



Fall 12-2004

How do singing, ear training, and physical movement affect accuracy of pitch and rhythm in an instrumental music ensemble?

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Hunter, Stephen Andrew, "How do singing, ear training, and physical movement affect accuracy of pitch and rhythm in an instrumental music ensemble?" (2004). *University of Tennessee Honors Thesis Projects*.
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UNIVERSITY HONORS PROGRAM

SENIOR PROJECT - APPROVAL

Name: S. Andrew Hunter

College: Arts & Sciences Department: Music

Faculty Mentor: Keith McClelland

PROJECT TITLE: How do singing, ear training, and physical movement affect accuracy of pitch and rhythm in an instrumental music ensemble?

I have reviewed this completed senior honors thesis with this student and certify that it is a project commensurate with honors level undergraduate research in this field.

Signed:  Faculty Mentor

Date: 12/9/04

Comments (Optional):

384-0577

S. Andrew Hunter
Bachelor of Music Education
Senior Honors Project

How do singing, ear training, and physical movement affect accuracy of
pitch and rhythm in an instrumental music ensemble?

For many years band and orchestra directors have utilized techniques such as singing, clapping, and listening to excerpts as methods to improve performance in their performing ensembles. However, little research has been done to verify the direct effects that these techniques have on student performance. While there may be a noticeable difference when these methods are utilized, one must wonder whether the improvement comes from the exercises performed or if the students are simply more focused through the integration of varying techniques. This project attempts to put real numbers with these methods and explain their effects on student performance in an instrumental ensemble.

Music, in its most basic form, comes down to two primary elements: pitch and rhythm. Pitch explains the proximity of a note, whether it is high or low and how high or low. Rhythm is the relationship of these notes to one another in a given time, also known as tempo. With these two elements a composer may make the simplest melody of a complex landscape of music. Of course, there are other elements of music, such as dynamics, phrasing, balance, blend, and many others too numerous to mention. These elements are also somewhat difficult to measure consistently, whereas pitch and rhythm can be clearly defined, making them more accessible for these purposes.

While working with the Farragut High School Band as a student teacher, I asked 50 students who play various instruments to participate in this study. The experiments would be conducted individually and the results combined to garner averages for further study. The instrumentation used included seven flutes, one oboe, eight clarinets, four alto saxophones, two bassoons, one bass clarinet, eight trumpets, two horns, five trombones, three baritones, three tubas, and six percussionists. I also chose students of varying grade and skill levels, though these two criteria are not necessarily linked.

The first experiment was used to measure the students' ability to tune a given pitch to a predetermined standard. The standard measurement used by most performing organizations is A=440 Hz, which is the frequency I used as a base. The actual pitch used for each instrument varied based upon individual pitch tendencies of the instruments. First, I had the students play a given pitch and measured how many cents, or waves per second, that the pitch they played was from center, or what is considered "in tune" according to the frequency previously mentioned. The students were given no verbal or physical indication as to their pitch's relationship to the "in tune" pitch. Next I used a machine that plays any designated pitch 100% in tune and had the student listen to the pitch and then match the pitch by singing. This utilizes both ear-training (listening to the pitch) and vocal technique (singing the pitch). The result should be an internalization of the pitch and increased accuracy. Finally, I had the student play the same pitch and again recorded the deviation from center, after which I measured the difference between the two and recorded the percentage of improvement. Note that the percentage of improvement is *not* in relationship to the first pitch; rather it is in relationship to what is "in tune."

The results of this experiment were generally impressive. It is important to note that the human ear can begin to distinguish between two pitches that are a minimum of three cents apart, or 3% of a semitone away from each other. When considering the broad range of harmonic frequencies, this number seems quite small, and it is. However, it is perceptible to the average human ear, making a gap even that small between two notes sound quite noticeable. The average improvement of the group was 7 cents, or 7%, closer to "in tune," meaning the students generally moved closer to center and consequently closer to each other in pitch, simply by hearing and singing a standardized pitch. The overwhelming majority improved their pitch by over 50%. These adjustments would assuredly make a dramatic difference in the sound of a performing group.

The following two phases of the experiment involved the student sight-reading, or playing for the first time upon seeing, two pieces of music of comparable difficulty. The student was asked to turn the first piece over and begin playing it immediately. This gave the student no time to evaluate anything other than meter (beats per measure) and the key signature (number of sharps or flats) before playing – a true sight-reading. I recorded this

example and reviewed the tape to determine how many missed pitches and missed rhythms occurred within the piece. After a short rest period, I asked the student to turn the second piece of music over and look at the meter and key signature. I then asked the student to clap and count through the rhythms of the piece and sing through the piece, all without playing a note. The student then played through the piece and I used the same process of recording and listening to gather the same information as with the first piece.

The results of this experiment indicate a strong improvement in both pitch and rhythmic accuracy. In the first sight-reading example, the students missed an average of 17.09% of the pitches and 15.42% of the rhythms. However, through utilization of singing, clapping, and counting, the students only missed an average of 9.59% of the pitches and 7.04% of the rhythms, an improvement of 7.5% and 8.38%, respectively. While those improvements seem somewhat small, consider that this means a student would miss one fewer pitch out of every 13 played, or roughly one less every two measures of music played. Also, this constitutes one fewer rhythmic error every 12 notes, a noticeable improvement even to the untrained ear.

In conclusion, the results of this experiment indicate that ear training, singing, and physical movement dramatically improve tuning and pitch and rhythmic accuracy in instrumental ensembles. If properly implemented into instructional strategies, these methods can continue to be used as tools to create more accurate and, consequently, more beautiful music.

Tuning Exercise

Instrument	Grade Level	Pitch Used	Pitch #1	Pitch #2 (Adjusted)	% Improvement
Flute	12	D	b13	#3	10%
Flute	12	D	b9	0	9%
Flute	11	D	#7	b3	4%
Flute	11	D	b21	b7	14%
Flute	10	D	#14	b2	12%
Flute	10	D	b16	0	16%
Flute	9	D	0	#5	-5%
Oboe	11	A	b10	#6	4%
Clarinet	12	E	#7	#2	5%
Clarinet	12	E	#10	b2	8%
Clarinet	12	E	#15	#5	10%
Clarinet	11	E	b10	b5	5%
Clarinet	11	E	#4	b7	-3%
Clarinet	10	E	#9	#3	6%
Clarinet	9	E	#3	#8	-5%
Clarinet	9	E	#25	#6	19%
Alto Saxophone	12	F#	b10	b4	6%
Alto Saxophone	11	F#	b8	#3	5%
Alto Saxophone	10	F#	#6	b2	4%
Alto Saxophone	9	F#	b14	b9	5%
Bassoon	11	A	#5	0	5%
Bassoon	10	A	#23	#9	14%
Bass Clarinet	10	C	#5	0	5%
Trumpet	12	A	#28	#12	16%
Trumpet	12	A	#12	b3	9%
Trumpet	11	A	0	#9	-9%
Trumpet	11	A	#8	b2	6%
Trumpet	10	A	b7	#3	4%
Trumpet	10	A	#35	#14	21%
Trumpet	9	A	b10	0	10%
Trumpet	9	A	#4	b4	0%
Horn	11	C	#8	0	8%
Horn	11	C	#17	b2	15%
Trombone	12	D	#11	b5	6%
Trombone	12	D	#9	0	9%
Trombone	10	D	0	0	0%
Trombone	9	D	b6	#12	-6%
Trombone	9	D	b20	b7	13%
Baritone	12	G	#6	0	6%
Baritone	12	G	#19	#7	12%
Baritone	10	G	#14	#3	11%
Tuba	12	C	#27	#10	17%
Tuba	11	C	#25	#14	11%
Tuba	9	C	#14	#5	9%
Percussion	12	n/a	n/a	n/a	n/a
Percussion	11	n/a	n/a	n/a	n/a
Percussion	11	n/a	n/a	n/a	n/a
Percussion	10	n/a	n/a	n/a	n/a
Percussion	9	n/a	n/a	n/a	n/a
Percussion	9	n/a	n/a	n/a	n/a
Average	10.62	n/a	n/a	n/a	7%

Pitch Accuracy

Instrument	Grade Level	S.R. #1 - Missed Pitches	S.R. #1 - Total Pitches	S.R. #1 - Missed Pitches %	S.R. #2 - Missed Pitches	S.R. #2 - Total Pitches	S.R. #2 - Missed Pitches %	% Improvement
Flute	12	18	127	14.17%	6	148	4.05%	14.42%
Flute	12	21	127	16.54%	9	148	6.08%	10.45%
Flute	11	12	127	9.45%	3	148	2.03%	7.42%
Flute	11	26	127	20.47%	15	148	10.14%	10.34%
Flute	10	17	127	13.39%	8	148	5.41%	7.98%
Flute	10	22	127	17.32%	11	148	7.43%	9.89%
Flute	9	24	127	18.90%	5	148	3.38%	15.52%
Oboe	11	13	142	9.15%	4	114	3.51%	5.65%
Clarinet	12	8	113	7.08%	6	130	4.62%	2.46%
Clarinet	12	15	113	13.27%	9	130	6.92%	6.35%
Clarinet	12	19	113	16.81%	7	130	5.38%	11.43%
Clarinet	11	16	113	14.16%	13	130	10.00%	4.16%
Clarinet	11	25	113	22.12%	11	130	8.46%	13.66%
Clarinet	10	29	113	25.66%	23	130	17.69%	7.97%
Clarinet	9	20	113	17.70%	14	130	10.77%	6.93%
Clarinet	9	12	113	10.62%	4	130	3.08%	7.54%
Alto Saxophone	12	10	136	7.35%	8	121	6.61%	0.74%
Alto Saxophone	11	21	136	15.44%	15	121	12.40%	3.04%
Alto Saxophone	10	23	136	16.91%	7	121	5.79%	11.13%
Alto Saxophone	9	16	136	11.76%	9	121	7.44%	4.33%
Bassoon	11	8	111	7.21%	4	120	3.33%	3.87%
Bassoon	10	30	111	27.03%	18	120	15.00%	12.03%
Bass Clarinet	10	13	160	8.13%	6	131	4.58%	3.54%
Trumpet	12	12	109	11.01%	12	144	8.33%	2.68%
Trumpet	12	18	109	16.51%	14	144	9.72%	6.79%
Trumpet	11	7	109	6.42%	4	144	2.78%	3.64%
Trumpet	11	22	109	20.18%	16	144	11.11%	9.07%
Trumpet	10	31	109	28.44%	21	144	14.58%	13.86%
Trumpet	10	28	109	25.69%	19	144	13.19%	12.49%
Trumpet	9	16	109	14.68%	26	144	18.06%	-3.38%
Trumpet	9	36	109	33.03%	11	144	7.64%	25.39%
Horn	11	35	126	27.78%	18	101	17.82%	9.96%
Horn	11	42	126	33.33%	24	101	23.76%	9.57%
Trombone	12	16	133	12.03%	14	162	8.64%	3.39%
Trombone	12	23	133	17.29%	18	162	11.11%	6.18%
Trombone	10	20	133	15.04%	20	162	12.35%	2.69%
Trombone	9	28	133	21.05%	15	162	9.26%	11.79%
Trombone	9	32	133	24.06%	27	162	16.67%	7.39%
Baritone	12	11	120	9.17%	3	121	2.48%	6.69%
Baritone	12	19	120	15.83%	10	121	8.26%	7.57%
Baritone	10	27	120	22.50%	17	121	14.05%	8.45%
Tuba	12	12	115	10.43%	6	100	6.00%	4.43%
Tuba	11	24	115	20.87%	9	100	9.00%	11.87%
Tuba	9	20	115	17.39%	13	100	13.00%	4.39%
Percussion	12	19	143	13.29%	19	129	14.73%	-1.44%
Percussion	11	18	143	12.59%	12	129	9.30%	3.29%
Percussion	11	36	143	25.17%	8	129	6.20%	18.97%
Percussion	10	33	143	23.08%	16	129	12.40%	10.67%
Percussion	9	27	143	18.88%	12	129	9.30%	9.58%
Percussion	9	22	143	15.38%	26	129	20.16%	-4.77%
Average	10.62			17.09%			9.59%	7.50%

Rhythmic Accuracy

Instrument	Grade Level	S.R. #1 - Missed Note Values	S.R. #1 - Total Pitches	S.R. #1 - Missed Rhythms %	S.R. #2 - Missed Note Values	S.R. #2 - Total Notes	S.R. #2 - Missed Rhythms %	% Improvement
Flute	12	15	127	11.81%	7	148	4.73%	7.08%
Flute	12	22	127	17.32%	11	148	7.43%	9.89%
Flute	11	14	127	11.02%	9	148	6.08%	4.94%
Flute	11	27	127	21.26%	17	148	11.49%	9.77%
Flute	10	13	127	10.24%	6	148	4.05%	6.18%
Flute	10	19	127	14.96%	10	148	6.76%	8.20%
Flute	9	26	127	20.47%	6	148	4.05%	16.42%
Oboe	11	11	142	7.75%	8	114	7.02%	0.73%
Clarinet	12	10	113	8.85%	13	130	10.00%	-1.15%
Clarinet	12	18	113	15.93%	8	130	6.15%	9.78%
Clarinet	12	17	113	15.04%	10	130	7.69%	7.35%
Clarinet	11	19	113	16.81%	5	130	3.85%	12.97%
Clarinet	11	27	113	23.89%	14	130	10.77%	13.12%
Clarinet	10	30	113	26.55%	9	130	6.92%	19.63%
Clarinet	9	16	113	14.16%	4	130	3.08%	11.08%
Clarinet	9	14	113	12.39%	14	130	10.77%	1.62%
Alto Saxophone	12	7	136	5.15%	2	121	1.65%	3.49%
Alto Saxophone	11	23	136	16.91%	12	121	9.92%	6.99%
Alto Saxophone	10	21	136	15.44%	11	121	9.09%	6.35%
Alto Saxophone	9	18	136	13.24%	7	121	5.79%	7.45%
Bassoon	11	6	111	5.41%	6	120	5.00%	0.41%
Bassoon	10	25	111	22.52%	10	120	8.33%	14.19%
Bass Clarinet	10	15	160	9.38%	8	131	6.11%	3.27%
Trumpet	12	11	109	10.09%	4	144	2.78%	7.31%
Trumpet	12	21	109	19.27%	10	144	6.94%	12.32%
Trumpet	11	10	109	9.17%	3	144	2.08%	7.09%
Trumpet	11	22	109	20.18%	14	144	9.72%	10.46%
Trumpet	10	30	109	27.52%	11	144	7.64%	19.88%
Trumpet	10	23	109	21.10%	13	144	9.03%	12.07%
Trumpet	9	19	109	17.43%	6	144	4.17%	13.26%
Trumpet	9	32	109	29.36%	8	144	5.56%	23.80%
Horn	11	17	126	13.49%	5	101	4.95%	8.54%
Horn	11	14	126	11.11%	10	101	9.90%	1.21%
Trombone	12	18	133	13.53%	18	162	11.11%	2.42%
Trombone	12	21	133	15.79%	13	162	8.02%	7.76%
Trombone	10	22	133	16.54%	16	162	9.88%	6.66%
Trombone	9	22	133	16.54%	5	162	3.09%	13.45%
Trombone	9	25	133	18.80%	9	162	5.56%	13.24%
Baritone	12	15	120	12.50%	4	121	3.31%	9.19%
Baritone	12	18	120	15.00%	16	121	13.22%	1.78%
Baritone	10	24	120	15.00%	17	121	14.05%	0.95%
Tuba	12	16	115	13.91%	8	100	8.00%	5.91%
Tuba	11	15	115	13.04%	6	100	6.00%	7.04%
Tuba	9	19	115	16.52%	17	100	17.00%	-0.48%
Percussion	12	21	143	14.69%	8	129	6.20%	8.48%
Percussion	11	14	143	9.79%	4	129	3.10%	6.69%
Percussion	11	26	143	18.18%	9	129	6.98%	11.21%
Percussion	10	23	143	16.08%	6	129	4.65%	11.43%
Percussion	9	17	143	11.89%	2	129	1.55%	10.34%
Percussion	9	26	143	18.18%	14	129	10.85%	7.33%
Average	10.62			15.42%			7.04%	8.38%