On the Use of the Auditory Pathway for Comprehending Complex Engineering Concepts

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Introduction

The auditory pathway constitutes an underused means of learning in the classroom. For a number of years, I have used appropriately designed sound files in an acoustics course, and found the effect on student learning very positive. Acoustics is, of course, a "natural" for the use of sound files, and students reported that the experience was both enjoyable and very useful.

Given this, albeit subjective, success, we speculated that the auditory system could be engaged more effectively in the learning of concepts not directly associated with acoustics. I wanted to test this in a rigorous way, and designed an experiment that would allow us to answer that question.

Hypothesis

In order to gain more qualitative information, we tested the following hypothesis:

The use of appropriate auditory/visual demonstrations improves the comprehension of a number of important signal processing concepts.

Methodology

Eight 20-minute long modules were developed on separate (and not interrelated) topics. The eight modules were chosen such that half were more theoretical, and half were more advanced. Sliced differently, half were on an introductory level, and half advanced. Finally half were natural candidates for acoustic demonstrations, the other half not. Each of the eight modules is a unique combination of those three dimensions see Table 1 below.

Volunteers were recruited from the undergraduate population in the engineering faculty, and were asked to sign a consent form, approved by the University's Ethics Review Board. The recruitment lecture explained the purpose and method of the experiment, and contained a sample module. During the following four weeks, a rigid presentation schedule was followed: In a given week, a set of two modules was presented during one lecture on two occasions. On the first occasion, Module A was presented with sound files, and Module B without. On the second occasion, A was without sound files, and B with sound. Otherwise the modules were identical. A given student would attend only one of the two lectures in a given week. Questions from the class, relating to the material, during and after the presentations were discouraged. After each module, a simple four-question multiple-choice quiz was administered. Each question had five alternative choices. Chance performance is therefore 20%. Answer sheets requested information about previous exposure to the material taught in the module, and the student's year and program of study.

The fifth and last set of lectures consisted of a retention quiz of all eight modules in the same format that was used in the preceding four weeks, plus a brief entertaining module on auditory illusions, included to ensure good attendance.

Results

The experiment ran in September and October 2000. A total of 33 students attended the two recruitment lectures, and an average of 11.1 students attended each of the eight sessions. The sessions were scheduled for Tuesdays and Thursdays 12:00 noon to 1:00 p.m., and light refreshments were available at all sessions.

Table 1: Modules can be classified along three dimensions

Module	Level	A priory suitability	Type
Convolution	Introductory	Not natural for acoustics	Applied
Fourier	Introductory	Natural for acoustics	Applied
Sampling	Introductory	Natural for acoustics	Theoretical
Taylor	Introductory	Not natural for acoustics	Theoretical
Dispersion	Advanced	Not natural for acoustics	Theoretical
FIR vs. IIR	Advanced	Natural for acoustics	Theoretical
Quantization	Advanced	Not natural for acoustics	Applied
ModulationTransfer Fct.	Advanced	Natural for acoustics	Applied

Quiz		Retention test	
No sound	With sound	No sound	With sound
0.713	0.755	0.611	0.583

Table 2: Overall performance (all modules taken together): Average mark out of 1.00, chance performance = 0.200

The overall result is shown in Table 2. Here the average mark is shown for all modules taken together. We notice that in the quiz at the end of the teaching module, sound files have a moderate positive effect: The average mark went from 0.713 to 0.755. On the other hand, the average mark was slightly lower (0.583 vs. 0.611) in the retention test for those students exposed to sound files.

The data was also broken down according to the classification shown in Table 1 above. The result is shown in the bar graph in Figure 1.

In order to determine the effect of sound files on retention, we subtracted the average scores on the retention tests from the average scores on the quiz administered immediately after the module was taught. The result is shown in Figure 2.

Conclusion

The results shown here do not support the hypothesis that learning is enhanced by the introduction of relevant sound files, although there is a slightly positive correlation between student performance immediately after the material was taught and the presentation of appropriate sound files. Retention seems to actually suffer from the presence of

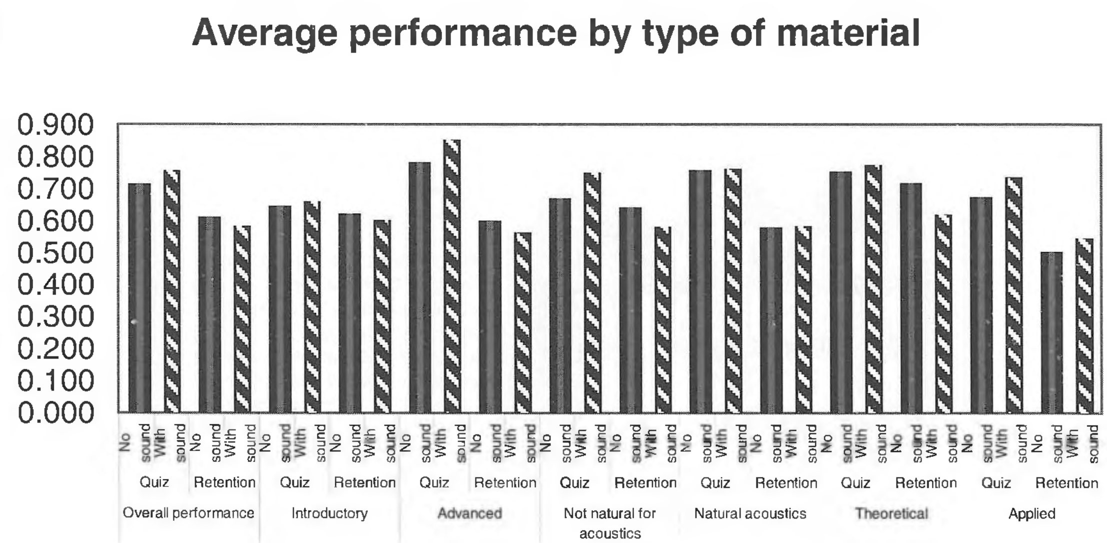

Figure 1: Performance on different classes of material, by quiz vs. retention test, and no sound vs. with sound

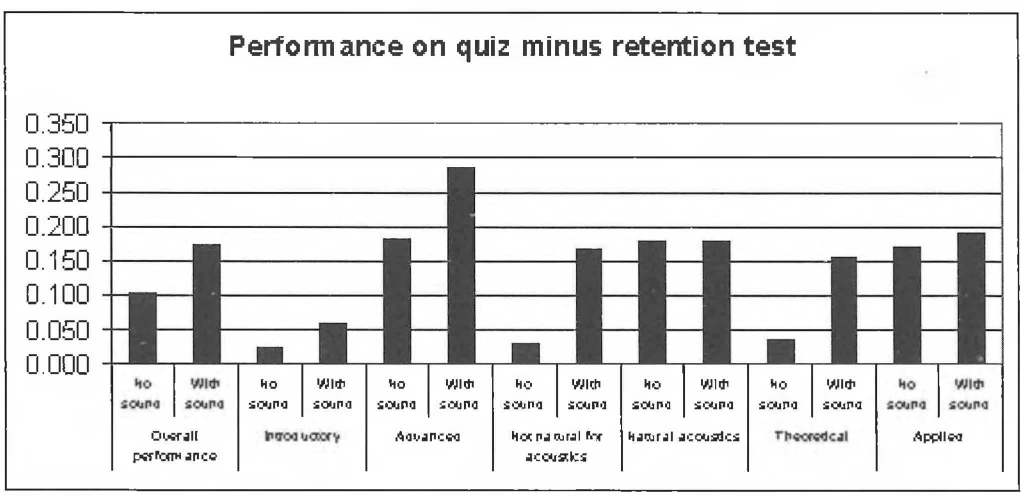

Figure 2: Effect of sound files on retention: Average quiz mark minus average retention test mark on different calluses of material.

sound files. This is a surprising outcome, given the intuitive appeal of sound files in teaching complex concepts, as well as the written comments provided by students throughout the experiment.

We were exceptionally careful to avoid undue bias in the work, including being fully aware of the effect on "professorial enthusiasm" in the classroom.

Bibliography

URL: http://www.ecf.utoronto.ca/~p2k/

Note

The University of Toronto Ethics Review Board approved the research reported in this paper.

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