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Judgments of Complexity and Pleasingness in Music: The Effect of Structure, Repetition, and Training

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This paper reports a study wherein assumptions usually associated with theories of visual pattern recognition are applied directly to the processing of musical patterns. The investigation was on the effects of musical training, repetition, and objective complexity on judgments of relative *pleasingness* and *complexity* of short musical compositions. Forty subjects judged the pleasingness and complexity of four piano compositions before, during, and after either successive or random repetition. As predicted, pleasingness judgments were found to be a function of both objective complexity and training. Whereas successive repetition precipitated changes in judged pleasingness, random repetition did not. Experiment 2 investigated the effect of interchange of the distinctive rhythm feature which brought about a subsequent reversal in judged complexity ranks, but had no effect on judged pleasingness. It was concluded that pleasingness relates to higher order interaction of features, such as cohesion and variation, and it is argued that the vision-audition analogue is a useful theoretical framework for future studies of music cognition.

The impact of repetition on judgments of musical pleasingness can be easily demonstrated. Individuals typically report that repetition of a simple piece, such as a nursery rhyme, becomes tedious and boring (Russell, 1987; Steck & Machotka, 1975). By contrast; repetition of a more complex piece, such as a Bach chorale, provides an opportunity for exploration and familiarisation with the melody and form of the work. Judgments of pleasingness are therefore not static but prone to change. Clearly, changes in judgments of pleasingness may be influenced by a number of factors such as composition complexity (Berlyne, 1974; Walker, 1973), repetition pattern (Zajonc, Crandall, Kail & Swap, 1974), and the level of musical experience of the listener (Smith & Cuddy, 1986; Vitz, 1966). This paper explores judgments of musical pleasingness as a function of repetition, composition complexity, and musical training.

A number of studies researching judgment and cognition of music have used stimuli which represent only *one* dimension of music, such as melody (Smith & Cuddy, 1986) or rhythm (Steedman, 1977). The stimuli used in the current study are more characteristic of *real* music in that they incorporate melodic, rhythmic, and harmonic features. The study also attempts to integrate findings of past research into a testable theory of music cognition. Visual pattern recognition theory has been adopted as a theoretical framework, and it will be shown that many of the principles of visual pattern recognition theory have predictive and explanatory value when applied to judgments of music. The pattern recognition analogue also provides means for a method of assessing composition complexity based on the relative *distinctiveness* of composition features.

Pattern Recognition Theory and the Vision-Audition Analogue

Judgment of a visual or auditory pattern involves the perception and cognition of distinguishing attributes or characteristics. The general assumptions adopted in this study are those encountered in visual pattern recognition theory where recognition is mediated by the extraction, differential weighting, and comparison of features (Biederman, 1987; Marr & Nishihara, 1978; Treisman, 1986). In these terms, judgments about a visual object (such as a scene, an upper-case letter, or a face) are preceded by recognition processes such as extraction, weighting, and comparison, of local and global features. Similarly, a musical composition (such as a Sonatina by Beethoven) can be considered as a pattern which consists of various features: Judgments of the composition are preceded by extraction and weighting of local features (such as frequency and amplitude) and/or global features (such as meter, tonality, and melody). Thus, visual pattern recognition theory is used in this context to provide possible mechanisms for, or ways of thinking about, processes which mediate qualitative judgments of music.

Although similarities between vision and audition may not be immediately apparent, they share a number of common neurophysiological and perceptual properties. For example, cells in both systems display excitatory responses to some stimuli and inhibitory responses to others. Evidence suggests that there are systems sensitive to particular features in both visual and auditory domains (Livingstone & Hubel, 1987; West, Cross & Howell, 1987). Warren (1982) has provided experimental support for the vision-audition analogue by identifying comparable adaptation phenomena in the two modalities. The Bezold-Brucke shift occurs in both visual and auditory domains. In vision, the shift involves a change in perceived hue as intensity increases. This is comparable with an auditory shift where tones less than 2000 Hz are judged lower in pitch and tones greater than 2500 Hz are judged higher in pitch as intensity increases. Kubovy (1981) also explored the analogue using pitch segregation to produce auditory patterns analogous to Julesz random dot stereograms.

Previous Research

Objective and subjective complexity. Traditionally, the measurement of complexity of visual pattern has involved quantitative assessment of information in the pattern (Attneave & Arnoult, 1956; Berlyne, 1974; Garner, 1962). The basic assumption has been that patterns possess a fixed amount of information from which complexity can be deduced. However, such measures fail to account for the role of the observer in perceiving and judging complexity (Green & Courtis, 1966). Measurements of complexity are relative: They are not simply a function of objective information and structure; they are also dependent on the selective responses of the perceiver. Recently, investigations of the relationship between subjective complexity and preference judgments of musical compositions have been guided by the optimal complexity model (Hargreaves, 1984; Smith & Cuddy, 1986) which suggests that this relationship can be characterised by an inverted-U function. In this study *independent* measures of objective and subjective complexity will be adopted.

Repetition. Contrasting results have been reported concerning the effect of repetition on judgments of music and art. Zajonc (1968) argued that repetition

The authors wish to thank Professor J.P. Sutcliffe for his assistance with the application of DCF theory. Copies of the piano compositions used as stimuli can be obtained from Catherine Stevens. Requests for reprints should be sent to Catherine Stevens, Department of Psychology, University of Sydney, Sydney NSW 2006. E-mail: kates@psychvax.psych.su.oz

increases familiarity and therefore the affective value of stimuli, whereas Berlyne (1970) argued that affective value is an inverse function of the frequency of occurrence of stimuli. The pattern of repetition is a significant factor (Zajonc et al., 1974). The present study assesses the differing effects of random and successive repetition, and explores claims made by Smith and Cuddy (1986) that two different processes are involved — one assessing similarity between sequences in successive repetition, and the other identifying the "degree of structural organisation in the pattern" (p. 30) which occurs during random repetition.

Training. The musical experience of subjects has been shown to influence judgments of both complexity and pleasingness. Vitz (1966) has shown that trained subjects (as opposed to untrained subjects) preferred greater variation in tone sequences. Smith and Cuddy (1986) found that "highly trained subjects gave higher pleasingness ratings to melodic sequences across all levels of structure" (p. 24).

Predictions from the Vision-Audition Analogue

Applying the pattern recognition analogy, musical compositions are initially cognised by serial extraction and recording of their local features (not asking, for the moment, just what those features are) and the derivation of their global features from these local features. Compositions are thus stored in memory as lists of features and their interrelationships. Recognition of a composition involves a matching of the input description with some already stored description. Repetition of a composition develops familiarisation with the piece by processes which progressively assign more weight to the more distinguishing features, or attributes, of the compositions (Uhr & Vossler, 1963; Fukushima, 1988). Assuming that such recognition processes and mechanisms mediate the cognition of musical compositions, what implications do they have for judgments of pleasingness and complexity?

First, after the compositions have been heard initially, those features which distinguish one composition from the other are weighted more heavily than features that are constant and common to many of the patterns. Consequently, over time, subjects perfect an efficient processing strategy whereby the judgment of complexity is mediated by these processes. In this context, musically trained subjects can be thought of as *experienced recognisers* in that their musical training provides practice in feature extraction, weighting, and comparison. For this reason, trained subjects quickly attain a greater knowledge of the structure of the musical pattern, its features and interrelationships, so that efficient analytic strategies for judging relative complexity are employed from the outset.

Second, successive repetition of a composition provides an opportunity for a subject to develop a thorough knowledge of its structure — since no comparison between different compositions and exploration of interrelations is possible. Where there is successive repetition of a simple composition the structure is learnt rapidly; the unfolding of the composition becomes predictable, and subsequent pleasingness decreases. Successive repetition of a more complex composition allows exploration of the piece, and development of knowledge of its structure. Where the composition is more complex and less predictable, interest is maintained and increases as knowledge develops so that judged pleasingness of complex compositions increases with successive repetition. Judgments of pleasingness are assumed to be *relative* to the set of compositions under investigation, as Steck and Machotka (1975) have shown that judgments are influenced by the context provided by the stimulus set.

Third, where repetition of compositions is distributed or random, a different form of processing and judgment strategy is induced (Corcoran & Jackson, 1979). Here, comparison between different compositions is possible. Knowledge of each composition develops from identification of similarities and differences between compositions and their features. Exploration of similarities, differences, and interrelationships ensures that interest in the compositions is maintained; so no change in judged pleasingness is expected with random repetition.

Fourth, the optimal complexity model assumes that subjects possess some preferred level of object or event complexity. The model predicts that compositions below a subject's optimal level will be judged less pleasing after successive repetition, whereas compositions higher than this optimal level will be judged more pleasing after successive repetition. In terms of the vision-audition analogue; experience with, and knowledge of, the structure of simple compositions is quickly attained so that predictability increases, and interest and pleasingness decrease, with successive repetition. However, the more intricate and detailed structure of complex compositions ensures that interest is maintained as new features and relations are identified, hence pleasingness increases with successive repetition. Finally, there will also be differences in the preferred compositions (or optimal levels) of trained and untrained subjects. Trained subjects, as *experienced recognisers*, prefer the composition which provides maximum exploration potential and interest; whereas untrained subjects prefer the composition that maintains interest but is not so intricate and unpredictable as to make recognition and judgment difficult.

Differential Concept Formation Theory and an Independent Measure of Complexity

It was suggested above that an assessment of objective complexity — independent of subjects' judgments of complexity — is necessary for investigation of the relationship between objective and subjective complexity. Complexity is a relative term. A composition which is complex in one context may be regarded as simple in another, and for different reasons. It is not possible in one experiment to control for all variables associated with complexity. However, it is possible to control and quantify complexity within a restricted experimental context. Intuitively, objects or musical compositions can be ordered according to their differences. This type of differential ordering is quantified in Sutcliffe's (1986) differential concept formation (DCF) theory, and it is this quantifiable ordering which was used as a measure of objective complexity.

The first step using DCF theory was to identify the component features of the objects (compositions) that were to be ordered, and then carry out a feature analysis. As the four compositions (A, B, C, D) were too long and varied to be characterised by a single feature analysis, they were divided into the three sections nominated by Heyduk (1975): beginning, middle, and end. Within the three sections, eight features or attributes derivable from the fundamental dimensions of frequency and time were defined. The defined features based on music analysis and the vision-audition analogue were: *tonality, rhythm, sounds per bar, melody, perceived speed, cohesion, variation,* and *finality*.

The *tonality* feature is a function of successive and simultaneous frequencies relating to key centres and harmonic progressions. *Rhythm* is a temporal feature and is analogous to the visual property of pattern regularity. *Sounds per bar* is also a temporal feature and relates to the number of chords sounded in each bar. *Melody* refers to the magnitude of intervals between notes forming the contour of musical patterns. *Perceived speed* is a higher order feature derivable from the interaction of time and meter with rhythm and sounds per bar. The use of this feature is based on the assumption that the greater the number of sounds per bar, the faster the tempo. *Cohesion* and *variation* are both higher order features derivable from the interaction of tonal and rhythmic patterns. *Cohesion* refers to the unity of a piece characterised by smooth harmonic and rhythmic progression. *Variation* refers to variety in pitch, rhythm, and chords. *Finality* refers to cadential close where different cadences have different characteristic sounds.

Individual profiles of the compositions were drawn assigning values from 0 to 3 to the features in each section of the compositions. The values represented categorical assessment of the feature. For example; for the *tonality* feature, 0 was assigned where the composition was in a major key, or a value of 1 was assigned where it was in a minor key. For the *sounds per bar* feature: 0 designated two sounds in a bar, 1 designated three to four sounds, 2 referred to five to six sounds, and 3 designated eight sounds per bar. Clearly, the feature analysis is relative to the set of musical pieces under investigation.

Given the feature analysis, DCF theory (through its associated computer model SYDNEY) computes orderings of the compositions and their features based on the summed difference between the compositions and between their features. A formal account of these procedures is provided by Sutcliffe (1986). In summary, the comparisons of the compositions and their features result in what Sutcliffe calls *conditional* and *unconditional* orders. In the present context, the unconditional order of features gives an *overall* ordering of the features in terms of their capacity to differentiate and distinguish the compositions from one another. In this order, the feature which is most differentiating is ranked first and the feature which is least differentiating is ranked last. This unconditional order of features was obtained within each section of the compositions. In addition to the unconditional order of the features, an unconditional order of the compositions was also obtained *within each section*. Again, by summing differences between the compositions within a particular section, it is possible to arrive at an order of the compositions in terms of how well they are differentiated, from one another. The composition most different from the others across sections is assigned first place in this order, and the composition least different is assigned last place.

Application of DCF theory can therefore provide a quantitative basis for an objective ordering of compositions according to differentiation, and in turn this ordering can be used as an objective measure of complexity. It is important to note that in this study objective complexity was taken as a function of form and number of stimulus features: The most complex composition being that which is the most distinctive or differentiated, and the least complex composition being that which is least differentiated. This objective order of complexity based on the eight a priori features is D > C > B > A. This is not to say that complexity and distinctiveness will always be positively correlated. For example, an advertising jingle in the context of three Bach chorales will be distinct but, it would generally be agreed, less complex.

EXPERIMENT 1

Method

Experimental design

Two levels of repetition and training factors produced four independent experimental conditions: Trained/Successive, Untrained/Successive, Trained/Random, and Untrained/Random — with 10 subjects in each condition. Subjects were assigned to one of the four treatment conditions stratified according to training, and subjects participated in each of the trial blocks: prerepetition, repetition, and postrepetition. The complete design involved four factors: *training, repetition, trial*, and *composition* — with repeated measures on the latter two factors.

Subjects

The 40 subjects were male and female undergraduate students of the University of Sydney. Mean age of subjects was 20 years, range: 17–44 years. Half of the sample had undertaken formal musical training in excess of 6 years (mean was 9.5 years; $SD = 2.5$), and the remaining 20 subjects had no training, or less than 3 years musical training (mean was 0.8 years; $SD = 1.1$). Group experimental sessions ranged in size from two to eight subjects.

Apparatus

The four compositions were played on an upright piano tuned to "concert pitch" ($A_4 = 440$) and were recorded in stereo on a master tape. The compositions were of equal duration, uniform pitch range, volume range, and speed. The master recordings were made via two Arista dynamic microphones set equidistant from the treble and bass of the piano using a Pioneer stereo cassette deck (model CT-10) with Dolby® noise reduction. The compositions were dubbed onto individual tapes from the master tape according to assigned random orders. There was a 5 second pause between compositions in the pleasingness rating section and between complexity judgment pairs, and a 1 second pause within pairs and between compositions in the repetition trial. Two tapes were prepared for each treatment condition counterbalancing the order of pleasingness and complexity judgments. Compositions were played back through Sony stereo headphones (model DR-S3).

Stimuli

Four short piano pieces composed by Heyduk (1975) were chosen as stimuli because of their resemblance to actual musical forms incorporating chordal, melodic, and rhythmic activity. The compositions also varied in objective complexity in terms of harmonic and rhythmic structure, and were unfamiliar to all subjects.

Procedure

Subjects read through instructions about the format of the experiment and were told of the need for judgments of complexity and pleasingness to be relative. A practice phase introduced subjects to the four compositions and were played in random order. Brief instructions were read aloud before each subsequent trial block.

In the prerepetition trial, subjects rated the pleasingness of the four compositions after each had been played once. Ratings were indicated by placing a cross on a 6-point rating scale at a point which reflected the relative pleasingness of the composition. The rating scale was divided into six equal sections labelled from *highly displeasing* through to *highly pleasing* with a corresponding numerical value from 0 to 6. The composition judged most pleasing by each subject in the prerepetition trial was taken as an approximation of that subject's optimal level of complexity (Hargreaves, 1984).

Judgments of complexity were in paired comparison form. Compositions were presented in pairs, and subjects ticked the composition in the pair which they considered to be the most complex. In the repetition trial, subjects in the successive repetition condition listened to each composition repeated six times in succession. Subjects rated the pleasingness on hearing the final (sixth) repetition in each of four blocks. In the random repetition condition, compositions were played in random order in four blocks of six random repetitions. Subjects rated the pleasingness of the last composition in each of the four blocks. The postrepetition trial was of the same format as the prerepetition trial but consisted of a different random order of compositions. The experiment concluded with a brief written protocol asking subjects to comment on the criteria used for judging complexity and pleasingness. The experiment lasted 40 minutes.

Data consisted of three sets of pleasingness ratings and two sets of complexity ranks. The use of paired comparisons to obtain complexity ranks minimised any influence of pleasingness judgments on complexity judgments, or vice versa, as complexity ranks were not evident until paired comparison matrices were drawn up in the data analysis stage. As complexity judgments consisted of ranks, nonparametric statistics were used for their analysis.

Results

Complexity

A significant positive correlation between judged complexity rankings and the objective complexity ordering was obtained. The overall coefficient of concordance of complexity ranks was $W = .84$, $p < .05$ (Kendall, 1962). The sum of ranks assigned by subjects revealed the general order of composition complexity to be D > C > B > A, corresponding to both the objective DCF order and Heyduk's (1975) ordering.

Repetition

Mean pleasingness ratings over trials, conditions, and compositions are listed in Table 1 for trained and untrained subjects. A four-way analysis of variance (training,

Table 1 Mean pleasingness ratings over trials and compositions

	Successive Repetition			Random Repetition		
Composition and Training	Pre Rep Trial	Rep Trial	Post Rep Trial	Pre Rep Trial	Rep Trial	Post Rep Trial
A Trained	2.66	1.90	1.47	2.54	2.43	2.05
A Untrained	2.41	1.85	2.22	3.48	3.89	3.93
B Trained	3.40	3.09	3.41	3.32	3.08	3.40
B Untrained	2.88	2.45	3.09	3.87	3.98	4.18
C Trained	3.45	3.57	3.85	3.55	3.55	4.20
C Untrained	3.95	4.07	3.70	3.72	3.79	3.71
D Trained	3.50	3.69	3.48	4.24	4.32	3.84
D Untrained	3.33	3.32	3.56	3.46	3.40	3.35

repetition, trial, and composition) with repeated measures on the latter two factors revealed a significant main effect of repetition $F(1,36) = 11.99$, $p < .05$. Planned comparisons with pooled error terms and a corrected significance level (Kirk, 1968, p. 267) showed that, as predicted, pleasingness ratings of composition A significantly decreased after successive repetition in the repetition trials $t = -2.91$, $p < .05$. A decrease in pleasingness ratings after successive repetition of composition B in the repetition trials approached significance $t = -1.61$, $p > .05$, but there was no significant successive repetition effect on compositions C and D. As expected, there was no significant effect of random repetition on pleasingness ratings of any of the four compositions in the random repetition condition.

The four-way analysis of variance revealed the expected main effect of the composition variable $F(3,108) = 6.32$, $p < .05$. Compositions defined less complex than a subject's optimal level were expected to decrease in pleasingness with successive repetition, and compositions defined more complex than a subject's optimal level were expected to increase in pleasingness with repetition. A χ^2 test of association was carried out comparing composition (optimal, above or below) and increase/decrease in pleasingness ratings (see Tables 2 and 3). A significant association was found for both trained and untrained subjects: Trained χ^2 (2, N = 10) = 7.64; Untrained χ^2 (2, N = 10) = 6.45, $p < .05$. However, it should be noted that, in general, pleasingness ratings of untrained subjects showed a general increase, even when the composition was below the optimal level.

Table 2 Changes in pleasingness ratings with successive repetition are predictable given an individual's optimal level of complexity.

Trained		Ratings: Increase		Ratings: Decrease		
Composition	Above Optimal	5	(2.63)	2	(4.38)	*7*
	Optimal	0	(2.63)	7	(4.38)	*7*
	Below Optimal	7	(6.75)	11	(11.25)	*18*
		12		*20*		*32*

Note: Compositions above optimal increase in pleasingness, whereas compositions below optimal tend to decrease in pleasingness.
Expected frequencies shown in brackets.

Table 3 Changes in pleasingness ratings — untrained subjects.

Untrained		Ratings: Increase		Ratings: Decrease		
Composition	Above Optimal	4	(3.09)	2	(2.91)	*6*
	Optimal	1	(4.12)	7	(3.88)	*8*
	Below Optimal	12	(9.79)	7	(9.21)	*19*
		17		*16*		*33*

Training

Figure 1 shows the frequency with which each composition was preferred by trained and untrained subjects. The most preferred composition (used as an approximation of the optimal level of complexity) for trained subjects was composition D, whereas untrained subjects tended to prefer composition C — supporting the claim that the optimal or preferred levels of trained subjects relate to more complex compositions than those of untrained subjects.

The preferred compositions in the prerepetition trial were D and C for trained and untrained subjects respectively, and were taken as the mode optimal levels of complexity for those groups. The nonoptimal or least preferred compositions were A and B. A significant difference between pleasingness ratings obtained from trained and untrained subjects was found across these nonoptimal compositions. The pleasingness ratings of trained subjects were significantly lower than those of untrained subjects on compositions A and B $t = -4.34$, $p > .05$ (see Table 1). However, no effect of training was evident in complexity rankings obtained from trained and untrained subjects in the prerepetition trial. Kendall's tau was used to calculate the correlation between defined and obtained complexity orders for each subject. Mean tau for trained subjects was .93 (SD = .14) and for untrained subjects was .84 (SD = .24). A one-tailed t-test revealed no significant difference between groups, $t(38) = 1.49, p > .05$.

Discussion

Although a positive correlation was obtained between the objective complexity order generated by DCF theory and judged complexity ranks, further experimentation is needed to investigate other possible combinations of features contributing to composition complexity.

Pleasingness decreased significantly with successive repetition of composition A, and there was a similar trend in judged pleasingness of composition B. It was predicted that compositions C and D, as exemplars of more objectively complex music, would increase in pleasingness with successive repetition; although no significant effect was found. The lack of change here may be attributed to the number of repetitions used. For the most simple compositions (A and B), six repetitions were adequate to bring about a decrease in affective value. However, more than six repetitions may have been required to bring about a significant increase in affective value of the more complex compositions (C and D). The rate of increase versus the rate of decrease appears to be asymmetrical.

As predicted, presentation of a random sequence of simple and complex compositions reduced the difference between prejudgments and postjudgments of pleasingness. As expected, random repetition did not appear to give subjects the opportunity to explore and record the structure (or lack of it) in particular compositions. Having identified an individual's optimal level of complexity from the initial pleasingness ratings, it was possible to predict the direction of change in pleasingness after successive repetition. Differences found between trained and untrained subjects may be accounted for by arguing that subjects with musical training are more adept at analysing and storing the features of compositions and their interrelationships.

EXPERIMENT 2

The form of Experiment 1 was based on the assumption that judgments of pleasingness and complexity are mediated by feature extraction, and that the eight features identified and ordered are those extracted in making such judgments. A second experiment was designed to test these assumptions and elicit further support for the conclusions drawn from Experiment 1. In visual pattern recognition research, features of a pattern can be manipulated in an attempt to investigate their contribution to the recognition of a pattern (Kolers, 1969; Shimron & Navon, 1981). Pursuing this analogy; a distinctive feature of a musical pattern can be manipulated, by reversal or interchange, to assess its effect on subsequent recognition or judgment. For example, manipulation of a distinctive feature such as rhythm may affect judgments of complexity and pleasingness.

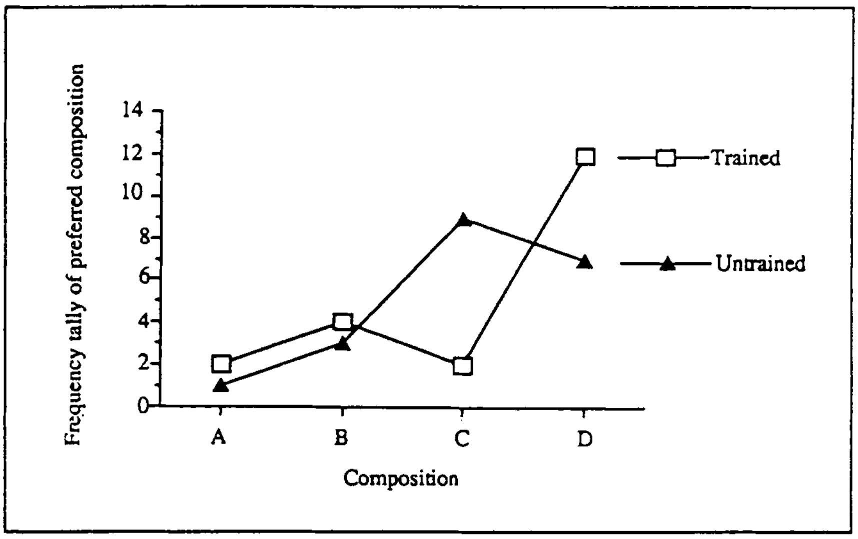

Figure 1 Frequency with which compositions were preferred by trained and untrained subjects. Trained subjects tended to prefer the most complex composition (D), whereas untrained subjects preferred composition C.

The DCF unconditional order of features of the four compositions revealed the higher-order feature *cohesion* as the most differentiating feature, followed by *rhythm* and *tonality*. As *cohesion* derives from the *interaction* of *rhythm* and *tonality*, manipulation of *cohesion* would involve alteration of both rhythmic and tonal qualities. To avoid possible confounding of these two dimensions, the *rhythm* feature was chosen as the distinctive feature to be manipulated in Experiment 2.

Experiment 2 followed the successive repetition condition procedure of Experiment 1; but, in the repetition trial, the rhythmic patterns of compositions A and D were interchanged. Midway through the repetition trial, the simple harmony of composition A was played to the complex, syncopated rhythm of composition D (called A′); and the complex, atonal harmony of composition D was played to the simple rhythm of composition A (called D′).

It was predicted that if a distinctive feature such as rhythm is important in judgments of complexity and pleasingness, then interchange of the rhythm of A and D should bring about a corresponding change in judgments of pleasingness and complexity of those compositions. Specifically, composition A′ will be judged *more complex* than composition D′ in postrepetition trials; and, after rhythm interchange, composition A′ will increase in judged pleasingness and composition D′ will decrease in judged pleasingness.

Method

Subjects were 12 male and female undergraduates of the University of Sydney (mean age was 19 years; range: 18–22 years). For control purposes, the sample was equally divided into trained and untrained subjects (mean number of years training for trained subjects was 6.6 years; SD = 1.5). Experiment 2 employed the same apparatus, stimuli, and procedure as Experiment 1, but used successive repetition of the compositions only: Midway through the successive repetition of compositions A and D, their rhythmic patterns were interchanged.

In the prerepetition trial, subjects rated pleasingness on a 6-point rating scale after the four compositions had each been played once. Complexity judgments were obtained using the paired comparison procedure. In the repetition trial, subjects rated pleasingness after each composition had been played six times in succession. The interchange of rhythms of compositions A and D occurred after the third repetition. The postrepetition trial was of the same format as the prerepetition trial, except that compositions were presented in a different order.

Results

The concordance amongst complexity ranks was significant $W = .49, p < .05$. The sum of ranks assigned by subjects revealed that, as predicted, composition A′ (simple harmony, complex rhythm) was now judged more complex than composition D′ (complex harmony, simple rhythm). Therefore, with the interchange of rhythms a corresponding reversal in judged complexity ranks was obtained (see Figure 2).

A one-tailed t-test was carried out to assess the effect of rhythm interchange on pleasingness ratings. Composition A′ failed to increase significantly in judged pleasingness, $t(11) = .452, p > .05$, and composition D′ failed to decrease significantly in judged pleasingness, $t(11) = .802, p > .05$.

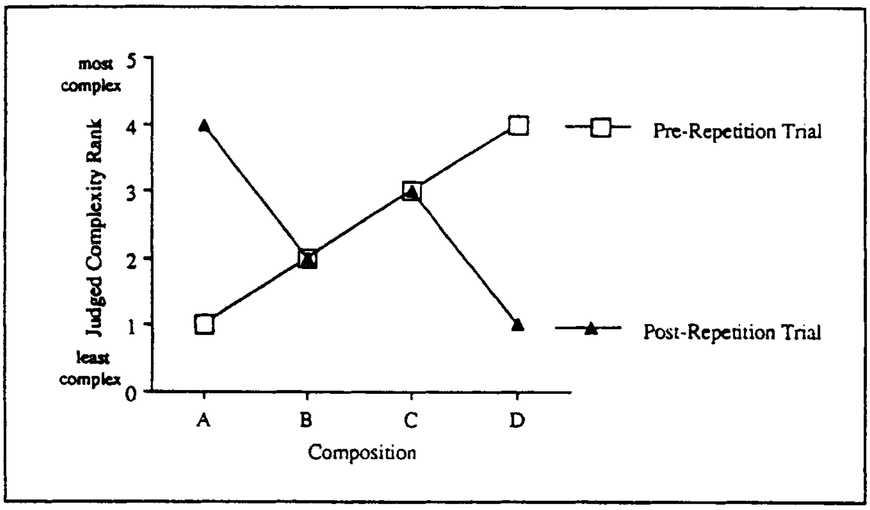

Figure 2 Experiment 2: Reversal of judged complexity order. After interchange of the rhythmic patterns of compositions A and D, judgments of relative complexity were similarly reversed: A was judged more complex than D in the postrepetition trials.

A disparity is evident here in that manipulation of the *rhythm* feature has affected judgments of complexity, but not pleasingness; suggesting that judgments of pleasingness are not easily susceptible to change by mere manipulation of the *rhythm* feature. This asymmetry brings into question the explanatory power of the optimal complexity model as judged pleasingness and complexity now appear disjunctive rather than inextricably linked. The apparent disparity, however, can be explained using the vision-audition analogue. Pleasingness may relate to *interactions* of features such as *tonality, melody* and *rhythm*. Examination of protocols from Experiment 1 revealed that variety in *harmony* and *melody* were important criteria used by subjects in judging pleasingness. As the *harmony* and *melody* of compositions A and D remained constant, manipulation of the rhythmic pattern alone was insufficient to bring about a significant change in pleasingness judgments. Rather than *tonality* or *rhythm* per se being important features, the higher order features derived from interaction of individual features are important. Therefore in this analysis, *variation, cohesion, sounds per bar* and *perceived speed* may be important higher order features. The results suggest that further experimentation is warranted on the role of higher order features in judgments of pleasingness and the role of temporal features (such as *rhythm*) in judgments of complexity.

CONCLUSION

Adoption of pattern recognition theory has provided a framework for discussion of processes involved in judgments of musical compositions. This approach has also enabled formal definition and quantification of objective complexity in terms of constituent features and differentiation.

The vision-audition analogue enables investigation of the possible *mechanisms* which underpin recognition and judgment of musical pieces. It has been argued here that *processes* preceding judgment of music involve extraction, relative weighting, and comparison, of the distinguishing features of the musical pieces. In visual pattern recognition research, theories have been proposed and models developed which make processes *and* mechanisms explicit (Marr & Nishihara, 1978; Fukushima, 1988). By pursuing the vision-audition analogue, a clearer statement of both processes and mechanisms underlying recognition is possible. One possible direction is to develop a *model* based on pattern recognition principles providing clear and concise descriptions of the *mechanisms* underlying cognition and appreciation of music.

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