Effects of a Hearing Protection Device on Performance of Students in Noisy Environments

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Students in agricultural mechanics laboratories in the United States are subjected to loud noise. These noise levels often exceed the safety limits for noise set by OSHA, as documented by Bates (1983), Bear (1969), Madou-Bangurah (1978), Shell (1972), Wall and Jessee (1971) and Weston and Stewart (1980). In addition to personal safety concerns, Daniels (1985) and Jewell (1977) documented reduced student performance as a result of noise. Devices are available to protect students from exposure to noise. Weston and Adams (1935) and Hartley (1974) found improved performance when subjects wore hearing protection devices (HPDs). Hearing protection devices range in effectiveness from 25dB(A) to 40dB(A) reduction, and vary in cost from more than $35.00 to less than $0.25 for bulk packaged disposable devices capable of reducing as much as 31dB(A). Does the use of these devices allow the student to gain back lost performance in agricultural mechanics laboratories?

Purposes

The study examined the effects of a hearing protection device on student performance of agricultural mechanics skills. The study addressed the following research questions:

1. Will students who wear HPDs while in a noisy environment score higher on cognitive activities than students who wear a placebo device?

2. Will students who wear HPDs while in a noisy environment score higher on motor skill activities than students who wear a placebo device?

Two null hypotheses were formulated and tested at an alpha level of $p<.10$.

Ho_1: There is no significant difference between group mean performance scores on cognitive agricultural mechanics activities with exposure to attenuated and non-attenuated noise of 100dB(A) for 30 minutes.

Ho_2: There is no significant difference between group mean motor skill performance scores with exposure to attenuated and non-attenuated noise of 100dB(A) for 3 minutes.

Procedure

The study was conducted as a randomized, posttest only, control group experimental design (Campbell & Stanley, 1963). Pilot tests were conducted on the source of noise to be used, the ability of the recordings and amplifiers to reproduce true frequencies, the format of the cognitive test, and the proper administration of the motor test. A field test was conducted to evaluate the functioning of the equipment and data collection procedures. Ten vocational agriculture teachers, enrolled in a workshop entitled Power Train II, were presented the entire testing procedure in August, 1985.

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The source of the noise selected was a Poulan Counter-Vibe model 3400 chain saw with the bar and chain removed. The noise was recorded using a Sanyo stereo cassette deck, a Realistic microphone, a Superscope Stereo Cassette Deck, and a Realistic Stereo Frequency Equalizer. Recorded frequencies were adjusted using the equalizer to reproduce the chain saw noise as closely as possible. Noise frequencies and levels were measured using an IVIE Electronics Audio Spectrum Analyzer and checked against a Radio Shack meter. The noise was reproduced using a Realistic 64 watt amplifier and the Sanyo tape deck through 4 channels and 4 speakers.

The population frame consisted of 162 advanced agricultural mechanics students enrolled in either 11th or 12th grade vocational agriculture programs in public schools. Students with observable hearing losses were removed from the population before the random sample was drawn. The random sample consisted of 60 students plus 22 replacements. Fifteen replacements were used (8 treatment and 7 control) for absent students and those who failed to follow instructions. Students were randomly assigned to treatment and control groups. Data collection began on January 21, 1986, and was completed on February 20, 1986. Equipment arrangement, student seating and instructions were replicated at each of the participating schools.

Standardized tests consisting of the General Aptitude Test Battery (GATB) section on finger dexterity, and the American Institute of Research (AIR) Test of Farm Equipment Mechanics on diagnosing malfunctions were used throughout the study.

The General Aptitude Test Battery was studied by Hawk (1970) for the period of 1950 thru 1966. He found predictive validity slightly higher than concurrent validity for the GATB. The median phi coefficient was .42 for predictive validity and .38 for concurrent validity. Reliability coefficients in the studies of Droege (1965), Ghinselli (1966), Montgomery (1967) and Samuelson (1956) ranged between .80 and .90 for reliability.

The reported validity of the AIR test was established using 74 employers from 20 states. They rated the performance tests as 3.4 on a 4 point scale with 4 indicating "very important." The overall reliability of the AIR test was .93 as reported by Chalupsky in 1983.

A placebo device was developed for the control group. It consisted of one-quarter of a cotton ball placed loosely in the outer portion of each ear. Hearing protection devices were placed in identical containers to eliminate Hawthorne effects (Isaac & Michael, 1981). The experimental group received a disposable foam hearing protection device capable of 31dB (A) attenuation. Sound levels were carefully monitored throughout the testing and 100dB(A) maintained at the student's ear.

Student semester grades in vocational agriculture and race were collected as variables for post hoc analysis. Both the treatment and control groups, as well as replacements, received all tests concurrently.

Analysis of Data

Statistical decisions were based on results of a one-way analysis of variance (Morse, 1985). Appropriate post hoc analyses were conducted to assure the data met the assumptions of ANOVA. Homogeneity of the data was established using the Bartlett-Box test. Post-hoc correlations were conducted using Pearson Product Moment correlations in a matrix format (Norusis, 1984). The decision for each hypothesis was based on the alpha level of $p<.10$.

Results

Hypothesis 1 was rejected. Students exposed to attenuated noise performed significantly better on the cognitive measure than students without attenuation ($F(1,58) = 7.68$, $p<.007$). Refer to Table 1.

Table 1

An ANOVA of Treatment by Control for Cognitive Scores

Source of Variation	SS	df	MS	F-ratio	Probability
Between	32.26	1	32.26	7.68	0.007
Within	243.46	58	4.19		
Total	275.73	59			

Hypothesis 2 was rejected. Students exposed to attenuated noise performed significantly better on the motor measure than students without attenuation (F $(1,58) = 3.89$, $p<.05$). Refer to Table 2.

Table 2

An ANOVA of Treatment by Control for Motor Scores

Source of Variation	SS	df	MS	F-ratio	Probability
Between	1033.35	1	1033.35	3.89	0.05
Within	15408.30	58	265.66		
Total	16441.65	59			

Conclusions

There were significant statistical and practical differences between group mean performance scores on cognitive agricultural mechanics activities with exposure to attenuated and non-attenuated noise of 100dB(A). Students who completed the cognitive measure with an HPD capable of reducing the noise by 31dB(A) scored significantly better ($p<.007$) than students completing the same test in the same environment wearing a placebo device. The improvement was 13% on the mean scores (Table 3). Therefore, it was concluded that wearing an HPD reduces the loss of student performance associated with noisy laboratory conditions.

Table 3

Mean, Standard Deviation, Standard Error, Minimum Score, Maximum Score, and Number for Control and Treatment Groups for the Cognitive Scores

Group	M	SD	SE	Range Min	Range Max	n
Control	6.20	1.88	0.34	2	9	30
Treatment	7.67	2.20	0.40	3	12	30
All	6.93	2.16	0.28	2	12	60

There were significant differences between group mean motor skill performance scores with exposure to attenuated and non-attenuated noise of 100dB(A) for 3 minutes. Students who performed a motor skill while wearing a HPD scored significantly ($p<.05$) better than students who completed the same activity in a non-attenuated environment. The improvement was 4% on the mean scores (Table 4). Therefore, it was concluded that wearing an HPD capable of reducing noise commonly found in agricultural mechanics laboratories by 31dB(A) will reduce performance losses of students.

Table 4

Mean, Standard Deviation, Standard Error, Minimum Score, Maximum Score, and Number per Group for Motor Scores

Group	M	SD	SE	Range Min	Range Max	n
Control	81.50	18.19	3.32	29	108	30
Treatment	89.80	14.15	2.58	50	115	30
All	85.65	16.69	2.15	29	115	60

While the results must be limited to the population tested, they may be viewed as empirical evidence by agricultural mechanics instructors that student performance loss in the cognitive and motor domains may be reduced by providing students with effective hearing protection devices when noisy conditions exist in the laboratory. The findings have practical significance. Effective personal hearing protection devices were available for less than $.25 per student. This cost was minimal when compared with a 4% and 13% student performance improvement. Teachers will reduce performance losses by providing hearing protection whenever noisy equipment is to be operated while students perform cognitive and/or motor skills. These reductions in performance losses occur well below levels that endanger student health. Routine use of HPDs will insure that they are in place when exposures reach health-threatening levels.

Recommendations

Because intense noise found in agricultural mechanics laboratories is detrimental to student performance on cognitive and motor skills and because quality HPDs can reduce these losses, the use of HPDs should be recommended for routine use equal to safety glasses. Students in agricultural mechanics laboratories should use efficient hearing protection devices during intense noise.

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