ABSOLUTE AND RELATIVE PITCH REVISITED ON PSYCHOACOUSTIC GROUNDS

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1. INTRODUCTION

Evidently certain basic features of tonal music are appreciated and "understood" by practically every human being.It is particularly appreciation of octave- and fifth-affinity and of the major triad's consonance which appear to be common to all humans. Our understanding of these phenomena, however, remains limited. A widely believed "explanation" is that normal individuals all possess a sense of *relative pitch*, i.e. the ability to readily recognize and memorize musical intervals,which in turn are specified by frequency ratios, while absolute pitch information is not normally preserved. Much theoretical and experimental effort has been devoted to looking for a physiological mechanism within the auditory system which is capable of directly recognizing frequency ratios. No such mechanism has been found. Instead, evidence has accumulated that the perception of successive intervals and of melodies involves a highly complex process of learning, categorization, and tonality perception (For a survey see /1/). Even in the case of simultaneous intervals, it has been shown that the width of a pitch interval, rather than its frequency ratio, determines which interval category it will fall into /3/. In other words, an interval is just what its name implies: a distance on a linear continuum corresponding to a difference between two values.

The present paper is intended to contribute further to the understanding of these basic aspects of musical perception. First, the concepts of absolute and relative pitch will be critically reconsidered. In the second part, the distribution of relative and absolute pitch abilities among musicians will be discussed on the basis of recent experimental data.

2. THE CONCEPTS OF ABSOLUTE AND RELATIVE PITCH

If the abilities known as absolute and relative pitch are to be meaningfully compared, and their roles in musical perception discussed, it is essential that they be equivalently defined. Absolute pitch is normally regarded as the ability to identify single musical tones by appropriate labels, usually their musical note name. In an experimental test of this ability, the possibility that subjects might use their sense of relative pitch as an aid to absolute pitch judgements should be avoided. Analogously, relative pitch is the ability to properly label musical intervals formed by pairs of successive or simultaneous tones. An experiment testing the latter ability would require that subjects are prevented from using absolute pitch information. The number of categories the subject would need to distinguish between in each type of experiment would also need to be considered. Usually, the argument behind the belief that the relative pitch sense is more fundamental than the absolute pitch sense does not take this "information load" aspect of the comparison into account. A careful revision of this way of thinking may well lead to a better understanding of the respective roles of absolute and relative pitch in musical perception. The sense of relative pitch as defined above must not be confused with the sense of harmony, i.e. sense of tonal affinity (octave and fifth affinity), of compatibility of certain chords, and of the roots of chords /6/. While most people have a good harmonic sense, only a few can actually identify (i.e. label) intervals. So it is not only the ability to name individual notes that is relatively rare. What *is* widely distributed appears to be the sense of harmony, not relative pitch.

Psychoacoustically based models of absolute and relative pitch will on the first place recognize that it is only sensory parameters that are available to the central auditory system. The relevant sensory parameter here is pitch, a one-dimensional quantity determined by several different physical parameters. The process of absolute pitch identification can then be illustrated as follows:

SOUND SIGNAL → FORMATION OF PITCH → CATEGORIZATION OF PITCH → MEMORY OF TONE CATEGORIES

Likewise, the corresponding model of relative pitch perception is:

SOUND SIGNAL → PITCH FORMATION → MEASUREMENT OF PITCH INTERVALS → CATEGORIZATION OF INTERVALS → MEMORY OF INTERVAL CATEG's

These models are based on the assumption that pitch is a one-dimensional sensory attribute - the " height" of a tone - and that a pitch interval represents a distance in the pitch continuum, i.e. the difference between two absolute pitch values. The pitch of complex tones is ambiguous: although a harmonic complex tone normally has a pronounced pitch corresponding to its fundamental frequency, it also possesses other pitches, each of which may with a certain probability be identified as "the" pitch of the tone. The fact that the most important alternative pitches of harmonic complex tones lie at octave and fifth intervals from the main pitch /5/ explains to a considerable extent the tonal affinity phenomenon which in particular includes the aspect of *tone chroma*.

Another highly important implication of the models is categorization. Pitch as such can be retained only for a relatively short time /1,2,4/. What is retained eventually in long-term memory is categorical labels. Categorization is an abstraction process by which stimuli which differ more or less distinctly in terms of sensory parameters, are assigned one and the same categorical label.

In terms of the present conceptualization, the abilities of absolute and relative pitch can then be described as follows. "Absolute pitch" is crucially dependent on the ability to immediately categorize individual musical tones such that categorical labels can be stored in long-term memory. A typical non-absolute-pitch possessor (NAP) is then an individual lacking that particular ability. Relative pitch is the ability to categorize pitch *intervals* (in the sense of distances), such that corresponding labels can be stored in long-term memory. Since the latter capability is obviously easier to achieve than the former, the question arises why categorization of pitch intervals is easy while that of absolute pitches is not. A tentative answer is provided by current theory of pitch perception, in particular the virtual-pitch model /5/: To extract the prevalent pitch of a complex tone, the auditory system takes advantage of those particular pitch intervals which are established by the harmonics of natural complex tones (corresponding to the frequency ratios 1:2:3, etc.). These intervals in fact are of a categorical nature. One can thus with regard to pitch perception of complex tones indeed say that categorization of (musical!) pitch intervals is natural, while categorization of pitch as such does not play any particular role.

3. EXPERIMENTAL DATA

3.1 Tone- and interval identification. Three experiments with NAP's of different musical experience as subjects were carried out: (1) identification of seven diatonic tones (A3 to G4); (2) identification of seven successive intervals from a diatonic scale with fixed reference (B3); and (3) identification of seven successive diatonic intervals with random reference (The lower note was taken from the diatonic scale B3 to A4sharp). The tones were produced on an electronic organ and contained many harmonics with a spectral shape of -12dB/oct. Test stimuli were presented through earphones with about 75 phon. Before each session the subjects were presented once with the tone- or interval sequence to be tested. Significant learning effects were observed; performance saturated after about 140-200 test items. Fig.1 shows the saturated results of four subjects (Two musically experienced, two without particular musical concern). As can be seen, under equivalent conditions (same no. of categories) performance is about the same with tone and interval recognition. Performance in strict interval recognition, i.e. with random reference (Exp.3) is significantly poorer than in experiments 1 and 2. Although generalizeability of these results should not be overestimated it is apparent that in this particular case NAP's did not perform significantly poorer in absolute tone than in interval identification.

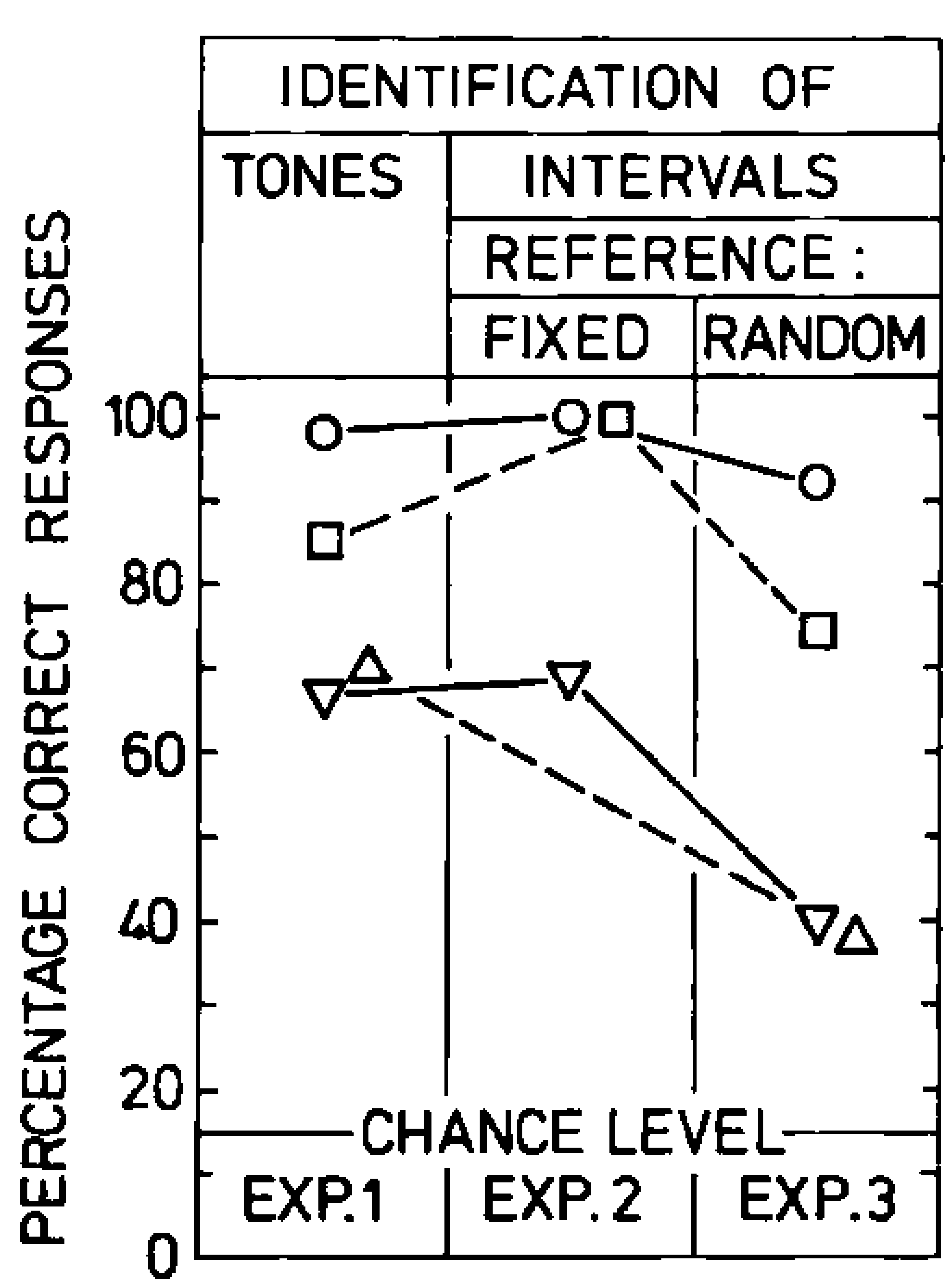

Fig.1. Performance of four NAP's (symbols) in identification of 7 categories. Exp.1 tones; Exp.2/3, intervals. cation.

3.2 Identification of musical key. In a comprehensive test series identification of musical key by APP's (absolute-pitch possessors) and NAP's was tested with 5s - samples of musical pieces, played on piano (J.S.Bach, major preludes of the Welltempered Clavier, Vol.1). As has been described elsewhere /7,8/, these experiments suggest that (1) key identification can be achieved not only by APP's but to a significant extent also by musically trained NAP's; and (2) key identification is dependent on pitch perception, as opposed to recognition of other auditory clues such as beats and instrumental timbre. Fig.2 gives a survey on the distribution of that particular absolute-pitch identification ability among musically trained subjects (135 subjects; data from /8/). Eight percent of the subjects claimed to have AP, while the other explicitly regarded themselves as NAP's. Performance is indicated on the abscissa, in terms of "identification rate". That is the difference between the relative number of correct identifications of the nominal key minus the relative number of cases in which test samples transposed by plus/minus one semitone were judged to be in nominal key; i.e., it is a guessing-normalized, crucial measure of performance (cf. /7,8/). On the ordinate is scaled the relative number of subjects whose performance was equal to or greater than the corresponding abscissa values indicated by the solid curve. It was found that those subjects whose performance was 0.8 or higher largely were the APP's. As indicated in the figure, also many NAP's achieved considerable key-identification performance.

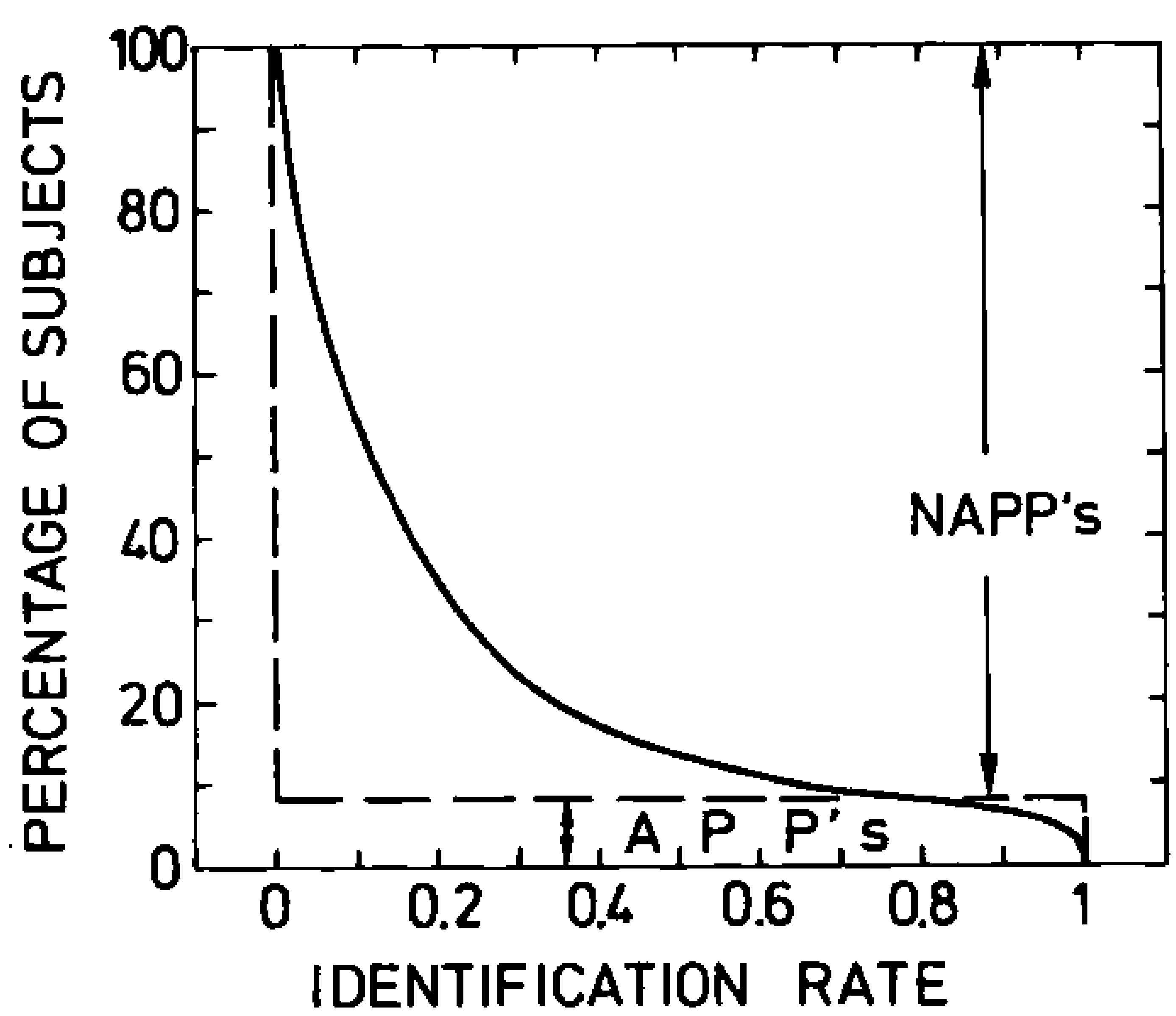

Fig.2. Integral distribution of performance in key identification, cf./8/.

If it were true that NAP's are completely unable to identify key, while APP's were perfectly able to do so, the solid curve would have to be replaced by the dashed lines. The actual result thus indicates that the difference between APP's and NAP's is not as "categorical" as usually assumed. What is categorical about AP appears to be its being aware of: Apparently, an AP capability represented by about 70-80% performance in the key identification experiment is necessary to be recognized by its possessor.

4. CONCLUSIONS

The findings discussed in this paper suggest a more balanced view of the respective roles of absolute and relative pitch in musical perception. According to psychoacoustically based concepts, relative pitch appears to be neither "simpler" nor more basic than absolute pitch. Experiments testing musical tone- and interval recognition show that the information conveyed by absolute and relative pitch judgments is about the same. What makes NAP's different from APP's is not that the former are completely ignorant of absolute pitch, but that they restrict their processing of absolute pitch to temporal periods of the order of one minute (short-term memory) and do not categorize pitches in order to retain them in long-term memory.

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