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During the 1978-79 academic year, sixteen freshman music majors participated in an experiment in which their response data were saved as they worked through 24 units of rhythmic dictation exercises in the University of Delaware's GUIDO® system. Analysis of the student data base showed perceptual patterns and learning styles common to exercises in both simple and compound meters. First, it was found that basic undotted, nonduplet, nontriplet notes are confused exclusively with themselves and never with dotted notes, duplets, or triplets. The same exclusive confusion pattern is seen for dotted notes, duplets, and triplets, except that they are also confused with their unmodified basic counterparts. By varying the time signatures used in the experiment, it was found that significantly more exercises are correctly answered in simple meter when a four is on the bottom, and the same pattern was found when an eight is on the bottom in compound meter. Randomly varying the pitch of the monotone stimulus between c and c2 had no effect on student achievement. As the level of difficulty increased in the 24 units, so did the average student response time and the number of times students asked for the stimulus to be replayed. The average speed at which students played the stimulus also decreased. Students who used high average dictation speeds tended to request fewer repetitions of the stimulus, as did students who used the metronome. However, neither speed of dictation, use of the metronome, nor number of repetitions had a high correlation with student achievement.

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Computer-Based Recognition of Perceptual Patterns and Learning Styles in Rhythmic Dictation Exercises

This is the fourth in a series of articles reporting the results of experiments in aural training using the University of Delaware's GUIDO system. The first three articles (Hofstetter 1978, 1979, 1980) dealt with student acquisition of dictation skills in harmonies, intervals, and chord qualities respectively; this article deals with rhythmic dictation. It is the purpose of these articles to serve as a starting point for more in-depth research into the acquisition of aural skills.

It is eventually hoped that as knowledge accumulates through this process of experimentation, a cognitive model of how students learn to internalize and

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conceptualize the music they hear can be developed. The present study of student perception of rhythmic dictation exercises is one step in this process.

APPARATUS

All of the rhythmic dictation exercises used as stimuli in this experiment were presented to students by means of the rhythmic dictation program in the University of Delaware's GUIDO system. Figure 1 shows a sample screen display from this program. At the top of the screen students are shown the number and title of the unit in that they are working, and immediately below that GUIDO displays the notes which the students have correctly answered so far. Four rows

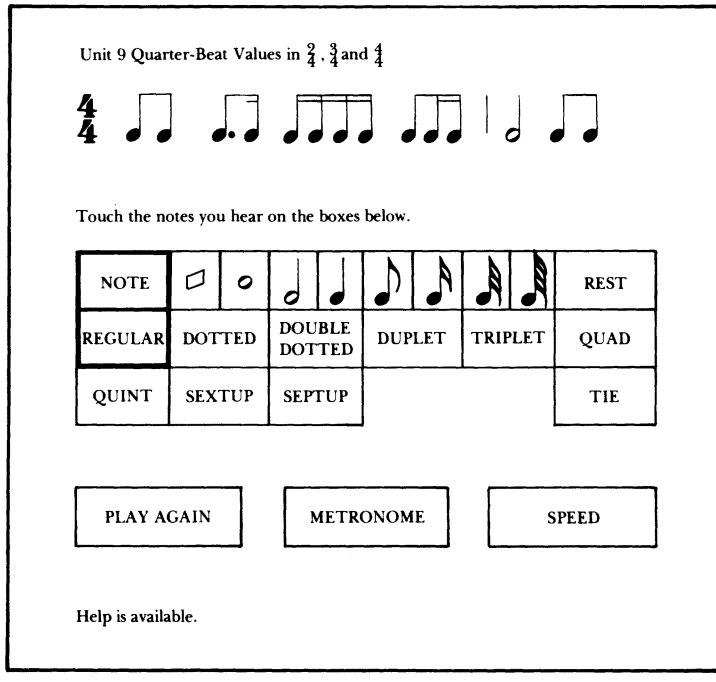


Figure 1—Sample display from the GUIDO rhythmic dictation program by Fred T. Hofstetter and William H. Lynch. Copyright © 1978 by the University of Delaware.

of touch-sensitive student input boxes are drawn at the bottom of the screen. By touching boxes in the first row, students can enter notes and rests with lengths varying from a double whole note down to a 64th note. Using the next two rows of boxes, the students indicate whether the note values are regular unmodified ones, or if they are dotted, tied, or involved in a borrowed or irregular grouping. The last row contains three larger student control boxes. By touching these boxes, students can ask for an exercise to be played again, they can turn on a metronome that causes one measure of the beat to be played immediately before the exercise, and they can touch a speed box that allows them to select dictation speeds varying from 30 to 300 beats per minute.

As with all of the dictation programs in the GUIDO system, dictation exer-

cises are generated according to a master table wherein a curriculum has been specified. Table 1 is a master table that shows the 24 rhythm units used in this experiment. Columns one and two show the numbers and titles for each of the 24 rhythmic dictation units. Column three shows the ratio of simple to compound exercises in each unit. Only ones and zeros were used to specify these ratios in this experiment, such that a ratio of 1:0 means simple meters only, 0:1 means compound meters only, and 1:1 means an equal mix of exercises in simple and compound meters. Column four shows the probability that notes would be tied over the bar line in a given exercise. The next 13 columns show the probabilities that various note-value patterns would occur in simple and compound meters. The last 18 columns of the table show what numbers were allowed on the top and on the bottom of time signatures for exercises in both simple and compound meters. At the bottom of the table are listed nine variables that can be manipulated in the master table of the rhythm program, but that had the same value for each of the 24 units in this experiment. The number of measures in each exercise was always two. The pitch at which the rhythm was dictated was always a single note randomly selected from the range of c to c2. The time limit was always 10 seconds per beat, and the advancement criterion was seven out of eight at 75% correct. This means that an exercise was considered to be correct if the student correctly answered 75% of its note values on the first try. To achieve mastery in a given unit, the students had to answer seven out of eight exercises at this 75% level. As was previously seen in Figure 1, students were given their choice of repeating exercises as often as they wanted, turning the metronome on or off, and selecting the speed of dictation.

PROCEDURE

During the 1978-79 academic year, 16 freshman music majors completed these units in partial fulfillment of the requirements for their freshman ear-training course. As a group they completed 5,393 rhythmic dictation exercises. For each exercise, the computer saved the name of the student, the number of the unit, the complete stimulus, the student's first response to each note value in the exercise, the time signature used, the pitch at which dictation was given, whether or not the exercise was judged correct, the number of seconds it took the student to get the right answer, the number of times the student played the exercise, the speed at which the student asked the exercise to be played, and whether or not the metronome was on. The students were required to work in order, from left to right, in answering note values in the rhythmic dictation exercises. If they answered a note value incorrectly, they were allowed to continue working until they could correct it. In this study, however, only the first response to each note value was considered for analysis.

Four kinds of analyses were applied to the student response data base. First, cross tabulations of correct answers and student responses were made to determine whether there were any confusion patterns in student perception of rhythm. Second, analyses were made of the percent of exercises correct at each time signature and at each dictation pitch used in the experiment. Third, a multiple correlation of instructional variables for each unit was made in order to show learning styles in the curriculum as a whole, and finally, a multiple correlation of instructional variables was made at the student level to measure

Table 1—Master Table Showing the 24 Rhythm Units Used in the Experiment.

				Probability of occurrence of rhythmic patterns												
				Simple meter									*Compound meter*			
Unit	*Title*	*Simple/ Compound ratio*	*Probability of ties*	*Full-Beat patterns*	*Half-Beat patterns*	*Syncopated half-beat patterns*	*Quarter-beat patterns*	*Syncopated quarter-beat patterns*	*Eighth-Beat patterns*	*Full-Beat triplets*	*Half-Beat triplets*	*Double-Beat triplets*	*Full-Beat patterns*	*Regular divisions*	*Regular subdivisions with syncopation*	*Borrowed divisions (duplets)*
1	Undivided Beat Values in 2/4, 3/4 and 4/4	1:0	0%	100%												
2	Undivided Beat Values in Other Time Signatures	1:0	0%	100%												
3	Half-Beat Values in 2/4, 3/4 and 4/4	1:0	0%	80%	20%											
4	Half-Beat Values in Other Time Signatures	1:0	0%	80%	20%											
5	Emphasis on Half-Beat Values in Simple Meter	1:0	0%	60%	40%											
6	Review of Rhythmic Patterns Studied So Far	1:0	0%	75%	25%											
7	Notes Tied Over The Bar Line in Simple Meter	1:0	100%	75%	25%											
8	Half-Beat Values in Syncopation	1:0	0%	25%	25%	50%										
9	Quarter-Beat Values in 2/4, 3/4 and 4/4	1:0	0%	20%	40%		40%									
10	Quarter-Beat Values in Other Time Signatures	1:0	0%	20%	40%		40%									
11	Emphasis on Quarter-Beat Values in Simple Meter	1:0	0%	10%	30%		60%									
12	Review of Rhythmic Patterns Studied So Far	1:0	51%	10%	30%	30%	30%									
13	Quarter-Beat Values in Syncopation	1:0	0%	10%	30%		30%	30%								
14	Introduction of Triplets in 2/4, 3/4 and 4/4	1:0	0%	40%	40%					20%						
15	Triplets in Other Time Signatures	1:0	0%	40%	40%					20%						
16	Regular Divisions in 6/8, 9/8 and 12/8	0:1	0%										50%	50%		
17	Regular Subdivisions in 6/8, 9/8 and 12/8	0:1	0%										20%	40%	40%	
18	Regular Divisions and Subdivisions in Other Compound Meters	0:1	0%										20%	40%	40%	
19	Review of Rhythmic Patterns Studied So Far	1:1	51%	17%	33%	33%	17%						20%	40%	40%	
20	Borrowed Divisions in Compound Meter	0:1	0%										40%	40%		20%
21	Borrowed Subdivision in Simple Meter With Syncopation	1:0	0%	25%	25%		25%				25%					
22	Eighth-Beat Values in 2/4, 3/4, 4/4, 2/2, 3/2 and 1/2	1:0	0%	33%			33%		33%							
23	Triplets Which Last Two Beats in Simple Meter	1:0	0%	25%	25%		25%					25%				
24	Review of Rhythmic Patterns Studied So Far	1:1	51%			25%		25%	25%	25%			25%	25%	25%	25%

Note. Variables that can be manipulated in the rhythm program, but which had the same value for each of the 24 units in this experiment:

Minimum number of measures: 2
Maximum number of measures: 2
Speed: student choice
Pitch range: from small c to c^2
Time limit per beat: 10 seconds
Number of plays: student choice
Metronome on or off: student choice
Advancement criteria: 7 out of 8 at 75% correct

Table 1 (continued)—Master Table Showing the 24 Rhythm Units Used in the Experiment.

Unit	Title	Numbers allowed on the top and bottom of time signatures																	
		Simple meter										Compound meter							
		Top					Bottom					Top				Bottom			
		2	3	4	5	7	1	2	4	8	16	6	9	12	15	2	4	8	16
1	Undivided Beat Values in 2/4, 3/4 and 4/4	1	1	1					1										
2	Undivided Beat Values in Other Time Signatures	1	1	1				1	1	1	1								
3	Half-Beat Values in 2/4, 3/4 and 4/4	1	1	1					1										
4	Half-Beat Values in Other Time Signatures	1	1	1				1	1	1	1								
5	Emphasis on Half-Beat Values in Simple Meter	1	1	1				1	1	1	1								
6	Review of Rhythmic Patterns Studied So Far	1	1	1				1	1	1	1								
7	Notes Tied Over The Bar Line in Simple Meter	1	1	1				1	1	1	1								
8	Half-Beat Values in Syncopation	1	1	1				1	1	1	1								
9	Quarter-Beat Values in 2/4, 3/4 and 4/4	1	1	1					1										
10	Quarter-Beat Values in Other Time Signatures	1	1	1				1	1	1	1								
11	Emphasis on Quarter-Beat Values in Simple Meter	1	1	1				1	1	1	1								
12	Review of Rhythmic Patterns Studied So Far	1	1	1				1	1	1	1								
13	Quarter-Beat Values in Syncopation	1	1	1				1	1	1	1								
14	Introduction of Triplets in 2/4, 3/4 and 4/4	1	1	1					1										
15	Triplets in Other Time Signatures	1	1	1				1	1	1	1								
16	Regular Divisions in 6/8, 9/8 and 12/8											1	1	1				1	
17	Regular Subdivisions in 6/8, 9/8 and 12/8											1	1	1				1	
18	Regular Divisions and Subdivisions in Other Compound Meters											1	1	1			1	1	1
19	Review of Rhythmic Patterns Studied So Far	1	1	1				1	1	1	1	1	1	1			1	1	1
20	Borrowed Divisions in Compound Meter											1	1	1				1	
21	Borrowed Subdivision in Simple Meter With Syncopation	1	1	1				1	1	1									
22	Eighth-Beat Values in 2/4, 3/4, 4/4, 2/2, 3/2 and 1/2	1	1	1				1	1										
23	Triplets Which Last Two Beats in Simple Meter	1	1	1				1	1	1	1								
24	Review of Rhythmic Patterns Studied So Far	1	1	1				1	1	1		1	1	1			1	1	1

Note. Variables that can be manipulated in the rhythm program, but which had the same value for each of the 24 units in this experiment:

Minimum number of measures: 2
Maximum number of measures: 2
Speed: student choice
Pitch range: from small c to c^2
Time limit per beat: 10 seconds
Number of plays: student choice
Metronome on or off: student choice
Advancement criteria: 7 out of 8 at 75% correct

individual student learning styles. The results of these four analyses are discussed in turn.

RESULTS

Since the student data base contained all exercises completed by each student throughout the curriculum, some of the exercises were done while students were just learning, while others were done as they approached mastery in a given unit. In making the cross tabulations of correct answers and student responses, it was decided to include only those exercises that counted toward mastery—that is, those exercises in which at least 75% of the note values were answered correctly on the first try. In this way, the cross tabulations show the most persistent confusion tendencies. Since the bottom number of the time signature varied throughout the curriculum as shown in Table 1, an adjustment was made before making the cross tabulations, so that all of the time signatures would have a four on the bottom in simple time, and an eight on the bottom in compound time. Therefore a quarter note in the cross tabulation for simple meter means a note that lasted a full beat, such as a half note with a two on the bottom, an eighth note with an eight on the bottom, or a sixteenth note with a sixteen on the bottom of the time signature. Notes larger than a beat unit were excluded because they occurred infrequently in the data base. Similarly, rests and tied notes were ignored.

Figures 2 and 3 show cross tabulations of correct answers and student re-

Figure 2—Cross Tabulation of Correct Answers and Student Responses in Simple Meter

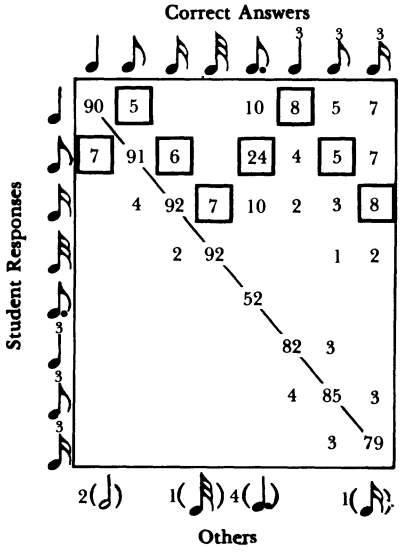
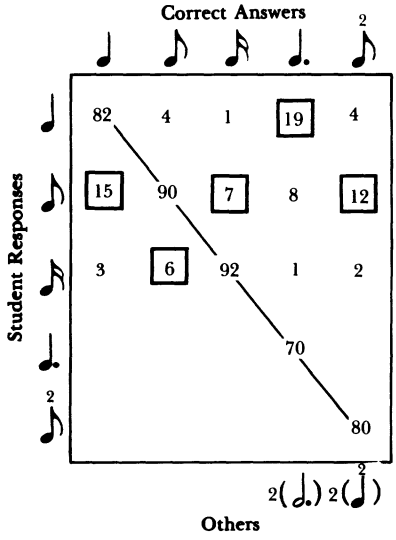


Figure 3—Cross Tabulation of Correct Answers and Student Responses in Compound Meter



Note: Numbers in the matrix indicate the percentage of times the student responses were given; squares indicate exercises that caused students primary confusion.

sponses for rhythmic dictation exercises judged correct in simple and compound meters, respectively. The two tables are similar in that the highest percentages on the diagonals are for basic quarter, eighth, sixteenth, and thirty-second notes, followed by duplets and triplets whose percentages are between the basic notes and the dotted notes where the lowest percentages are found. Basic notes are confused only with basic notes. Even in the other responses given at the bottom of Figure 2 for exercises in simple meter, the notes answered are either twice as big or half as big as the stimulus. For dotted, duplet, and triplet notes, on the other hand, confusions are made both with other dotted, other duplet, and other triplet notes, as well as with basic notes. However, dotted notes are never confused with duplets or triplets, triplets are never confused with dotted notes or duplets, and duplets are never confused with dotted notes or triplets. It was expected that the dotted quarter note in compound time would have a much higher percentage correct than it did because, like the quarter note in simple time, it represents a full beat value.

The similarity between the cross tabulations for simple and compound meters is summarized in Figure 4, which graphically portrays how for both meters, basic notes are only confused with basic notes; dotted notes are only confused with other dotted notes and with basic notes; duplets are confused only with other duplets and with basic notes; and triplets are confused only with other triplets and with basic notes. Since it is a full beat value in compound time, one could argue that the dotted quarter note should be considered a basic note in compound time. However, on the basis of these cross tabulations, it can be seen that dotted notes are perceived in a similar manner in both simple and compound meters.

The second phase of the analysis involved measurement of the effect of time signatures and dictation pitches on student achievement in rhythmic dictation

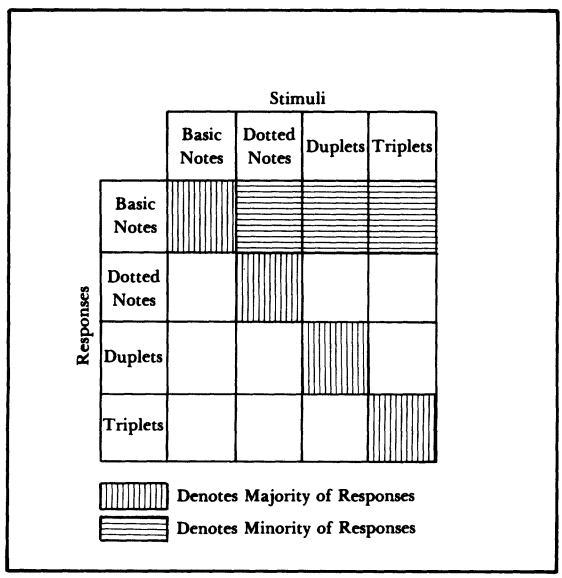


Figure 4—Summary of the Interaction of Basic Notes, Dotted Notes, Duplets, and Triplets in Simple and Compound Meters

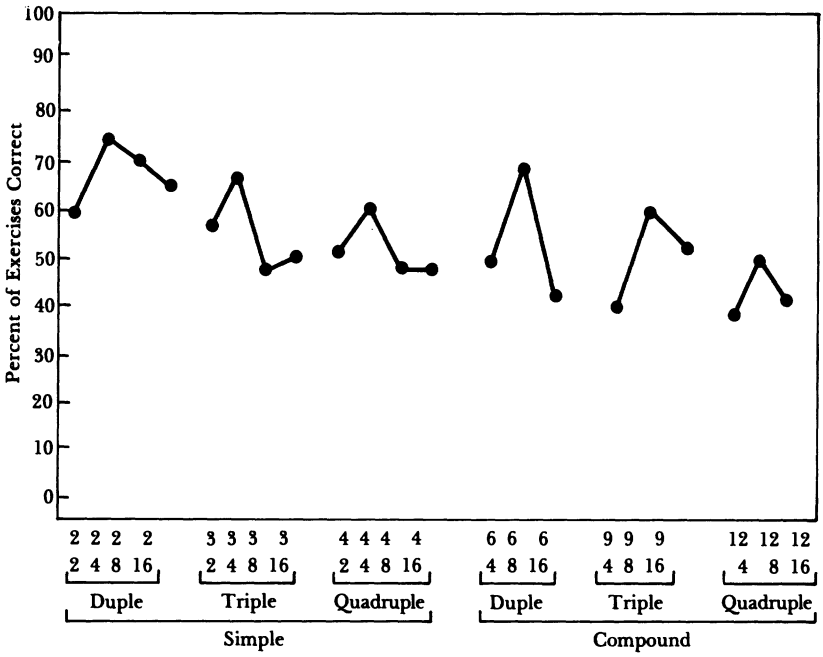


Figure 5—Plot of means for Course main effect

exercises. Figure 5 shows a graph of the percentage of exercises answered correctly for each time signature used throughout the curriculum. Interaction effects among the top and bottom numbers of the time signature were measured using a fixed effects model. A randomized block factorial design (Kirk, 1968) was applied to exercises in simple meter and then in compound meter. Table 2 shows the results of a 3 × 4 analysis of variance, using the three numbers on top of time signatures in simple meter as *W1* and the four numbers on the bottom as *W2*. Table 3 shows a 3 × 3 analysis of variance similarly applied for compound meter. In both analyses, the number on the bottom of the time signature had a significant impact on the percent of correct responses, with students scoring higher when a four was on the bottom in simple meter, and when an eight was on the bottom in compound meter. For both simple and compound meters, the higher the number on the top of the time signature, the lower the scores on the dictation exercises. Since the exercises all had two measures, those with smaller numbers on the top had fewer beats to answer than did those with larger numbers. In both simple and compound meters interaction effects were not significant, indicating that the patterns seen in Figure 5 are essentially the same for each of the nine sets of time signatures.

All of the rhythms played in this experiment were presented by means of a monotone stimulus. The pitch of this tone was randomly varied between *c* and c^2. The average percent of exercises correct was 58%. The lowest percentage for any individual pitch was 57%, and the highest was 63%, with a standard deviation of 49%, indicating that the pitch of the stimulus had little effect on the percentage of exercises answered correctly.

Table 2—Analysis of Variance Table for Time Signatures in Simple Meter

Source	*DF*	*SS*	*MS*	*F*	*P*
Subjects	15	24910.1			
Top Number	2	5463.6	2731.8	14.936	< .01
Error	30	5486.9	182.9		
Bottom Number	3	4017.3	1339.1	5.287	< .01
Error	45	11398.6	253.3		
Interaction	6	2501.8	417.0	2.468	NS
Error	90	15207.1	169.0		
Residual	176	44075.2			
Total	*SQ/N* = 779407.8		*N* = 192	*SST* = 68985.3	

Table 3—Analysis of Variance Table for Time Signatures in Compound Meter.

Source	*DF*	*SS*	*MS*	*F*	*P*
Subjects	15	22063.4			
Top Number	2	2446.6	1223.3	1.786	NS
Error	30	20547.3	684.9		
Bottom Number	2	25651.3	12825.6	10.065	< .01
Error	30	28227.3	1274.2		
Interaction	4	488.5	122.1	0.175	NS
Error	60	41877.6	698.0		
Residual	128	129238.6			
Total	*SQ/N* = 399424.0		*N* = 144	*SST* = 151302.0	

In order to analyze student learning style in the curriculum as a whole, an analysis of student learning time was made for each unit, showing (1) the number of exercises completed, (2) the percentage of total exercises, (3) the average number of exercises per student, and (4) the average student response time, number of plays, and speed for each exercise. Table 4 shows the values of these student variables for each of the 24 units in the curriculum. The students spent between 2% and 7% of their time in each of the rhythmic dictation units, with the greatest time spent in reviewing units 12 and 24, and with the least time spent on half-beat values in simple meter and on triplets that last two beats in simple meter. There are trends for the average response time to increase, for the average number of plays to increase, and for the average dictation speed to decrease as students progressed through the curriculum. Table 5 shows the inner correlations of these variables. The average response time and the average number of plays per exercise increased with the number of exercises students had to do before achieving mastery in a unit. Additionally, the students lowered the speed of the exercises when (1) they had to work on more exercises to achieve mastery in a unit, (2) they took longer to do an exercise, and (3) they had to listen to exercises more often before feeling able to answer them.

Learning style was also studied on an individual basis. Table 6 shows the average dictation score for each student, the averge dictation speed, the per-

Table 4—Analysis of Student Learning Time

Unit Number	Number of Exercises Per Unit	Percentage of Total Exercises (N = 5393)	Average Number Per Student (N = 16)		Average Response Time Per Exercise		Average Number of Plays Per Exercise		Average Speed Per Exercise	
			Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1	231	4	14	4.9	10	7	1.1	0.3	115	14
2	148	3	9	3.2	16	11	1.3	0.6	111	14
3	134	2	8	3.3	16	9	1.3	0.9	102	19
4	213	4	13	10.2	18	11	1.3	0.6	107	24
5	131	2	8	2.1	19	11	1.4	0.7	99	18
6	224	4	14	9.9	22	16	1.5	0.7	103	22
7	189	4	12	8.1	29	19	1.7	0.8	106	17
8	214	4	13	9.7	19	12	1.4	0.7	107	15
9	313	6	20	13.8	32	21	2.1	1.1	96	19
10	234	4	15	8.2	39	22	2.7	1.4	101	23
11	235	5	15	8.1	51	27	3.2	1.6	83	17
12	367	7	23	15.3	46	28	2.7	1.4	72	11
13	294	5	18	7.4	34	21	2.3	1.3	81	12
14	161	3	10	5.4	22	14	1.6	0.8	76	9
15	144	3	9	3.6	29	19	1.6	0.9	89	23
16	202	4	13	11.0	31	20	2.2	1.2	83	19
17	284	5	18	13.2	60	32	3.4	1.7	66	12
18	220	4	14	12.3	58	31	3.3	1.7	61	9
19	254	5	16	7.1	50	32	2.8	1.7	64	11
20	148	3	9	4.2	37	22	2.5	1.1	59	9
21	302	6	19	15.7	52	32	2.9	1.7	61	7
22	242	5	15	13.6	59	31	3.4	2.1	58	9
23	138	2	9	2.2	37	24	3.3	1.3	66	10
24	371	7	23	8.9	62	37	3.4	2.1	59	11
All Units	5393	100			42	30	2.5	1.6	78	23

Table 5—Inner Correlations of the Average Number of Exercises

	Average Number of Exercises Per Student	*Average Response Time Per Exercise*	*Average Number of Plays Per Exercise*	*Average Speed Per Exercise*
Average Number of Exercises Per Student	1.0	0.6	0.5	−0.4
Average Response Time Per Exercise		1.0	0.9	−0.8
Average Number of Plays Per Exercise			1.0	−0.9
Average Speed Per Exercise				1.0

centage of time the student used the metronome, and the average number of times the student played an exercise. Table 7 contains a multiple correlation of these variables that shows that dictation speed, use of the metronome, and the average number of times an exercise was played had little effect on the percent of exercises answered correctly during training. The average number of plays was negatively correlated with speed of dictation and with use of the metronome, indicating that students who used the metronome and used higher dictation speeds did not need to listen to the exercises as often as the other students.

DISCUSSION

It is appropriate at the conclusion of an experiment like this one to compare generally held pedagogical beliefs with actual results of the study. There are four such beliefs that can be addressed here with regard to rhythmic training. First, it is generally believed that there are important differences between simple and compound meters. In this study, care was taken to analyze separately the units in simple and compound meter so that comparisons of student perception could reveal some of these differences. However, no differences could be found between simple and compound meters on the basis of student perception of dictation exercises.

Second, it is generally believed that varying the bottom number of the time signature affects the relative difficulty of dictation exercises. This belief was strongly supported by the finding that when a four is on the bottom in simple meter or an eight is on the bottom in compound meter, dictation exercises are much more accurately answered than when smaller or larger bottom numbers are used.

Third, it is generally believed that when a monotone stimulus is used for rhythmic dictation the pitch of the stimulus has little or no effect on student achievement. This belief found strong support in this study.

Fourth, it was expected that as the level of difficulty increased, the students

Table 6—Individual Breakdown for Each Student

Student #	*Average Dictation Score During Training*	*Standard Deviation*	*Average Speed in Beats Per Minute*	*Standard Deviation*	*Percentage of Time Metronome Was On*	*Average Number of Plays Per Exercise*	*Standard Deviation*
1	83	38	75	3	0	3.1	2.0
2	53	50	63	15	0	3.4	1.7
3	62	49	60	7	97	2.8	1.6
4	63	48	56	17	3	3.8	2.0
5	68	47	72	22	83	3.0	1.7
6	77	42	93	27	24	2.5	1.5
7	60	49	97	28	78	1.7	1.2
8	64	48	65	19	71	2.6	1.6
9	74	44	100	22	70	2.0	1.5
10	44	50	79	25	68	1.9	1.0
11	71	46	76	18	96	1.8	1.2
12	76	43	98	27	16	2.1	1.4
13	61	49	76	18	51	2.9	1.8
14	60	49	84	14	99	2.7	1.4
15	81	39	77	6	57	3.8	2.9
16	46	50	85	16	43	2.5	1.4
All Students	59	49	78	23	58	2.5	1.6

Table 7—Multiple Correlation for Each of the Sixteen Students in the Experiment.

	Average Speed of Dictation	*Percentage Use of the Metronome*	*Average Number of Plays*	*Percent Correct During Training*
Average Speed of Dictation	1.0	0.1	−0.7	0.2
Percentage Use of the Metronome		1.0	−0.5	−0.2
Average Number of Plays			1.0	0.2
Percent Correct During Training				1.0

$R = 0.5$
$F = 1.1$
$P = 0.4$

Beta Weights: Speed = .49
Metronome = .13
Plays = .63

would take longer to answer, would lower the speed of dictation, and would ask for more frequent repetition of the exercises. These expectations were met. However, it was also believed that speed of dictation and number of repetitions would affect student achievement during training, but they did not. Not even the use of the metronome had an impact upon student achievement. As the dictation units progressed in difficulty, the students tended to slow down the exercises and to repeat them more often, but neither dictation speed nor number of exercises were related to individual student grades.

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