucci

FEATURE AT A GLANCE:
Interfaces play a crucial role in a device's success or failure. Although visual aspects generally receive more attention, findings from sonic interaction design increasingly illustrate the importance of auditory aesthetics in creating desirable products. Here we show that small changes to the amplitude envelope (i.e., "sound shape") of tones affect user preference. Specifically, participants are willing to pay 9% more for products using sounds with decaying-amplitude envelopes rather than abruptly ending envelopes that are common in many device sounds. These findings hold important implications for cost-effective changes that could potentially improve a product's desirability and perceived value.

KEYWORDS:
auditory interfaces, auditory perception, audition, timbre, human–computer interaction, auditory ergonomics, tone sequence, pitch, consumer preference

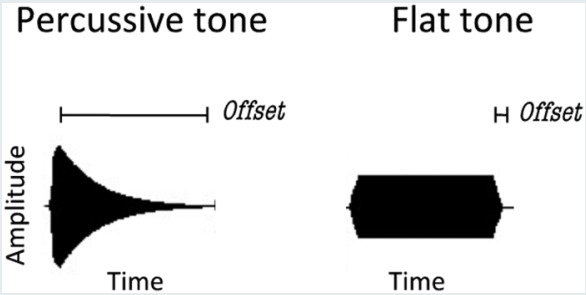
Auditory interfaces can be powerful tools for human–computer interactions. Electronic devices use sounds to convey messages ranging from mundane ("You've got mail") to urgent ("Doors are closing") to critical ("This patient is dying"). Although the specific sounds used have often been chosen based on engineering constraints, the importance of formally designing (Rocchesso et al., 2008) and assessing such sounds is gaining recognition (for an overview of approaches, see Jeon, 2015). Studies of auditory interfaces often focus on utility – for example, that medical device alarms are difficult to learn (Wee & Sanderson, 2008) and are frequently confused (Edworthy & Hellier, 2005). However, the growing field of sonic interaction design complements such work by exploring better interface design, incorporating a range of issues including sound classification, the efficacy of information transfer between sounds and users, and the ways in which sounds can be better synthesized (Rocchesso et al., 2008).

For example, it is important to recognize how product sounds are situated within their broader context (Harrison, Tatar, & Sengers, 2007), as users might disable unpleasant auditory alerts (Edworthy, 1998) even if they are actually informative. This is a major problem in the design of useful medical alarms, which are effective in principle yet continually problematic when actually implemented in hospital environments (Rayo & Moffatt-Bruce, 2015). Here, we offer an exploratory contribution to sonic interaction design focused on the aesthetic implications of an underresearched property of sound: amplitude envelope. Specifically, we test whether sounds with natural amplitude envelopes enhance our preference for – and the perceived value of – products producing them.

AMPLITUDE ENVELOPE IN PERCEPTION RESEARCH

Many studies of auditory perception use sounds with "flat" amplitude envelopes, which have abrupt onsets and offsets (see sidebar). Auditory research focuses disproportionately on these sounds in experiments (Schutz & Vaisberg, 2014), making them logical choices for use in auditory interfaces, such as supermarket checkout machines, touch-tone dialing systems, alarm clocks, and fire alarms. However, their flat shapes appear to trigger different processing strategies than natural sounds when estimating duration (Vallet, Shore, & Schutz, 2014), integrating sight and sound (Chuen & Schutz, 2016; Schutz, 2009) and making associations (Schutz, Stefanucci, Baum, & Roth, 2017). These differences in processing might help explain why flat tones are annoying (Rayo & Moffatt-Bruce, 2015) and problematic (Phansalkar et al., 2010), as they lack the temporal variation common to musical sounds (Schutz, in press).

Sounds form part of the elusive "look and feel" of products that play a crucial role in consumer choice amid crowded retail markets. Sounds may also be key in increasing positive experiences with products as assessed through user evaluations (Özcan, Van Egmond, & Jacobs, 2014). Here, we explore the role of amplitude envelope in product aesthetics by examining its effect on consumer preference. By asking participants to evaluate products differing only in the amplitude envelopes of their sounds, we explore the degree to which this understudied



Percussive (left) and flat (right) tones. Like most natural sounds, the percussive tones used in this study exhibit decaying offsets of variable length (dropping to half their peak value in approximately 1/8 s), informing listeners about the materials involved in their creation. In contrast, flat sounds used in this study (which are common in auditory research) possess abrupt offsets that present the perceptual system with sounds violating structural properties common in the environment in which we evolved. Figure taken from Schutz, Stefanucci, Baum, and Roth (2017). © The Experimental Psychology Society, reprinted with permission of Taylor & Francis Ltd, http://www.tandfonline.com on behalf of The Experimental Psychology Society.

property could hold important aesthetic applications. This holds significant implications for the design of consumer products, given that manipulating this property is both acoustically simple and comes with minimal cost.

EXPERIMENT: DOES AMPLITUDE ENVELOPE AFFECT CONSUMER PREFERENCE?

Cellular and touch-tone phones produce tones with flat envelopes to communicate information regarding dialing. As familiarity generally predicts judgments of liking (Berryman, 1984; Innes, 1974), the common experience of associating phones with flat tones could lead to a preference for the use of flat sounds in auditory interfaces. On the other hand, the lack of ecological connection of these sounds to our natural environment (Schutz, 2016) and recent documentation of user frustration with some products using them (Rayo & Moffatt-Bruce, 2015) suggest they can be problematic. To assess preference for flat and percussive sounds, here we allowed participants to compare the two types of tone sequences by presenting them as cell phone ringtones. One sequence used only flat tones, and the other, only percussive (naturally decaying) tones.

METHOD

Participants. Twenty (nine female, 11 male) College of William and Mary undergraduates participated for course credit.

Materials. We presented participants with descriptions and pictures of two cell phones differing only in display and orientation (a green display that opened to the right vs. a yellow display opening to the left). The four-note tone sequences were taken from Schutz et al. (2017), which provides technical details on the sounds' construction (samples can be heard at www.maplelab.net/memory). The percussive and flat sequences were matched on dimensions other than amplitude envelope.

Procedure. We told participants we were interested in how cell phone companies could increase their appeal to customers and that they would be asked to indicate which of the two phones they preferred after studying their features. Participants saw a picture and the description of the first phone on a piece of paper (randomized in presentation order). The experimenter informed participants they would be presented with the sound associated with a missed call in order to demonstrate the phone's sound quality and then played either the percussive or flat sequence of tones. This procedure was repeated with the second cell phone. We counterbalanced the pairing of phone and tone sequences.

Participants indicated (a) which of the two phones they preferred and (b) the amount they would be willing to pay for each if shopping for a new phone. Finally, after hearing the sequences again, participants (c) rated the sequences themselves on a scale from 1 (*absolutely detest*) to 100 (*adore*) as well as which they preferred (if any).

RESULTS AND DISCUSSION

Overall phone preference. Eighty-five percent of the participants (17/20) preferred the percussive phone to the flat phone.

Estimated phone value. Participants were willing to pay \$5.25 (SD = \$8.50) more for the phone with the percussive ring tone (M = \$63.75, SD = \$33.87) compared with the phone with the flat ring tone (M = \$58.50, SD = \$32.45), a significant difference, $t(19) = 2.76$, $p = .012$, when assessed by a paired-samples t test. There was no difference in willingness to pay for the percussive phone based on presentation order, $t(9) = .51$, $p = .63$.

Sound sequence preference. Participants rated the percussive ring tone (M = 55.65, SD = 17.34) as more likeable than the flat ring tone (M = 30.10, SD = 16.26), $t(19) = 7.18$, $p < .001$, $d = 1.52$ (Figure 1). Within-subjects ratings indicated an average preference of 25.6 (SD = 15.9) for percussive tones. When asked about sequence preference, 90% (18/20) chose the percussive sequences, and 10% (2/20) said they preferred neither. No participant preferred the flat sequences.

IMPLICATIONS

This exploratory study suggests participants preferred percussive to flat sounds and that this preference may affect

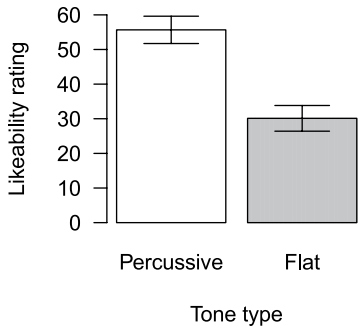


Figure 1. Phones using percussive tones were rated significantly more likable. Error bars represent ±1 standard error about the mean.

product desirability and perceived value. Specifically, after hearing both types of tone sequences, 90% of the participants preferred the percussive tones, and for 85%, this preference translated to a preference for the phone itself. Furthermore, participants indicated that they would pay 9% more for phones using percussive tones. Although future research is needed to examine the degree to which these findings generalize, the potential implications of these results are considerable. Moreover, our methods for assessing preference (self-report ratings and perceived value of the product) may contribute to ongoing discussion of approaches to user evaluations of product sounds.

In the field of human factors, much research has been done on the *irrelevant sound effect* (for reviews, see Banbury, Macken, Tremblay, & Jones, 2001; Beaman, 2005). In this effect, operators are distracted by irrelevant sounds in the environment when performing complex tasks. Irrelevant sounds disrupt the ability of working memory to maintain information and distract operators from their primary tasks, which then requires recovery from the interruption. Variations in background noise can affect a range of cognitive activities, such as completing homework in front of a television (Pool, Koolstra, & van der Voort, 2003). These studies suggest that reducing the variability of sounds in the environment may lower the incidence of the effect. Although not tested, percussive tones may also lower the variability in environmental sounds (as compared with flat tones) given their natural prevalence. It would be interesting to explore whether more widespread use of these tones in devices could reduce problems with irrelevant sounds, an area of study germane to sonic interaction design.

Issues of why listeners prefer some sounds over others are gaining interest in the field of auditory perception (McDermott, 2012). Curiously, although certain frequency ranges (Kumar, Forster, Bailey, & Griffiths, 2008), spectral roughness (Terhardt, 1974), and relative mix of harmonics to noise (Ferrand, 2002) affect preferences, our tone sequences did not differ on those properties. However, it is possible that the natural decay of percussive tones allows them to function as "auditory cartoons" providing the stereotypical-yet-abstract representations of natural sounds that are easy to process (Rocchesso, Bresin, & Fernstrom, 2003). Although further research is clearly needed to better understand the reasons for this preference, the prevalence of flat tones in numerous electronic devices means even small improvements in their reception could potentially hold tremendous improvements for user experiences with auditory interfaces.

REFERENCES

Banbury, S., Macken, W. J., Tremblay, S., & Jones, D. M. (2001). Auditory distraction and short-term memory: Phenomena and practical implications. *Human Factors*, *45*, 12–29.

Beaman, C. P. (2005). Auditory distraction from low-intensity noise: A review of the consequences for learning and workplace environments. *Applied Cognitive Psychology*, *19*, 1041–1064.

Berryman, J. C. (1984). Interest and liking: Further sequential effects. *Current Psychological Research & Reviews*, *3*, 39–42.

Chuen, L., & Schutz, M. (2016). The unity assumption facilitates cross-modal binding of musical, nonspeech stimuli: The role of spectral and amplitude cues. *Attention, Perception, & Psychophysics*, *78*, 1512–1528.

Edworthy, J. (1998). Does sound help us to work better with machines? A commentary on Rauterberg's paper "About the Importance of Auditory Alarms During the Operation of a Plant Simulator." *Interacting with Computers*, *10*, 401–409.

Edworthy, J., & Hellier, E. (2005). Fewer but better auditory alarms will improve patient safety. *Quality and Safety in Health Care*, *14*, 212–215.

Ferrand, C. T. (2002). Harmonics-to-noise ratio: An index of vocal aging. *Journal of Voice*, *16*, 480–487.

Harrison, S., Tatar, D., & Sengers, P. (2007, April/May). *The three paradigms of HCI*. Paper presented at the Alt.chi session at the SIGCHI Conference on Human Factors in Computing Systems, San Jose, CA.

Innes, J. M. (1974). The effect of familiarity and incentive on liking and exploration. *European Journal of Social Psychology*, *4*, 489–494.

Jeon, M. (2015). Auditory user interface design: Practical evaluation methods and design process case studies. *International Journal of Design in Society*, *8*, 1–16.

Kumar, S., Forster, H. M., Bailey, P., & Griffiths, T. D. (2008). Mapping unpleasantness of sounds to their auditory representation. *Journal of the Acoustical Society of America*, *124*, 3810–3817.

McDermott, J. (2012). Auditory preferences and aesthetics: Music, voices, and everyday sounds. In *Neuroscience of Preference and Choice* (pp. 227–256). San Diego, CA: Academic Press. doi:10.1016/B978-0-12-381431-9.00020-6

Özcan, E., Van Egmond, R., & Jacobs, J. J. (2014). Product sounds: Basic concepts and categories. *International Journal of Design, 8*, 97–111.

Pool, M. M., Koolstra, C. M., & van der Voort, T. H. A. (2003). The impact of background radio and television on high school students' homework performance. *Journal of Communication, 53*, 74–87.

Phansalkar, S., Edworthy, J., Hellier, E., Seger, D. L., Schedlbauer, A., Avery, A. J., & Bates, D. W. (2010). A review of human factors principles for the design and implementation of medication safety alerts in clinical information systems. *Journal of the American Medical Informatics Association*, *17*, 493–501.

Rayo, M. F., & Moffatt-Bruce, S. D. (2015). Alarm system management: evidence-based guidance encouraging direct measurement of informativeness to improve alarm response: Table 1. *BMJ Quality & Safety*, *24*, 282–286.

Rocchesso, D., Bresin, R., & Fernstrom, M. (2003). Sounding objects. *IEEE MultiMedia*, *10*, 42–52.

Rocchesso, D., Serafin, S., Behrendt, F., Bernardini, N., Bresin, R., Eckel, G., … Visell, Y. (2008). Sonic interaction design: Sound, information and experience. In *CHI EA '08 CHI '08 Extended Abstracts on Human Factors in Computing Systems* (pp. 3969–3972). Florence, Italy.

Schutz, M. (2009). *Crossmodal integration: The search for unity*. Charlottesville: University of Virginia.

Schutz, M. (2016). Clarifying amplitude envelope's crucial role in auditory perception. *Canadian Acoustics*, *44*, 42–43.
Schutz, M. (in press). Acoustic structure and musical function: Musical notes informing auditory research. In M. H. Thaut & D. A. Hodges (Eds.), *The Oxford handbook on music and the brain*. Oxford, UK: Oxford University Press. Available from http://www.oxfordhandbooks.com/view/10.1093/oxfordhb/9780198804123.001.0001/oxfordhb-9780198804123-e-7
Schutz, M., Stefanucci, J., Baum, S. H., & Roth, A. (2017). Name that percussive tune: Associative memory and amplitude envelope. *Quarterly Journal of Experimental Psychology*, *70*, 1323–1343.
Schutz, M., & Vaisberg, J. M. (2014). Surveying the temporal structure of sounds used in Music Perception. *Music Perception: An Interdisciplinary Journal*, *31*, 288–296.
Terhardt, E. (1974). On the perception of periodic sound fluctuations (roughness). *Acta Acustica United with Acustica*, *30*, 201–213.
Vallet, G., Shore, D. I., & Schutz, M. (2014). Exploring the role of amplitude envelope in duration estimation. *Perception*, *43*, 616–630.
Wee, A. N., & Sanderson, P. (2008). Are melodic medical equipment alarms easily learned? *Anesthesia & Analgesia*, *106*, 501–508.

Michael Schutz *(schutz@mcmaster.ca) is associate professor of music cognition/percussion at McMaster University, where he directs the MAPLE Lab researching Music, Acoustics, Perception, and LEarning (www.maplelab.net). He is active in exploring the role of amplitude envelope in a variety of auditory perception tasks, including applying his team's insights to improving auditory interfaces. He is a fellow of the Psychonomic Society, a professional percussionist, and a core member of the McMaster Institute for Music and the Mind.*

Jeanine K. Stefanucci *(jeanine.stefanucci@psych.utah.edu) is associate professor in the Psychology Department at the University of Utah. She received her PhD in psychology from the University of Virginia in 2006. Her research investigates if a person's bodily states, whether emotional, physiological, or physical, affects perception and cognition. She conducts this research in natural settings and in virtual environments. This work is inherently interdisciplinary given it spans research on emotion, health, spatial cognition, and virtual environments.*

DOI: 10.1177/1064804618810031
Article reuse guidelines: sagepub.com/journals-permissions