1999

Physiological Responses to Music: The possible link between volume and hand grip strength

Holly Harrom

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Honors Project

April 15, 1999

ABSTRACT

Both stimulating and relaxing music have been shown to affect human physiology. The affect of music volume on hand grip strength is reported in this study. Eighteen subjects listened to four diverse music types at four different decibel levels, with strength being measured after each combination of style and volume. The data of individual subjects showed no correlation between volume and hand grip strength, however, the collective values of all subjects indicate that a direct relationship may exist.

INTRODUCTION

It has long been believed that music affects individuals emotionally. Psychologists have learned that music has the ability to induce both elated and depressed moods (24). Music has also been shown to reduce stress and anxiety (9). Researchers have even used music to produce certain facial expressions (2).

More recently, scientists have discovered that music has physiological effects. Relaxing music has been shown to reduce affective and observed post-operative pain (8), decrease heart and respiratory rates (3), and induce demented nursing home patients to eat more (19). Researchers have found that stimulating music increases both frontal interhemispheric coherence (10) and hand grip strength (12), in comparison to sedative music. These discoveries constitute an exciting first step toward a better understanding of the relationship between physiology and music.

However, many questions remain unanswered. In each of these experiments, music is simply categorized as either stimulating (fast and loud) or relaxing (slow and soft). Neither of these parameters--speed or volume--has been examined individually, leaving us to wonder--*Why* does the music we characterize as stimulating or relaxing have the observed physiological effects? Does stimulating music, for example, enhance hand grip because it is fast or loud, or for another reason? Likewise, does relaxing music decrease heart rate because it is typically slow and soft? Would increasing the volume of otherwise relaxing music alter this physiological response? A related psychological experiment found that loudness does affect human response to music emotionally. Medium volumes were shown to improve music tone and influence subjects' listening experience more positively than low or high volumes (17). Do volume and other parameters have similar effects *physiologically*?

To answer these kinds of questions, many parameters of music will have to be evaluated, including volume, rhythm and syncopation, speed, and style. Without an understanding of the effects of these parameters, we are unable to efficiently use music to obtain improved physiological responses. This project attempted to answer one of these questions.

The effect of volume changes on hand grip strength was examined. Subjects listened to four diverse music styles at various volume levels, with grip strength being measured after each segment. It was hypothesized that a direct relationship would be observed between decibel level and muscle strength, however, this relationship was not evident in the data of individual subjects.

MATERIALS AND METHODS

Musical Selections

Four styles of music were used: easy listening, classical, jazz, and hard rock. Each style was designated by a number, as specified below. Selections used to represent each music style are in brackets [ ]. For the purpose of this experiment, these styles were defined by the following key features:

Style 1 (Easy listening)--It is soothing and calming. Volume and speed typically stay within a narrow range. This music style is not very dynamic.

[Paul Hovda's "Simple Faith" from the "Inner Image" album, 1992]

Style 2 (Classical)--This was the prominent music style between the mid eighteenth and early nineteenth centuries. It is "graceful and clearly written, elegant . . . . [It] conforms to established forms and rules." Balance and uniformity are accentuated, emotion becomes less important than "controlled precision of design and style" (6). Music of this style is played by orchestral instruments.

[J. S. Bach's "Concerto No. 3 in D Major, Allegro" from the "Love Story" original motion picture soundtrack, 1970]

Style 3 (Jazz)--This style of music is characterized by improvisation and syncopation (13). Improvisation refers to the addition of both embellishments and short interludes (breaks); variations are played which are not written into the music. Syncopation is a special type of rhythm in which accents are moved from the main beats to those that are not normally accented.

[Al Hirt's "Bourbon Street Parade" from Al Hirt's Greatest Hits album, 1988-89]

Style 4 (Hard Rock)--Rock began in the mid 1950's and has remained the most popular music of the late twentieth century (13). It is characterized by its amplified beat (4). Other noteworthy features include its "song forms with odd-numbered formations, shifting meters, radical stanza patterns, and changing time signatures" (23). Hard rock is typically faster than soft rock or pop music.

[Metallica's "Through the Never" 1991 album]

Test Subjects

Eighteen human test subjects were recruited from the student body of Southern Adventist University.

Music Equipment

Stereo equipment (Yamaha Natural Sound Compact Disc Player CDC-625 RS) and headphones were used. Volume levels were measured in decibels using a Sound Level Meter (EMCO, SLM-Model 120), and the stereo volume was calibrated for each music selection according to these measurements (Table 1).

Table 1. Stereo-decibel meter volume calibrations

Volume (dB)	Style 1 (# of clicks)*	Style 2 (# of clicks)*	Style 3 (# of clicks)*	Style 4 (# of clicks)*
60	4	4	3	1
70	9	10	7	5
80	14	13	12	11
90	19	19	18	17

*Each click represents one push of the stereo's volume button.

Physiology Equipment

A 100 kg BSL Hand Dynamometer (Biopac Systems Inc., CA) was used to gage hand grip strength in millivolts.

Computer Analysis

The Biopac Student Lab Software (Biopac Systems Inc., CA) was used on a 486 MHz computer.

Experimental Design

Subjects listened to the first two minutes of each musical selection at four different volume levels. Music style and decibel level combinations were tested in random order, although the same order was used for each subject. Hand grip strength was gauged initially after a two minute control with no music (0 dB) and then again after each two minute segment. Subjects were instructed to squeeze the Hand Dynamometer for two seconds, using all of their strength. This process was then repeated twice, with a five second rest period between each squeeze.

Data Analysis

The data was analyzed in several ways. First, the average of the three grip strength measurements for each music segment was determined for each subject (see sample of peak data in Figure 1). In this study, a music segment is defined as the two minute listening period for a given volume and music style. A composite average was then calculated for each volume and style using the data from all subjects. In a second analysis of the data, the highest peak of each music segment for each subject was analyzed similarly. In order to define the influence of volume differences alone, the composite averages for all music styles in each volume level were totaled for comparison. The influence of style differences was determined similarly.

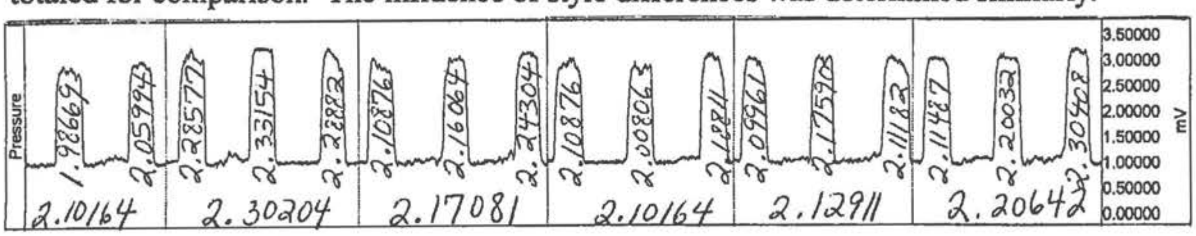

Figure 1. Sample of peak data

RESULTS & DISCUSSION

The strength values in Tables 2 and 3 (shown graphically in Figures 2 and 3) do not vary directly or indirectly with volume for any style. Furthermore, no other relationship between strength and volume is evident from this data, because the patterns are different for each style. For example, for style 1, strength increases as volume increases from 60 dB to 80 dB, but then decreases at 90 dB (Figures 2 and 3). For style 4, strength decreases when volume increases from 60 dB to 70 dB, but then increases at higher decibels (Figures 2 and 3). The patterns in Figures 2 and 3 are very similar, so it does not seem to matter whether the average or highest strength values for each segment are used to calculate the composite averages.

Table 2. Average strength values in each category, as calculated from the average peaks of all subjects

Volume (dB)	Style 1	Style 2	Style 3	Style 4	*Volume Totals (mV)*
0	1.56	1.56	1.56	1.56	*6.24*
60	1.42	1.44	1.5	1.64	*6*
70	1.49	1.53	1.45	1.51	*5.98*
80	1.56	1.5	1.55	1.55	*6.16*
90	1.53	1.52	1.57	1.65	*6.27*
Style Totals (mV)	*7.56*	*7.55*	*7.63*	*7.91*	

Table 3. Average strength values in each category, as calculated from the highest peaks of all subjects

Volume (dB)	Style 1	Style 2	Style 3	Style 4	*Volume Totals (mV)*
0	1.68	1.68	1.68	1.68	*6.72*
60	1.55	1.55	1.62	1.76	*6.48*
70	1.6	1.65	1.58	1.63	*6.46*
80	1.7	1.67	1.67	1.67	*6.71*
90	1.66	1.63	1.71	1.81	*6.81*
Style Totals (mV)	*8.19*	*8.18*	*8.26*	*8.55*	

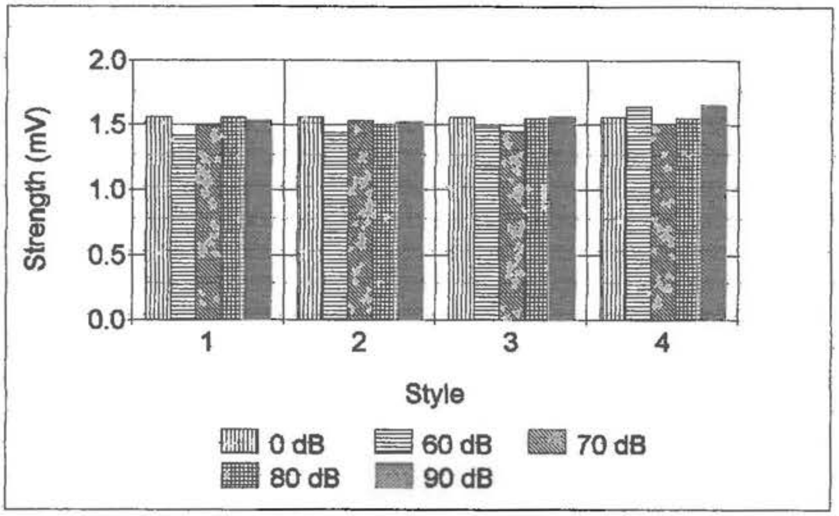

Figure 2. Average strength values for all styles at each volume, using the average peaks from each subject's data.

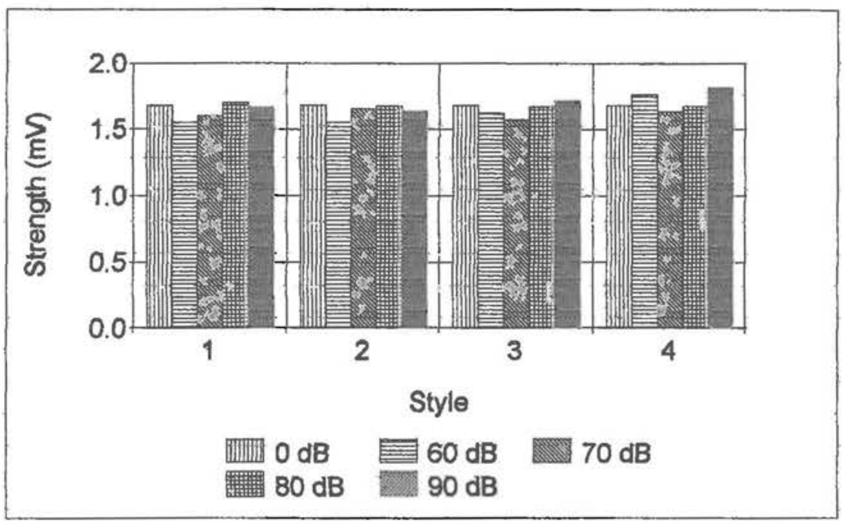

Figure 3. Average strength values for all styles at each volume, using the highest peaks from each subject's data.

The total strength values at each volume indicate that an unusual relationship between strength and volume may exist. Grip strength decreases as volume increases from 60 to 70 dB, but then increases directly with volume at higher decibels, just as it does for style 4 (Figures 4 and 5). The patterns in Figures 4 and 6 are fairly similar, so it does not seem to matter whether the average or highest strength values for each segment are used to calculate the volume totals. This increase in strength at higher decibels seems to indicate that strength may vary directly with volume within certain decibel ranges.

However, such a relationship can neither be supported conclusively or rejected. Some studies have contradicted the hypothesis that stimulating music (with its loud volume) increases physiological responses. Two experiments found that stimulating music had no effect on physical endurance or grip strength, while relaxing music decreased these responses (5, 18). However, not all of the literature shares these results. Ferguson, et. al. and Karageorghis did find that stimulating music increased physical strength relative to white noise (7, 12), so it is possible that loud volumes could increase hand grip strength. This possibility seems even more likely when the results of another experiment are considered. Schwartz, Fernhall, and Plowman found that fast music did *not* influence stationary bicycle performance (22). If experiments which claim that stimulating music affects physiological responses are correct, and speed is not responsible for these affects, it is likely that volume is responsible.

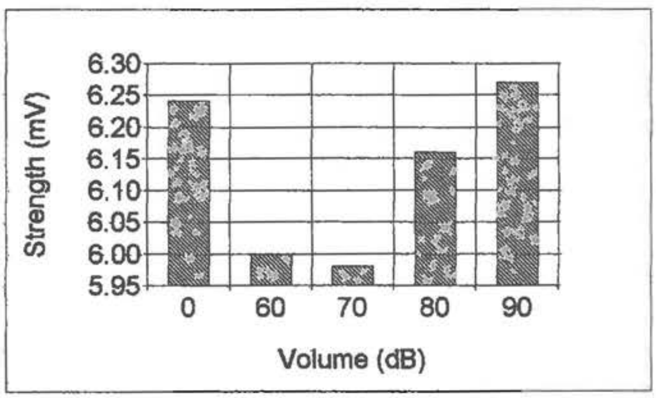

Figure 4. Volume totals from Table 2

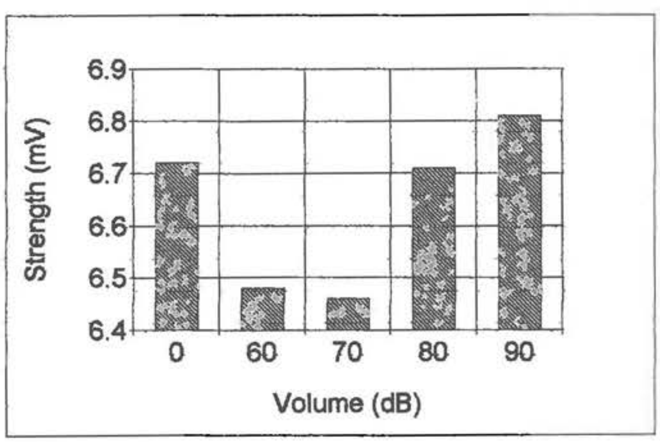

Figure 5. Volume totals from Table 3

The effects of different music styles on grip strength did vary. Figures 6 and 7 show that style 4 increases grip strength relative to styles 1, 2, and 3. Style 3 averaged higher strength values than styles 1 and 2; style 2 averaged the lowest strength values. Once again, it does not seem to matter whether the average or highest strength values for each segment are used to calculate the data, because the results are very similar in Figures 6 and 7.

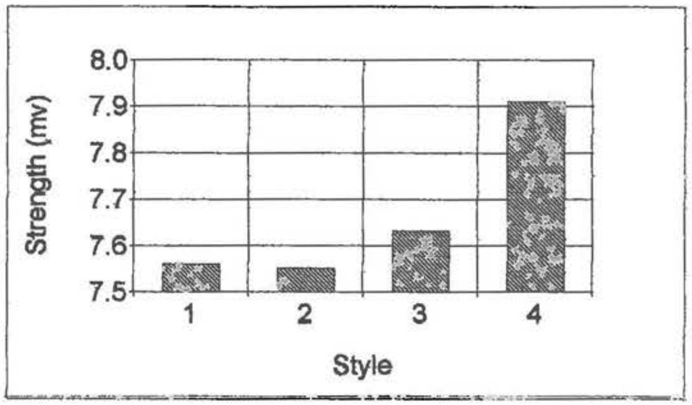

Figure 6. Style totals from Table 2

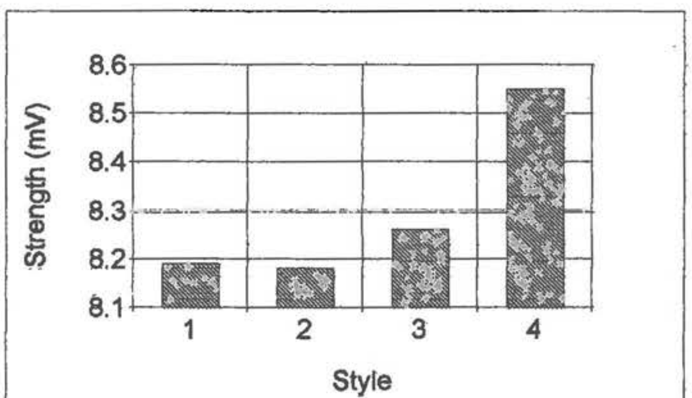

Figure 7. Style totals from Table 3

The connection between grip strength and music preference found in the data of subjects 14 and 17 is interesting. Lipschultz and Chambliss found that stimulating and relaxing music are differentially related to happy and sad emotions, respectively (7). So it is possible that subjects 14 and 17 associate music styles 4 and 3 with feelings which can affect their physiological responses. This is very likely in light of an enormous amount of data which relates emotion to music (1, 11, 14, 15, 16, 20, 21, 25). It may be that music alters our *physiological* responses through our emotions.

Table 4. Strength values for subject 14

			Strength (mV)	**Strength (mV)**	**Strength (mV)**	**(mV)**
Subject	*Music Preference*	*Volume (dB)*	*Style 1*	*Style 2*	*Style 3*	*Style 4*
14	Style 4	60	1.46	1.74	1.52	**3.13**
		70	1.66	2.19	1.75	**2.23**
		80	2.35	1.68	1.83	**2.52**
		90	1.74	1.94	2.19	**3.03**
		Average strength	1.8	1.89	1.82	**2.72**

Table 5. Strength values for subject 17

			Strength (mV)	**Strength (mV)**	**Strength (mV)**	**Strength (mV)**
Subject	*Music Preference*	*Volume (dB)*	*Style 1*	*Style 2*	*Style 3*	*Style 4*
17	Style 3	60	1.55	1.69	**2.14**	1.38
		70	1.57	1.69	**2.26**	1.23
		80	1.59	1.91	**2.13**	1.59
		90	1.79	1.65	**2.34**	2.13
		Average strength	1.63	1.74	**2.22**	1.58

CONCLUSION

The initial hypothesis that louder volumes increase grip strength cannot be ruled out or supported conclusively. However, the results of this experiment provide much opportunity for future research. Individual preferences for style and volume may affect grip strength. Gender differences might also cause male and female subjects to react diversely to various volumes and styles. In addition, it is not known how much hand fatigue subjects experience as a result of squeezing a hand dynamometer repeatedly. Hand fatigue may affect grip strength, and would need to be accounted for when analyzing results. The possibilities for expansion and modification of this research are endless.

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SOUTHERN SCHOLARS SENIOR PROJECT

Name: Holly Harrom Date: 8-24-98

Major: Biology

Senior Project

A significant scholarly project, involving research, writing, or special performance, appropriate to the major in question, is ordinarily completed the senior year. Ideally, this project will demonstrate an understanding of the relationship between the student's major field and some other discipline. The project is expected to be of sufficiently high quality to warrant a grade of A and to justify public presentation. The completed project, to be turned in in duplicate, must be approved by the Honors Committee in consultation with the student's supervising professor three weeks prior to graduation. The 2-3 hours of credit for this project is done as directed study or in a research class.

Keeping in mind the above senior project description, please describe in as much detail as you can the project you will undertake:

Many experiments have been performed to determine the ~~phys~~ psychological effects of music. Researchers are now becoming increasingly interested in the relationship between music and physiology. Experiments are needed which will examine the effects of specific music parameters on various physiological functions. A better understanding of these effects will enable us to more efficiently use music to produce desired physiological responses.

The purpose of this research project is to identify the relationship between volume and hand grip strength. Twenty SAU students will listen to music →

Expected date of completion Christmas '98

Signature of faculty advisor Keith Snyder

Approval to be signed by faculty advisor when project is completed:

This project has been completed as planned: yes

This is an "A" project: yes

The project is worth 2-3 hours of credit: 2

Advisor's Final Signature Keith Snyder

Chair, Honors Committee ________ Date Approved: ________