A music teacher's blog of educational reflections, philosophy, and research.

SUNDAY, NOVEMBER 27, 2011

Music (sort of) and the Brain: On Fingernails and Chalkboards

If you're anything like me, the mere act of reading the words "fingernails" and "chalkboard" in the same sentence makes you cringe. Personally, I find the most detestable sound to be that of squeaky styrofoam.

Table 1
List of 16 Sounds Used in Experiment 1, and the Average Rating (Expressed as Position in Centimeters Along the Line) and Standard Error Assigned to Each

Sound	Average Rating (cm)	SE
1. Chimes	4.72	0.57
2. Rotating bicycle tire	5.49	0.50
3. Running water	5.89	0.55
4. Jingling keys	6.25	0.67
5. Pure tone	8.79	0.62
6. Pencil sharpener	8.81	0.54
7. Shaking metal parts	8.89	0.53
8. White noise	9.09	0.57
9. Compressed air	9.58	0.58
10. Blender motor	10.90	0.46
11. Dragged stool	11.43	0.43
12. Metal drawer being opened	12.12	0.43
13. Scraping wood	13.03	0.38
14. Scraping metal	13.08	0.39
15. Rubbing two pieces of styrofoam together	13.39	0.38
16. Scraping slate	13.74	0.18

Note—The descriptor "scraping" refers to dragging the three-pronged garden tool across the designated surface.

My nightmares consist entirely of 11-16.
(Table from Halpern et al.)

I applaud those brave scientists who venture to study such horrific sounds. Back in 1986, Halpern et al. (PDF) conducted research regarding what aspects of awful sounds contribute most to our aversions. 20 years later, Randolph Blake of that *et al.* was awarded an Ig Nobel Prize (▶ interview) by The Society For Improbable Research for their work. Evidently, this recognition in 2006 of research that "first makes people laugh, then makes them think," inspired a wave of further ugly-sound studies. In 2008, Kumar et al. (abstract) "addressed the question of what aspects of the auditory representation of such sounds are associated with judgments of unpleasantness," and Cox (abstract) seemed to negate a small part of Halpern and Blake's work while reaffirming some other parts. Within the past month, Rendall et al. (abstract) landed an interview on NPR to talk about their recently presented work on the subject.

I'll spare you the squeaky styrofoam and other sounds because I'm such a nice guy, but listen to this:

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Classically torturous. But what is it about that sound that makes it hurt our ears so? You should reason that the frequencies that make up this sound must play a major part, and you might reason that psychology and physiology could play roles, as well. Let's begin with frequency, since it's most easily tested. Since people generally describe very highly pitched sounds as more irritating than sounds in a speaking or singing range, a reasonable hypothesis would be that if one removed high frequencies from this sound, it would sound better...well, less awful.

Better, yes. Best? Maybe. Let's try the opposite and remove the low frequencies.

Ouch. What about middle frequencies?

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According to both the 1986 and 2011 research, people would most likely find this final sample to be the least unpleasant. Their determined ranges were slightly different, and I used a sort of median of the two, but the effect essentially stands.

The psychological aspect is interesting but not surprising. Reuter and his partner Oehler experimented with telling some subjects that a sound, such as fingernails on a chalkboard, was a part of a contemporary musical composition. Subjects reported a preference for the sounds when they were thought to be musical over when they knew the source. However, measurements of skin conductance indicated that subjects responded with equal distaste, regardless of the perceived source. This reestablishes the results of a very similar study in 1975 by D.J. Ely using skin potential.

It has also been hypothesized (I haven't yet found confirmation) in these studies that the shape of our auditory canal is such that this middling range of frequencies (about 2-5kHz) is amplified relative to higher and lower frequencies, presumably to aid in hearing people speak. It seems possible then that even if we were to dislike high and middle frequencies of an ugly sound equally, removing that which is internally amplified thereby removes more total unpleasant sound than removing that which is not amplified. I propose that the next logical study of this material would attempt to determine the truth of this amplification and then factor the degree of amplification into a comparison of frequency removals, thus determining if there are frequencies that we dislike more than others for no discernable reason.

There are at least two valuable directions that further research could go. Halpern et al. compared their results to warning calls of macaque monkeys, suggesting zoological, anthropological, and even evolutionary knowledge to be gained from increased understanding of the acoustical properties of animal-generated sounds (Cox's work opposed this theory). Reuter et al. have suggested that their research could be applied to the commercial arena—perhaps vacuums or other items could be designed to more efficiently sound less unpleasant. While writing this post, the world's most sensitive smoke alarm went off in my family's house and I couldn't help but wonder if they could be made less irritating with an innovative application of this type of knowledge. A combination of these studies even suggests that hearing aids could be designed to cut out the most displeasing frequencies of *only* unpleasant audio.

Of course, musicians will find a way to apply any additional acoustic knowledge to their work. Therefore, this is totally relevant to my blog.

I lament that there doesn't seem to be a complete, published paper by Reuter et al., at least not yet (but I couldn't wait any longer). I have no way

to draw further information from their raw data or even determine how they decided what frequency range qualified as that which the ear is most sensitive to — I assumed they cited some other work, but in my search of all of their cited work, nothing seems to present such research. They presented their work in a 15 minute session at a meeting of the Acoustical Society of America in San Diego on November third.

Cox, Trevor J. (2008). Scraping sounds and disgusting noises *Applied Acoustics, 69* (12), 1195-1204 DOI: 10.1016/j.apacoust.2007.11.004

Halpern, D.L., Blake R., and Hillenbrand J. (1986). Psychoacoustics of a chilling sound. *Perception & psychophysics, 39* (2), 77-80 PMID: 3725541

Kumar, S., Forster, H., Bailey, P., and Griffiths, T. (2008). Mapping unpleasantness of sounds to their auditory representation *The Journal of the Acoustical Society of America, 124* (6) DOI: 10.1121/1.3006380

Reuter, Christoph, and Michael Oehler (2011). Psychoacoustics of chalkboard squeaking. *Journal of the Acoustical Society of America, 130* (4), 2545

Posted by Luc Duval at 12:11 PM

Labels: acoustics, blake, cox, ely, halpern, kumar, music and the brain, oehler, research, reuter

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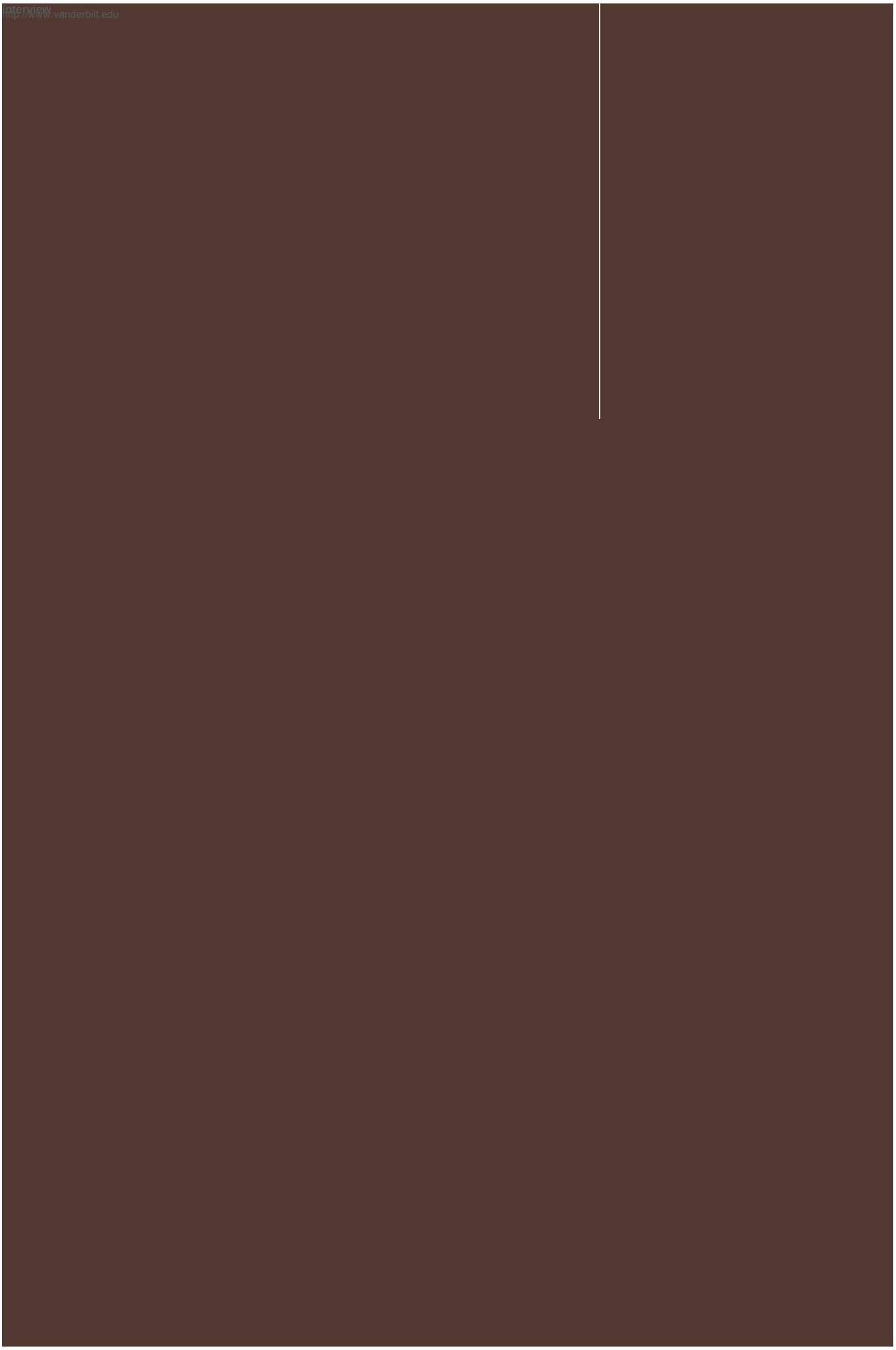
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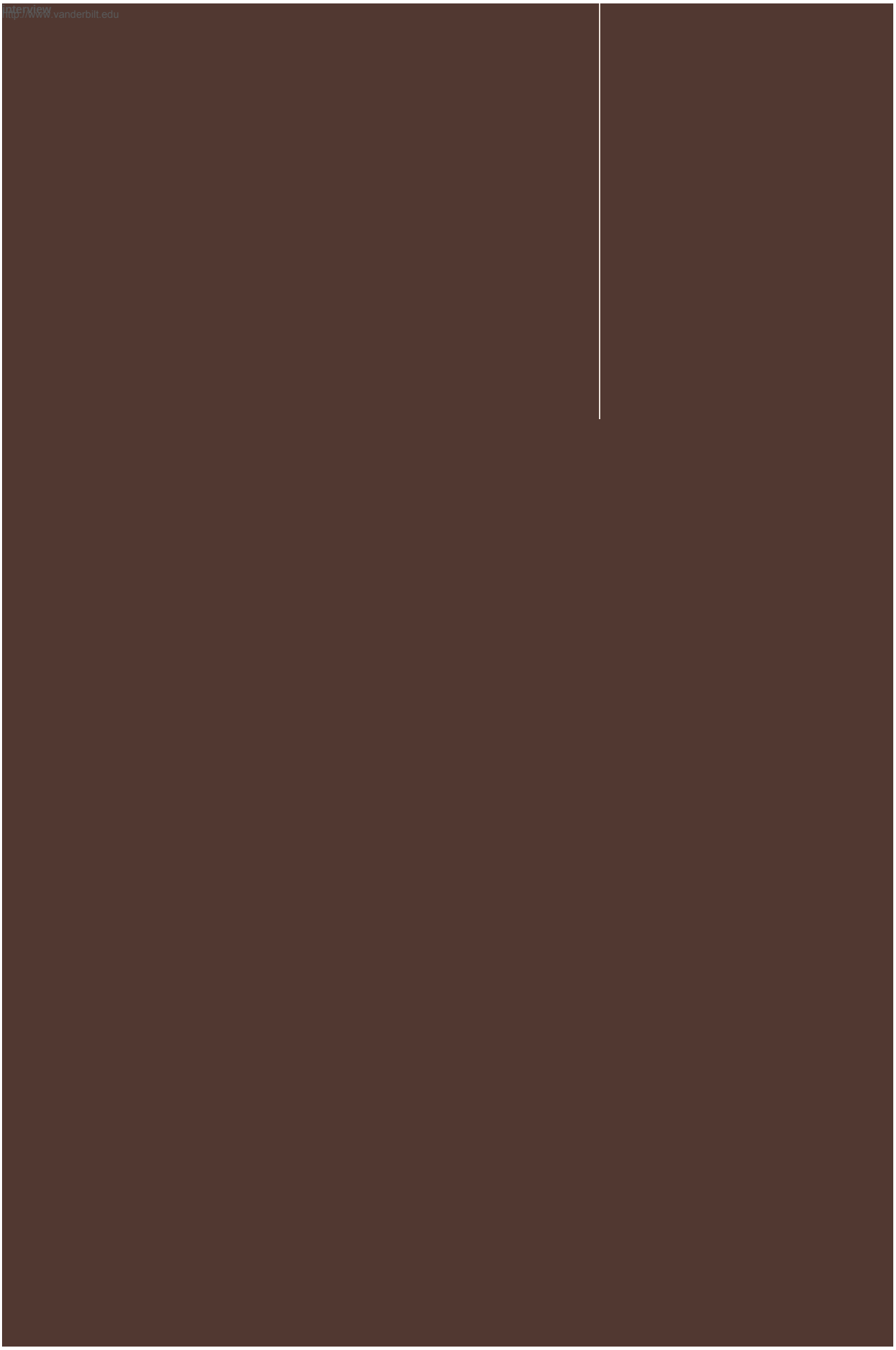
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