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Abstract

The twelve harmonic intervals possible within an octave and reproduced octave in both a high register and low register (geometric mean respectively: 1,510 and 185 Hz) over a three-octave range were judged by 43 university students using a semantic differential. The semantic differential scale was made up of 30 bi-polar adjective rating scales chosen from descriptions of musical interval expressiveness developed by music theorists. Factor analysis of the students' responses grouped the scales along three factors: emotional evaluation, activity and potency. The first two factors proved to be important in interval discrimination and to have the same trend; the latter was less important and resulted in neutral scores. Analysis made with ANOVA revealed a significant Register × Interval interaction for the thirds, the perfect fourth, the sixths and the minor seventh. For these, a high register presentation tended to polarise the bichord perception positively, while with a low register presentation the bichords tended to be perceived as neutral or moderately negative. For intervals with a clear harmonic connotation of consonance or dissonance (octave, fifth, seconds, augmented fourth and major seventh), however, profiles were univocal. The influence of register on the students' semantic differentiation of the intervals was significant: low register bichords were evaluated more negatively emotionally in comparison to high register bichords. Dissonant bichords were clearly perceived as more negative, unstable and tense than consonant ones which were evaluated within a neutral zone. Musical expertise was not a significant factor in the evaluation of the intervals. Mode proved to be significant on seven scales with a weak effect. Gender proved to influence interval evaluation in that females responded with a greater polarisation of scores and greater perception of a sense of activity and tension.

Musical intervals represent music's elementary tonal relations. A musical interval is encountered whenever two notes are sounded simultaneously or sequentially and is defined, in musical terms, as the distance between two sounds expressed in tones and semitones and, in physical terms, as the ratio between the vibration frequency of one note and that of the other (Backus, 1969). Between octaves and excluding the unisons, twelve possible music intervals may be formed and are listed in Table 1 with their technical names, sample notes with which they can be formed, their "consonance–dissonance" functions according to *The Harvard Dictionary of Music* (Apel, 1945), and their expressive functions according to Cooke (1959) and other authors, mainly famous music theorists of the past.

The idea that the various musical intervals have widely disparate psychological effects has a long history in the literature of aesthetics, music theory and composition but not in experimental psychology. Most of the past studies, mainly by music theorists, have attempted to study intervals within a musical context – either abstract or concrete and real – with a recurrent exemplification from music of the Western world. Chailley (1985), for instance, studied intervals within musical systems which distinguish consonances from dissonances. According to Chailley the most critical factor is related to the rule of tension–relaxation. A feeling of tension is experienced when a certain interval expressed by a piece of music is perceived, because of our cultural frame, as dissonant. At that point the sounds of the interval tend to a consonant resolution and when this is reached it is perceived as a sense of relaxation.

Another music theorist, Meyer (1953, 1973) states that intervals cannot be considered as lexical units such as words that have a semantic content. They behave as clues that refer to more general events ("patterns") that should embrace them (as for example thunder is a clue for the more general storm phenomenon) or refer to events that should usually follow the clues (lightning makes us expect thunder). This distinction between two types of meanings, one belonging to words and the other referring to connections of the part to the whole, and of the antecedent to the consequent, is indicated by Meyer as "designative meaning" and "embodied meaning"; it is the latter the author is interested in.

The most complete and famous description of the expressive functions of musical intervals, however, was given by Cooke (1959, see Table 1) in his book *The Language of Music*. In this work, Cooke attempted to ascribe specific "expressive functions" to the various musical intervals, ranging from "spiritless anguish" (for the minor second) through "stoic acceptance" (for the minor third) to "joy" (for the major third) with many specific examples. Unlike Meyer, who did not concentrate on the lexical units in music, Cooke's did attempt to establish terms for a musical dictionary. His affirmations are based on the following point: in order to understand certain music mechanisms, it is helpful to see whether the same interval can always have, in different pieces, the same meaning. In his book, therefore, he gives many examples from opera excerpts in which there is a persistent correspondence between the meaning of the phrase that is sung and the type of interval that is in the score. However, this theory is undermined by the possibility that the author only reported the examples that supported it. This is a major shortcoming of many previous studies. Nevertheless, some very systematic work was done by Stefani, Marconi and Ferrari (1990), and Stefani (1984), who took examples from classic or popular music with a strong presence of a certain interval and then checking if the global emotional sense of the phrase could be modified by a substitution with other intervals or by altering the interval from major to minor or from ascending to descending. Other investigations have evaluated the intervals in isolation, out of the larger context of melody or an entire piece of music and any type of musical organisation (scales, chords, consonance hierarchy). Belgian educator Edgar Willems, for instance, (Willems, 1977) used the introspection method (observation and description of mental contents according to psychological categories) in an attempt to organise the interval meanings along three categories: sensorial, affective and intellective (see Table II, Willems 1977, p. 138, p. 162). His goal, however, as an educator, was not to acquire knowledge on the understanding of the sense of interval, but to help students learn how to describe the intervals verbally, more and more carefully, especially by using sensory, affective and rational categories.

Bozzi (1985) in a more experimental fashion, had the subjects judge, on a semantic differential, the twelve possible bichords of a tempered scale produced using sinusoidal or triangular wave sounds. The bi-polar rating scales used adjectives reported by Cooke (1959) and other music theorists such as, Castiglioni (1959), Galilei (1638), Rousseau (1782) and Tartini (1754) (see Table 1). Bozzi found a clear correspondence between the theoretical description and the results from the semantic differential only for dissonant bichords (seconds, sevenths) and the octave, whereas for the consonant bichords he found less correspondence: the adjectives with high scores on the semantic differential were not the same as those hypothesised by theorists. Surprisingly, the strictly experimental psychology literature addressing the issue of musical interval expressiveness provides little in the way of convincing empirical support for the idea that musical intervals differ in their psychological effects, since most researchers in the area – having taken this for granted – have concentrated on other areas of research. However, several investigations have been conducted in order to establish a ranking of the musical intervals on some dimension (*e.g.* "familiarity") for subsequent comparison with theoretic rankings for consonance (Butler and Daston, 1968; Guernsey, 1928; Valentine, 1914). Another group of investigations has explored relations between ratings for the intervals on evaluative and descriptive dimensions (*e.g.* Ugly–Beautiful, Wide–Narrow) and their objectively measurable characteristics (Kameoka and Kuriyagawa, 1969a; 1969b; Levelt, van de Geer and Plomp, 1966; Plomp and Levelt, 1963; 1965). A study by van de Geer, Levelt and Plomp (1962), on the other hand, focused on interrelations between various ratings for musical intervals on a number of semantic continua.

In some experiments concerning musical intervals (Maher, 1976; Maher and Jairazbhoy, 1975) attempts have been made to determine whether the subjects, in fact, discriminate the various musical intervals reliably. Perhaps the most accurate study in this sense is Maher's (1980), in which two complete sets of harmonic musical interval stimuli being formed at a different geometric mean frequency (500 Hz and 250 Hz) with pure sine waves were rated on 10 bi-polar adjective rating scales related to four main dimensions: evaluative (happy–sad, pleasing–displeasing, interesting–uninteresting), uncertainty (familiar–unfamiliar, simple–complex, stable–unstable), arousal–potency (restful–restless, weak–powerful) and psychophysical (quiet–loud, one tone–many tones). The results of this study demonstrated that there was no interaction between registers (the octave distance between two intervals of the same type) and intervals indicating that the register and interval main effects were free from contamination by effects of frequency and frequency-difference. On the 14 musical intervals used in the research, 7 were never discriminated from one another and, as in Bozzi (1985), many of the discriminations that were expected on the basis of theoretic writings on music did not appear. The seconds and the minor ninth were widely discriminated from other intervals, especially the thirds, the fourth and fifth, the sixths and the octave, as simply the "dissonances" *vs.* the "consonances". The intervals ranging from the minor third to the major sixth were never discriminated from one another on any rating of the four emotional dimensions. The subjects found the high-register (geometric mean: 500 Hz) stimuli to be more arousing and potent than the low-register (geometric mean: 250 Hz) ones. In addition, high-register stimuli were rated as happier, more interesting, powerful and loud, and subjects reported more restlessness and feelings of "activation-and-liveliness" in connection with them. In a subsequent study in 1982 Maher investigated whether melodic intervals differ in their psychological effects as do harmonic musical intervals. In this study, 72 participants found that the musical interval stimuli were reliably differentiated from one another on the basis of a factor other than that of interval size on 7 of 14 dependent measures, supporting the contention that musical intervals differ in their psychological effects. Furthermore, responses to these melodic intervals seemed to correspond rather closely to descriptions of the special characters of the harmonic intervals as found in his previous study, supporting the position that the laws of harmony are also valid with regard to melody.

The present study had two goals. First, to analyse the semantic differential used in this experiment and in Bozzi (1985) in order to verify whether adjectives used by music theorists in the past were actually suitable to characterise musical intervals and at the same time explore the main factors and the hierarchy according to which scales clustered together. The second and most important aim was to acquire a greater knowledge about the role of consonance, register, mode (major and minor), listener expertise and gender in the evaluation of the expressive characteristics of musical intervals.

For the evaluation a semantic differential (Osgood, Suci and Tannenbaum, 1957) was utilised, as it was in Bozzi (1985), with adjectives taken from Cooke (1959) and other classic music theorists who, in the past, have dealt with the emotional meaning of musical intervals. Maher used only 10 scales (1980) and this could be a reason for the failure of his attempt to prove that musical intervals have different psychological effects. Previous research has demonstrated that semantic differential is a good tool for musical stimuli evaluation (see Miller, 1990, for a review). Van de Geer, Levelt and Plomp (1962) used it for their study on consonance. Edmunston (1966) verified and supported its application for his study on aesthetic evaluation of musical stimuli. Nordenstreng (1968) and Wedin (1972) demonstrated the validity of this technique by comparing it with other psychometric instruments, Tessarolo (1979; 1981) and Porzionato and Nanti (1992) utilised this method for the evaluation of musical excerpts.

Method

Subjects. A total of 43 subjects underwent the experiment (15 males and 28 females; mean age: 23·05, standard deviation: 5·9). Study participants were enrolled in an undergraduate course of psychology of perception for a degree in art, music and performing and therefore some had music skills and some did not. Participants' musical skills were evaluated by questionnaire at the time of the interval evaluation. Twenty-three resulted as experts and 20 naïve. Participants were told only that the purpose of the experiment was to collect descriptions of sounds.

Stimuli construction and apparatus. A computer was used to produce two-tone chords on magnetic tapes. Two sets of stimuli, one in a low register and one in a high register and each consisting of equal-tempered intonation musical intervals (one set for one tape), ranging from the minor second to the octave were constructed. The intervals in the low-register set had a geometric mean of 185·13 Hz, and for those in the high-register set geometric mean was 1,510·38 Hz for a total distance of three octaves. The fundamental frequencies of component tones making up the 24 musical interval stimuli are listed in Table 3, as are their frequency ratios.

TABLE 1

Information about musical intervals and their expressiveness.

Interval name	*Sample notes*	*Theoretical status*	*Expressive function according to Cooke (1959, pp. 89–90)*	*Expressive function according to other authors**
minor second	C-C♯	dissonance	Semitonal tension down to the tonic, in a minor context: spiritless anguish, context of finality	Dissonant, painful, uptight, afflicted, discouraged, humiliated
major second	C-D	dissonance	As a passing note, emotionally neutral. As a whole-tone tension down to the tonic, in a major context, pleasurable longing, context of finality	Dissonant, in suspense, tormented, sad, uptight, eager, pleasant
minor third	C-E♭	imperfect consonance	Concord, but a "depression" of natural third: stoic acceptance, tragedy	Painful, severe, languid, sweet, melancholy, frank, still, submitted
major third	C-E	imperfect consonance	Concord, natural third: joy	Sonorous, joyous, furious, strong, cheerful, pleasant, happy, right, pure, quiet, stable, shining
perfect fourth	C-F	perfect consonance	As a passing note, emotionally neutral. As a semitonal tension down to the minor third, pathos	Lugubrious, active, tense
augmented fourth	C-F♯	dissonance	As modulating note to the dominant key, active aspiration. As "augmented fourth", pure and simple, devilish and inimical forces	Hostile, averse, destructive, mysterious
perfect fifth	C-G	perfect consonance	Emotionally neutral; context of flux, intermediacy	Consonant, pleasurable, stimulating, gentle, acrimonious, healthy, agreeable
minor sixth	C-G♯	imperfect consonance	Semitonal tension down to the dominant, in a minor context: active anguish in a context of flux	Pleasant, consonant, painful, discontented, strained, distressing, active, unstable
major sixth	C-A	imperfect consonance	As a passing note, emotionally neutral. As a whole-tone tension down to the dominant, in major context, pleasurable longing in a context of flux	Pleasant, consonant, unstable, sweet, desirous, bright, tense
minor seventh	C-B♭	dissonance	Semitonal tension down to major sixth, or whole-tone tension down to minor sixth, both unsatisfactory, resolving again down to the dominant: "lost" note, mournfulness	Dissonant, sad, painful, empty, melancholy, severe, strained, bewildered, lugubrious, unsatisfied
major seventh	C-B	dissonance	As a passing note, emotionally neutral. As a semitonal tension up to the tonic, violent longing, aspiration in a context of finality	Dissonant, tense, bitter, disagreeable, gloomy, optimist
octave	C-c	perfect consonance		Consonant, easy, solemn, majestic, strong, severe, full, stable, energetic

*Castiglioni (1959), Galilei (1638), Gervasoni (1800), Gianelli (1801), Rousseau (1782), Steiner (1975), Tartini (1754).

TABLE 2
The expressive values of the intervals according to Willems (1977).

Interval	*Sensorial*	*Affective*	*Intellective*
Unisonous	fusion, smoothness	will, peace	insistence, serenity
Minor second	derangement, roughness	fear, anger	shyness, illness
Major second	movement, friction	wish, vulgarity	request, displeasure
Minor third	heaviness, shadow	sadness, pain	lament, discouragement
Major third	clearness, limpid	joy, happiness	hope, balance
Perfect fourth	hardness, cold	firmness, indifference	achievement, simplicity
Augmented fourth	fracture, heat	disdain, excitement	pretension, surprise
Diminished fifth	excitement, instability	restlessness, anxiety	doubt, uncertainty
Perfect fifth	balance, emptiness	love, calm	certainty, mastery
Minor sixth	upsetting, penumbra	suffer, melancholy	worry, pity
Major sixth	radiant, light	effusiveness, kindness	satisfaction, gratification
Minor seventh	dynamic, warmth	exaltation, love	lyricism, romantics
Major seventh	limitation, wound	wickedness, hate	pride, rebellion
Octave	solid, stable	courage, exaltation	heroism, liberation

Phase relations between component tones were left to chance. The duration and pause of each stimulus interval were, respectively, 6 and 3 s, repeated up to a total duration of 2' 30", a timing considered to be appropriate for filling out the semantic differential. Stimuli were repeated in order to eliminate interference due to memory sound processes.

Because pure-sine waves are usually felt as strange and unfamiliar, a digital version of the sound of a cathedral organ (MIDI sound: 20/127) was used. The reproduction was well sampled and had plenty of harmonics so that its timbre emphasised the harmonic aspects of the bichords. Furthermore, using this timbre, the sounds could be protracted with the same loudness without any decay. The decision to use harmonic musical intervals instead of melodic ones was based on three factors: first, the simultaneity of component sounds underlines the aspect of consonance; second, temporal organisation is always characteristic of melodic intervals and thus melodic presentation could affect expressiveness, for example, a slow succession could be perceived as more quiet, peaceful and sad than a fast one, regardless of the interval; third, a melodic interval always has a direction: either ascending or descending and this can also influence the psychological interpretation of it. All stimuli were presented with headphones at a loudness of 75 dB measured with a Quest electronic type CA-12 sound level meter.

The intervals presentation order was randomised. In Figure 1 an example of presentation of all bichords is shown.

Bi-polar adjective rating scale battery. Thirty scales – with opposite adjectives rated from 1 to 7 – were used for the evaluation of musical interval expressiveness.

TABLE 3

Fundamental frequencies, frequency differences, and frequency ratios of component tones used in forming musical interval stimuli.

	Musical intervals											
	min2nd	maj2nd	min3rd	maj3rd	per4th	aug4th	per5th	min6th	maj6th	min7th	maj7th	octave
	High pitch bichords (Geometric mean frequency = 1510·38 Hz)											
Component tone												
Upper	1396·9	1568	1568	2093	1760	1760	1760	1864·7	1975·5	2093	1975·5	2093
Lower	1318·5	1396·9	1318·5	1760	1318·5	1244·5	1174·7	1174·7	1174·7	1174·7	1046·5	1046·5
Difference	78·4	171·1	249·5	333	441·5	515·5	585·3	690	800·8	918·3	929	1046·5
	Low pitch bichords (Geometric mean frequency = 185·13 Hz)											
Component tone												
Upper	174·61	196	196	220	220	220	220	233·08	246·94	261·63	246·94	261·63
Lower	164·81	174·61	164·81	174·61	164·81	155·56	146·83	146·83	146·83	146·83	130·81	130·81
Difference	9·8	21·39	31·19	45·39	55·19	64·44	73·17	86·25	100·11	114·8	116·13	130·82
Frequency ratio	17/16	9/8	6/5	5/4	4/3	7/5	3/2	8/5	5/3	9/5	15/8	2/1

Note: All values, except those for frequency ratios, are expressed in Hz.

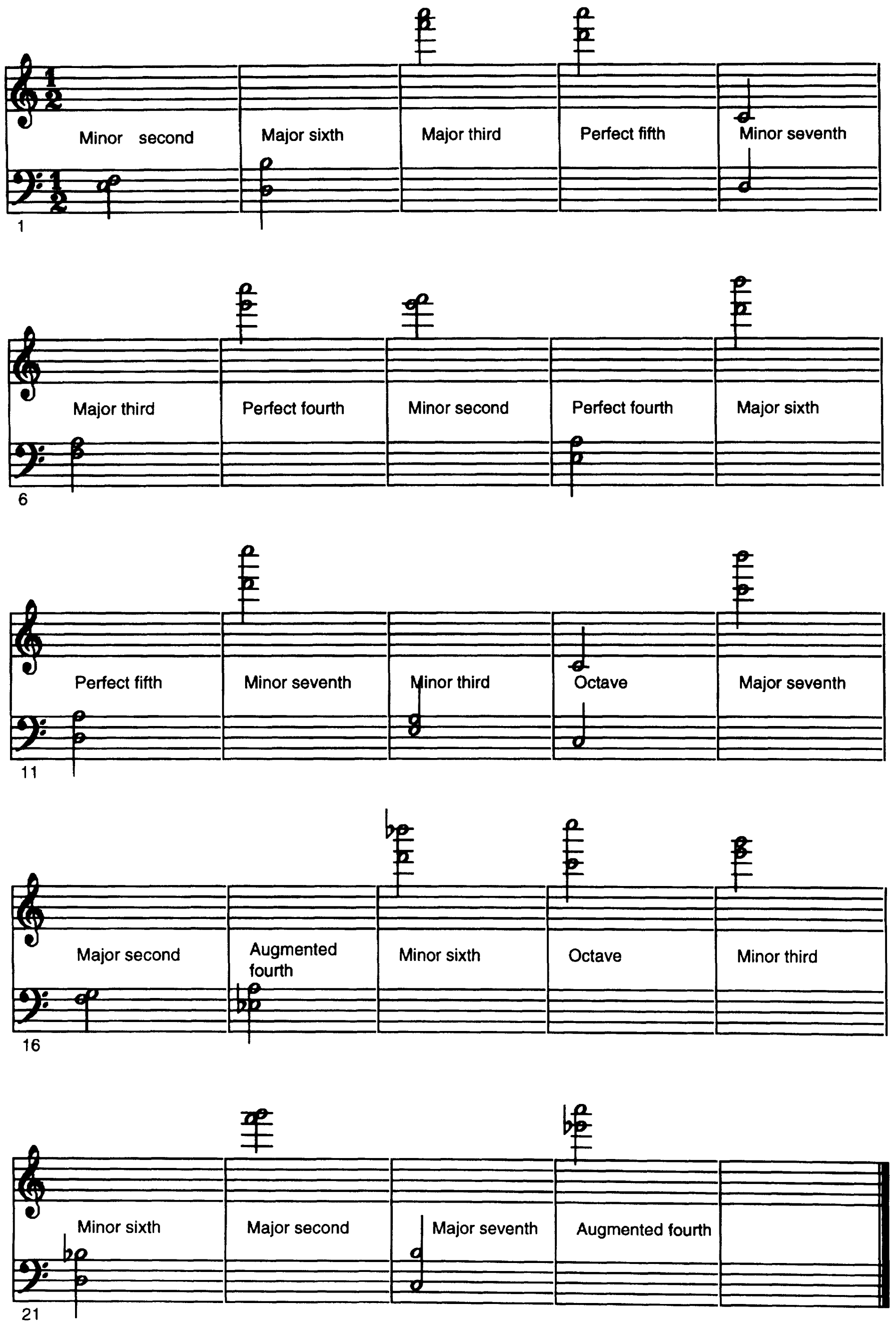

FIG. 1
Example of a 24 bichords sequence with indication of notes.

The adjectives, taken from Cooke (1959) and other musical theorists, are listed in Table 1. Presentation order and polarisation were randomised. The complete scale list can be obtained by adding two more scales, active–passive and full–empty, to the ones listed in Figure 4.

Procedure. Subjects were given a questionnaire on which they reported general information and their level of musical expertise. Subjects that had played an instrument regularly for al least five years were classified as experts. Scales were rotated against stimuli, which is to say that each subject expressed his/her adjectival rating on all 30 scales for the first stimulus, before hearing the second one. Each interval was presented for a total time of 2' 30". The whole experiment took about one hour.

Results

In order to verify whether musical intervals were described as significantly different a three-way ANOVA was performed with the intervals (twelve levels), register (two levels) and the thirty scales being one factor with thirty levels, as independent variables. Different musical intervals were demonstrated to have significantly different connotations ($F\,(11{,}985) = 50{\cdot}34, p < {\cdot}001$). Also the Intervals × Register interaction was significant ($F\,(11{,}985) = 2{\cdot}62, p < {\cdot}002$) demonstrating that an interval profile is influenced by the register. In Figure 2 the mean scores for all the intervals in function of their register presentation are represented. *Post-hoc* analysis with the Tukey test in particular proved that register is crucial in the semantic characterisation of the following intervals: maj3rd ($p < {\cdot}05$), min3rd ($p < {\cdot}01$), per4th ($p < {\cdot}01$), maj6th ($p < {\cdot}001$), min6th ($p < {\cdot}001$) and min7th ($p < {\cdot}001$). Apart from this last interval, the semantic profile is well defined when considering the purest consonances (per5th and Octave) and dissonances (min2nd, maj2nd, aug4th, maj7th) whereas the register effect is predominant when the harmonic properties are not as well defined and for the same interval there are different connotations depending on register presentation.

Separate ANOVA tests were conducted using, as independent variables respectively – register: low pitch *vs.* high pitch bichords (Fig. 3); harmonic properties: consonant *vs.* dissonant bichords; expertise: skilled musicians *vs.* untrained subjects; mode: major *vs.* minor bichords; gender: male *vs.* female subjects. In Figures 3 the bipolar scales are grouped together according to the three factors that emerged from factor analysis. *Post-hoc* analyses were carried out using the Tukey HSD test.

Register. Figure 3 represents graphically the influence of register on scale scores. Regarding the first factor – emotional evaluation – apart from tender/harsh, all differences were significant: main effect probability was $F\,(1{,}1007) = 86{\cdot}25$, $p < {\cdot}001$. In general low register bichords were emotionally evaluated more negatively in comparison to high register bichords that received however a neutral evaluation (a score of 4 is equivalent to a neutral judgement) with the exception of bright and sonorous. As concerns the second factor, activity, all differences were significant, being high register bichords judged more unstable, mobile, restless, dissonant, furious and tense in comparison to low register bichords. As to the third factor, potency, high register bichords were in general judged as stronger, more vigorous and rebellious.

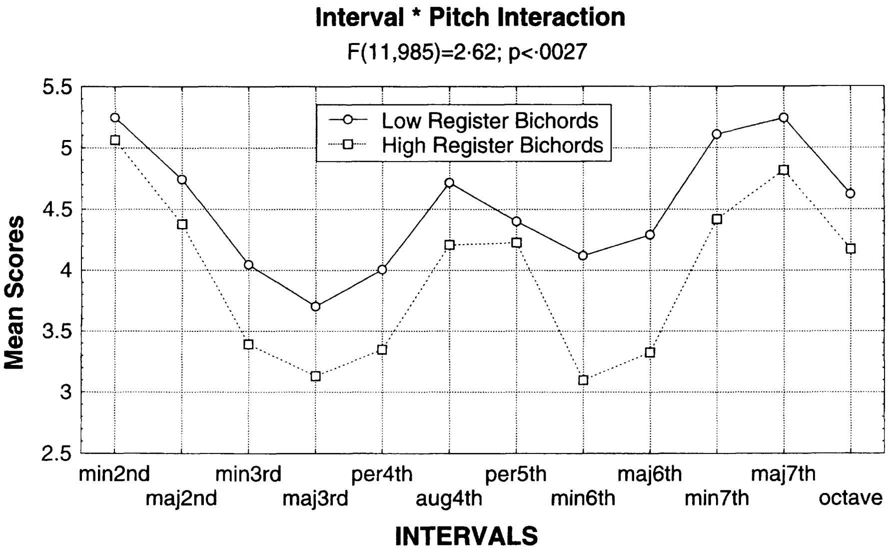

FIG. 2

Mean scores for all the intervals in relation to their register presentation.

Consonant/Dissonant. Figure 4 illustrates the profiles of consonant and dissonant bichords in relation to the 30 scales. The effect of this independent variable was highly significant: $F(1,1007) = 292{\cdot}92, p < {\cdot}001$. On all scales dissonant bichords related to the first factor were significantly judged more negatively, in comparison to consonant bichords which were in a neutral zone. Concerning the second factor – activity – dissonant bichords were perceived as more unstable, moving, restless, dissonant, worried, furious and tense compared to consonant ones. As to the third factor, potency, dissonant bichords were significantly stronger, more bewildered and rebellious.

Expertise. For this independent variable the main effect was not significant: $F(1,1007) = {\cdot}382, p < {\cdot}53$.

Mode. This analysis pertains to differences between major and minor bichords excluding perfect, augmented and diminished intervals. The main effect was significant for $F(1,1007) = 3{\cdot}24, p < {\cdot}02$ and *post-hoc* analysis evidenced six significant differences. As to the first factor – affective evaluation – minor bichords were perceived as more dull ($F = 3{\cdot}80, p < {\cdot}05$), mysterious ($F = 9{\cdot}09, p < {\cdot}05$), gloomy ($F = 5{\cdot}91, p < {\cdot}01$) and sinister ($F = 10{\cdot}05, p < {\cdot}001$). Pertaining to the activity factor, there was no significant difference in all the scales, whereas for potency, the third factor, minor bichords were judged weaker ($F = 8{\cdot}85, p < {\cdot}003$) and more bewildering ($F = 4, p < {\cdot}04$) in comparison to major ones.

Gender. The main effect of male/female differences proved to be significant: $F(1,1007) = 3{\cdot}25, p < {\cdot}001$. Differences were concentrated on the second factor, activity, while they were completely absent in potency. In particular, regarding the first factor, females judged the bichords heavier ($F = 9{\cdot}66, p < {\cdot}001$), harder

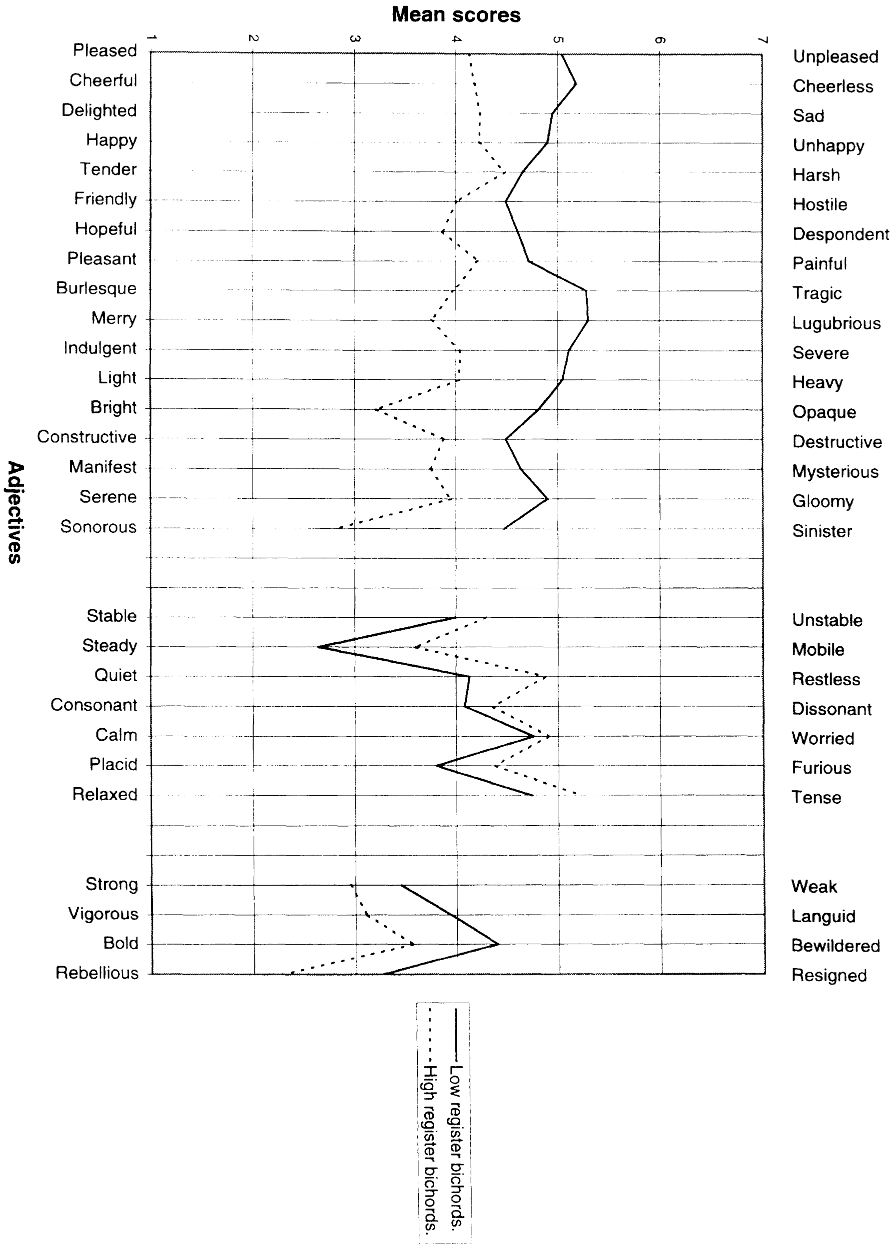

FIG. 3

Scores relating to low- and high-register bichords on the 28 scales used in semantic differential. From the top the first 17 couples of opposites refer to the first factor, emotional evaluation, the second 7 to activity and the last 4 to potency.

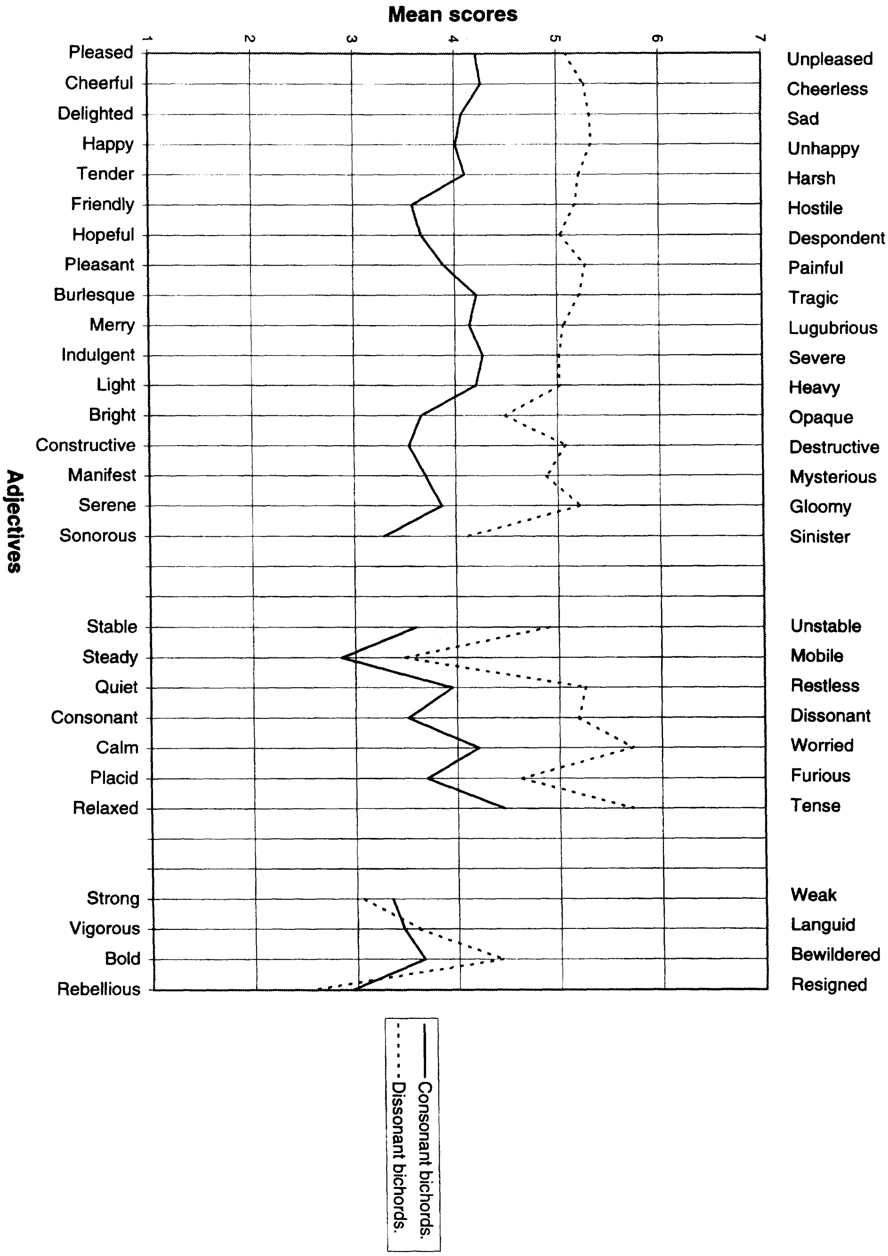

FIG. 4

Semantic profiles of consonant and dissonant bichords on the 28 scales from the semantic differential. From the top the adjectives belong to these factors respectively: emotional evaluation, activity and potency.

($F = 3{\cdot}65$, $p < {\cdot}05$), and more gloomy ($F = 4{\cdot}21$, $p < {\cdot}04$) than males. As to the second factor, females always felt more activity than males; in particular they significantly perceived the bichords as more restless ($F = 8{\cdot}96$, $p < {\cdot}002$), worried ($F = 15{\cdot}66$, $p < {\cdot}001$), furious ($F = 3{\cdot}40$, $p < {\cdot}05$), and tense ($F = 8{\cdot}24$, $p < {\cdot}004$).

In order to verify whether the bi-polar adjective rating scales used in semantic differential were appropriate, a factor analysis was run. First a correlation matrix was computed for the 30 scales of all 24 bichords. The basic components method was applied for extraction and a Scree test determined that 3 was the optimal number of factors. The correlation matrix was rotated with Varimax normalised. Eigenvalues were respectively 11·62, 4·14 and 1·93 with the following explained variance in percentage: 38·76, 13·81 and 6·45 for a total of 59·03%. A bi-polar adjective rating scale was assigned to a factor if its loading was greater than ·50. Two pairs of adjectives were not found in any factor, these were: active/passive and full/empty. Therefore, we may presume these are not appropriate for the evaluation of musical intervals.

The results of the factor analysis for each of the adjective pairs were as follows. The first factor clustered the following adjectives: pleased/unpleased, cheerful/cheerless, delighted/sad, happy/unhappy, tender/harsh, friendly/hostile, hopeful/despondent, pleasant/painful, burlesque/tragic, merry/lugubrious, indulgent/severe, light/heavy, bright/opaque, constructive/destructive, manifest/mysterious, serene/gloomy, sonorous/sinister. This factor groups all the adjectives concerning the affective and emotional evaluation. The second factor, related to the sense of activity, clustered these adjectives: stable/unstable, steady/mobile, quiet/restless, consonant/dissonant, calm/worried, placid/furious and relaxed/tense. The third factor clustered these opposites: strong/weak, vigorous/languid, bold/bewildered, resigned/rebellious. All these adjectives are related to the sense of potency expressed by musical intervals. The three factors (evaluation, activity and potency) are the classic factors described by Osgood, Suci and Tannenbaum (1957) and Osgood (1962). Compound factor analytical scores were computed for these three factors. Calculation of these scores – that is of the co-ordinates of a concept in the semantic space – makes it possible to develop a spatial model representing the system of meanings. The compound factor analytical score for a specific concept (bichord in this experiment) is determined by the score means for all scales related to each factor. In this case three co-ordinates (evaluation, activity and potency) were obtained for each bichord, by calculating the score means of all the scales related to each factor. Figure 5 shows the graphic representation of compound factor analytic scores for each of the 12 intervals studied, regardless of high or low register. Figure 5 also shows that emotional evaluation and activity have the same trend and are important in interval discrimination whereas the factor expressing power is flat, spread out on neutral zone and it is not affected by this kind of musical stimuli.

Discussion

The most relevant result of this research is that when musical intervals are evaluated on semantic scales as described by Maher and Berlyne (1982), there is a significant interaction between semantic profiles of the intervals and register. For some intervals the register force is greater than that of the interval itself and

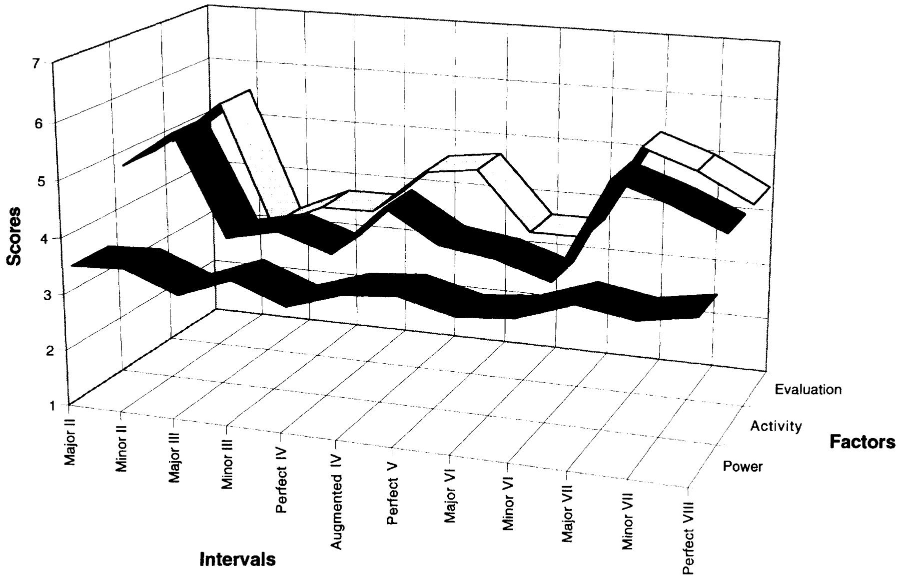

FIG. 5

Trends for the three factors of emotional evaluation, activity and potency in relation to the 12 musical intervals.

it determines the interval characterisation. Specifically, if the minor seventh is excluded, register does not affect the perception of those intervals which have a strong harmonic connotation of dissonance and consonance, such as minor second, major second, augmented fourth, major seventh, perfect fifth and octave. In these cases, profiles are univocal for low- and high-register bichords whereas with the thirds, perfect fourth and the sixths high-register presentation tends to polarise the bichord perception positively while a low-register presentation tends to make the bichord be perceived as neutral or moderately negative. As regards good dissonance and consonance, to the contrary, there is growing evidence that the special perceptual status has a natural or biological basis (Schellenberg and Trehub, 1996; Zentner and Kagan, 1996). This Register × Interval interaction was not found by Maher (1980) who used only one octave difference (geometric means were 500 and 250 Hz respectively) between high- and low-register bichords instead of the three octaves adopted in this experiment. For this reason, it can be assumed that the interaction becomes meaningful at greater distances.

The finding that this interaction did emerge for the thirds, fourth, sixths and minor seventh provides compelling evidence that data for intervals must – when the distance is greater than one octave – not be collapsed across registers in order to derive an interval effect. Register also influenced almost all scores on the scales that were used. Low-register bichords were emotionally evaluated more negatively in comparison to high-register ones which were not polarised positively but were arranged in the neutral zone. As to the activity factor, high-register bichords were judged more unstable, mobile, restless, dissonant, furious and tense. As to potency, high-register bichords were in general evaluated as stronger, more vigorous and rebellious.

The effect of consonance/dissonance on all scales has been impressive. Dissonant bichords were perceived as negatively polarised on all scales belonging to the first factor. As to activity, dissonant bichords were judged more unstable, moving, restless, dissonant, worried, furious and tense in comparison to consonant ones. As to the third factor, these were significantly stronger, more bewildered and rebellious. What must be noticed is that consonant bichords were not polarised positively as regards the factor of emotional evaluation, but they spread out over the neutral zone. It can be hypothesised that emotional characterisation of these intervals is influenced much more by the musical context in which they are arranged, than by the interval *per se.*

The use of semantic differentials can be appropriate for the purpose of interval expressiveness investigation. In this study 40% of variance was explained by terms related to emotional evaluation, the first and most important factor. The second factor, activity – which clustered terms related to time such as stable/unstable, mobile/steady, restless/quiet – accounted for approximately 14% of the variance. The activity factor is particularly important in interval discrimination if the tendency of dissonant intervals is to resolve with a strong sense of movement toward a consonant interval that is perceived as more stable, quiet and relaxed. These two factors showed the same trend in the direction of an increase of activity perception when the semantic differential scores for the emotional factor were polarised negatively. The third factor, potency, related to semantic differential scales expressing the dimensions such as strong/weak, vigorous/languid, bold/bewildered. It proved to be the less important one, explaining only about 6% of the variance. The values for this factor were concentrated in the neutral zone along all intervals, thus it is of no help in interval discrimination. It is possible that this factor could be most influential in music with changes in loudness, dynamics variations such as accelerando, or using different timbres, a trumpet *vs.* a flute for instance.

The study of intervals in isolation, out of musical context or in a primitive set, is justified for two reasons. The first one is methodological: with this kind of stimuli it is possible to ascertain the exact influence of intervals in comparison to other factors on the determination of the affective meaning of certain sound combinations. Certainly, if a composition is expressive of some emotions, this is not merely the results of its interval set. The instrumentation employed in a piece, its tempo, rhythm, tessitura, and other factors all contribute to its expressiveness. Without a selected modification of few variables, such as interval type and register in this study, and the contemporary control of all the other aspects that can influence the emotional response to music, it is only possible to determine a variation that cannot be attributed to specific factors. The second reason is that there is some research that shows that the perception of interval is in some way independent of the particular context, or environment, within which its psychological factors are measured. Bolzano and Liesch (1982), for instance, in two experiments have shown that, whether in the context of an orchestral performance or in isolation, harmonic and melodic components bear similar auditory stimuli. Cohen, Granot, Hillel and Barneah (1993) made six experiments on responses to harmonic and melodic intervals, using two complementary methods:

event-related potentials (ERP) and verbal responses. Three experiments were performed with each method, using the same musical material: isolated harmonic intervals; nine pairs of melodic intervals comprising combinations of three intervals; and 27 pairs of harmonic intervals comprising nine different combinations. The results showed specific responses to intervals, including those without context, indicating that intervals may be viewed as meaningful musical elements, even when presented in isolation.

Neumann (1974), on the opposite, emphasise the relativity of interval meaning. Starting from a philosophical point of view he affirms, according to Hegel, that *Eigenshaft, i.e.,* a specific characteristic of something, is only a means of relating. For example, the interval of the fourth can be a labile consonance as part of a second inversion dominant chord, but as a fourth suspended before a third is a stable dissonance. The triad is therefore not invariable, either: in the context of an authentic cadence the tonic triad is more satisfying and conclusive than as part of a plagal cadence. The ear actively imagines in certain tonal relationship a "conjunction" or "opposition" of voices, and this is the reason why a given interval is variously interpreted according to the harmonic context.

The role of future researches in this field is to disentangle how the above-mentioned factors of rhythm, timbre, tempo, register and harmony interact on the determination of expressiveness of musical intervals. It can be hypothesised, for instance, that the force of interval characterisation is maximum for medium speed and that a dissonance perceived as lugubrious and sinister in an Andante can modify its expressiveness and acquire brightness in a fast Allegro. On the other hand, it is necessary that in a melodic interval the two component sounds have to be perceived as linked and not as separate and distinct entities as happens if the execution speed is slowed to a degree that the melodic line looses its continuity. Other interactions between interval type and timbre or rhythm can be easily hypothesised.

In reference to a listener's musical ability on the evaluation of simple and primitive stimuli such as bichords, the expertise variable has no influence. Two explanations can be suggested: the first, that expertise can influence the cognitive, and not the emotional aspect of musical perception, and the second could be that this variable may be important for more structured and complex music. In Hantz, Crummer, Wayman, Walton and Frisina (1992), for example, training increased the amplitude and shortened the latency of the P3, a component of event-related brain potential, during perceptual tasks involving the discrimination of musical intervals. Musical training was also critical in the a study by Rowe and Ivinskis (1972) that however focused on the cognitive task of melodic interval discrimination. Whether musical appreciation is enhanced by musical training was addressed in the study by Edmunston (1969). In this research familiarity was reduced by the use of Indian music and semantic differential aesthetic evaluations of musical pieces indicated that musical expertise neither increased nor disrupted a natural propensity for the recognition of certain musical qualities related to activity and potency. Results also indicated that evaluative ratings were positively related to familiarity than to formal musical training.

Finally, the influence of gender was significant, especially for the activity factor. As found in other research about emotions (see Brody and Hall for a review, 1993; Manstead, 1992) females evaluated emotional stimuli in a more polarised manner. Furthermore, there is extensive evidence for greater emotional affect intensity in females. Fujita, Diener and Sandvik (1991), for instance, found that college females reported greater intensity of experiencing both positive and negative emotions. Observers well acquainted with the subjects, who responded as they thought the subject would, produced the same pattern of results. Consistent with females' generally greater intensity of affect, Brody (1994) found that self-rated emotional reactions to written scenarios were more intense for female across a range of emotions, including annoyance, disgust, sadness, warmth, happiness, hurt, fear, nervousness and anger. In this experiment, most of the differences where concentrated around the second factor, where females connected the bichords to feelings of being more restless, worried, furious and tense. Specifically in the musical field, Coffman, Gfeller and Eckert (1995) comparing the effects of audiotaped recordings of atonal music and text on ratings of affective response, complexity, liking and mood found that females responded with higher complexity ratings and reported their feelings more intensely than males in several instances. The higher evaluation on the activity factor confirms the results obtained by Nielzen and Cesarec (1981). In this study a sample of 50 people listened to 13 short, newly composed pieces of symphonic music and then rated each piece on a semantic differential. Analysis revealed that women experience tense music as more tense than men.

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