AMPLITUDE ENVELOPE AND AUDITORY ALARMS

Michael Schutz ¹, Jeanine Stefanucci ²

¹ McMaster University, CANADA; ² University of Utah, USA

ABSTRACT

Auditory alarms are an important feature in medical devices, allowing doctors to monitor patients’ vital signs by ear while simultaneously observing them visually. However, such alarms rely on a doctor’s ability to remember associations between sounds and messages, a task that has proven difficult even when using the sounds recommended by the International Electrotechnical Commission, which use flat amplitude envelopes (exhibiting a long sustain and an immediate offset). We found that alarms based on sounds with percussive envelopes (exhibiting an immediate exponential decay with no sustain) may be preferable for such applications by asking participants to associate various household objects (e.g., cell phone, key, credit card) with 4-note melodies made of tones using one of two amplitude envelopes: “flat” or “percussive.” Participants repeated a training block in which they were exposed to ten melody-object pairs until able to recall at least 7 of the 10 melody-object associations. Participants then performed a distracter task, after which we evaluated retention using a modified version of the old/new paradigm allowing for testing of both melody recognition and melody-object association. We found that participants listening to melodies of percussive tones required 40% fewer trials to learn the associations, yet performed no differently in the final evaluation (either with respect to the old/new judgments, or to the melody-object associations). We conclude that envelope shape may play an important role in explaining previous problems with designing effective auditory alarms in medical devices, a finding that raises theoretical questions about learning, memory, and timbre.
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Michael Schutz\textsuperscript{1}, Jeanine Stefanucci \textsuperscript{2}

\textsuperscript{1} McMaster University, Canada; \textsuperscript{2} University of Utah, USA

BACKGROUND AND AIMS

Auditory alarms are an important feature in medical devices, allowing doctors to monitor patients’ vital signs by ear while simultaneously observing them visually (Block et al., 2000). However, such alarms rely on a doctor’s ability to remember associations between sounds and messages, a task that has proven difficult (Block, 2008; Sanderson, 2009) even when using the sounds recommended by the International Electrotechnical Commission (IEC, 2005). The melodies proposed in the IEC standards (2005) are based largely on sounds with flat amplitude envelopes (exhibiting a long sustain and an immediate offset). Here we will show sounds with percussive envelopes (exhibiting an immediate exponential decay with no sustain) hold significant advantages for tasks involving learned associations.

METHOD

We asked participants to associate various household objects (e.g., cell phone, key, credit card) with 4-note melodies made of tones using one of two amplitude envelopes: “flat” or “percussive.” Participants began in a training block, where they were exposed to ten melody-object pairs. After completing this training block, they were asked to identify the paired object for each of the 10 melodies. This training block was repeated as necessary until participants learned at least 7 of the 10 melody-object associations. Participants then performed a distracter task, after which we evaluated retention of the associations using a modified version of the old-new paradigm (Mandler, 1980; Tulving, 1985). This involved presenting 20 sequences during the evaluation phase, only half of which were heard during training. Participants indicated whether each of these 20 sequences were “old” (i.e., heard during training) vs. “new” (i.e., not heard during training), and named the target object with which each of the “old” sequences was associated.

RESULTS

Participants listening to sequences of percussive tones required 40% fewer trials to learn the associations, yet performed no differently in the final evaluation (either with respect to the old/new judgments, or to the sequence-object associations).
CONCLUSIONS

Previous attempts to create easily associable melodies based on tones with flat envelopes (as per the IEC recommendations) have been ineffective (Block, 2008; Sanderson, 2009). Therefore, our data showing that associations involving melodies with percussive envelopes are learned significantly more quickly than associations involving melodies with flat envelopes. Therefore, percussive tones may be helpful as effective building blocks auditory alarm melodies in medical devices. Additionally, this outcome raises interesting theoretical questions about learning, memory, and timbre, with implications for our understanding of the ways in which melodies evoke memories.

REFERENCES


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