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DETECTION THRESHOLDS & PURE TONE THRESHOLDS

IN AUDITORY ACUITY

Progress Report No. 2

on

Bureau of Medicine and Surgery Research
Project NM 003 022 (X-747)(Sub. No. 154)

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22 January 1948

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DETECTION THRESHOLDS AND PURE TONE THRESHOLDS
IN AUDITORY ACUITY.

By

Cecil K. Myers
and
J. Donald Harris

Progress Report No. 2
Bureau of Medicine and Surgery
Research Project No. NM 003 022
(X-747 (Sub.No. 154))
"The Psychophysiology of Pitch
Discrimination in a Noise Background".

The first of this series of reports of pitch discrimination in noise was published and distributed as Report No. 1 under BuMed Project X-619 (Sub.No. 134), titled "Pitch Discrimination in Noise", dated 6 July 1945. This report is considered as Report No. 1 under Project NM 003 022.

22 January 1948

U. S. Naval Medical Research Laboratory
U. S. Naval Submarine Base
New London, Conn.

DETECTION THRESHOLDS & PURE TONE THRESHOLDS IN AUDITORY ACUITY.*

A few months ago we were trying to determine the exact point of 50% detectability of a pure tone either in quiet or in a noise mask. In this work we were seriously troubled by the fact that some subjects on repeated testing showed a variability over short time intervals greater than experimental error, and we suspected it was greater than could be accounted for by changes in physiological condition of the subject. Questioning these men brought out the fact that some of them were shifting their criterion of whether they heard the stimulus. At one time they were reporting positively whenever they heard anything at all, while at another time they would wait until they heard a sound which they could identify as the tone for which they knew they were listening.

Since several dozen subjects were affected by the phenomenon in more or less degree, and since it was causing systematic differences of the order of a few decibels, it obviously had to be reckoned with. We wanted to know whether subjects could set up and maintain some criterion of minimum tonal quality and if so, whether such a threshold could be even more precise than the threshold of detection. A more precise threshold, in the sense of a steeper psychophysical function, would be of some use in determining the loudness level of pure tones, in defining signal-to-noise differentials in psychological terms, and the like.

The present data is limited to our own ears. For each of 5 frequencies between 500 and 14000 cps inclusive, we determined two thresholds simultaneously, a threshold of detectability and a so-called pure-tone threshold. For the latter we reported positively whenever a sound seemed to possess any tonal quality. We have refrained from elaborating on this statement.

Our data indicate that a zone of detectability of the order of 2-3 decibels exists between the intensity at which a tone is just detected 50% of the time and the intensity at which it may be assigned a pitch quality 50% of the time.

* Read to the Eastern Psychological Association, Atlantic City, April 1947.

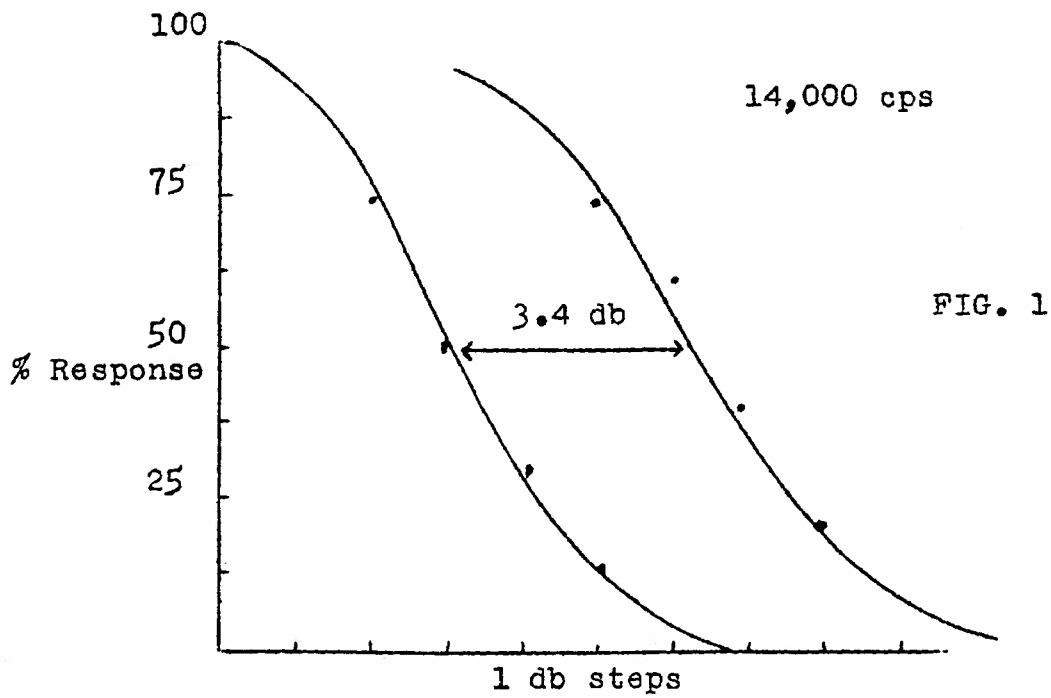
This zone where some unidentified sound can be heard is somewhat less for the medium tones, and it decreases slightly if not quiet, but a white noise, is used as the limiting background. We find the precision of the pure-tone threshold to be about the same as that of the detection threshold: through the transition zone the two psychophysical curves are parallel. For higher and higher frequencies, the psychophysical curves are less steep; but for louder and louder noise masks, the curves are more steep.

The equipment consisted of two Hewlett-Packard beat-frequency oscillators connected to an electronic switch and fader amplifier and led through filters and attenuators to a Permoflux headphone. One oscillator served merely as a 1 second warning signal. The other oscillator delivered a sine wave $1/4''$ long, with $1/10$ second onset and termination. The tone was set very low, and the subject stated after each presentation whether he heard nothing, something, or a tone.

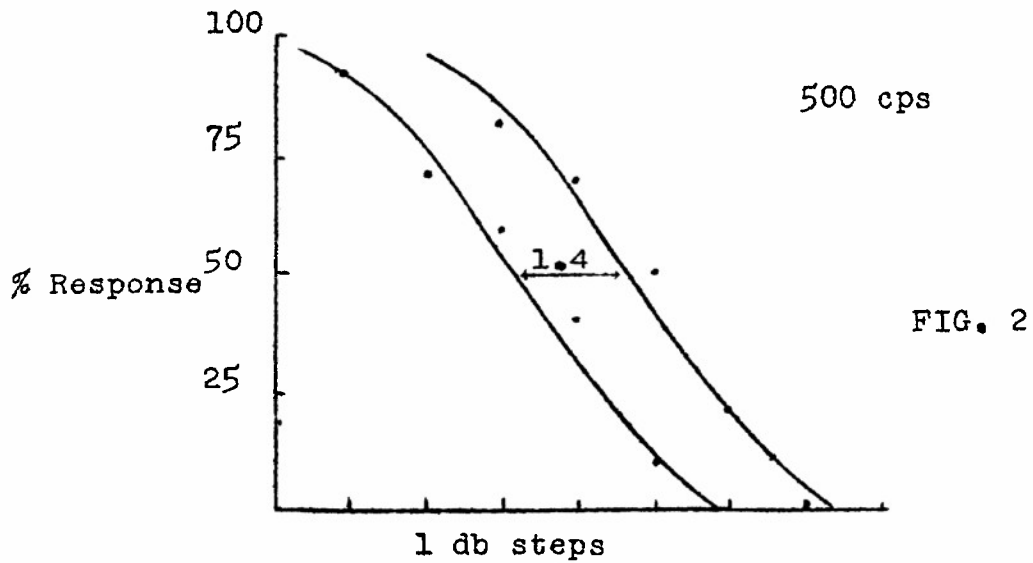
Ascending and descending series were discarded because of the intrusion of constant errors; stimuli were presented at random in 1-db steps through the whole transition zone. It was found best to ask for no more than 15 judgments at every stimulus during one session.

Some typical results are presented here, as simply as possible, in the form of curves relating percent response against stimulus intensity. (See Fig. 1) Here, at 14000 cycles, the left-hand curve represents the transition zone for the pure-tone threshold, while the right-hand curve represents that for the detection threshold. The baseline is in 2-db steps. The separation between the 50% thresholds is 3.4 db, and the curves are parallel. Notice that Q, the interquartile distance, is 2 db, the largest we have found so far.

Fig. 2, at 500 cycles, has the same coordinates except the baseline is drawn out in 1-db steps. Here the separation between the thresholds is only 1.4 db, though this is over 4 times the Probable Error of that difference. These curves remain parallel throughout their length. Notice that Q has dropped from 2 at 14kc to about 1 at 500 cycles; this figure is about the average for the 500 cycle data.



Left-hand curve: transition "Nothing" - "Something"
 Right-hand " : " " "Something" - "Pure tone"



Left-hand curve: "Nothing" to "Something"
 Right-hand " : " "Something" to "Pure tone"

The next Figure is an extreme example of a case in which the two curves do not remain parallel. See Fig. 3. At 1000 cycles the separation is 2.1 db only at the 50% point. It is rare for the detection data to slope more steeply than the pure-tone data. Usually they are parallel.

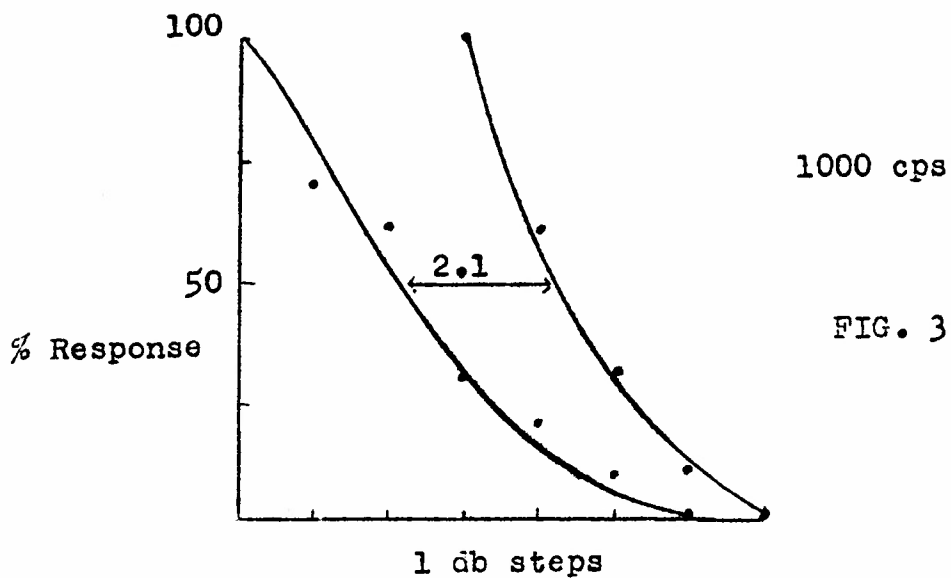
The average differences between the two thresholds are seen in Fig. 4. Each average is from at least a dozen determinations; it is surrounded by plus and minus 1 standard error. Differences are statistically significant between 500, 1000, and any of the higher tones. Nothing much can be said from this figure as to the effect of frequency except that there is a low tone-high tone difference.

As examples of the slight change in the relative characteristics of the two thresholds when a low noise is introduced, Fig. 5 gives the data at 8 kc in a 10 db mask. The low mask has not perceptibly changed the slopes of the curves.

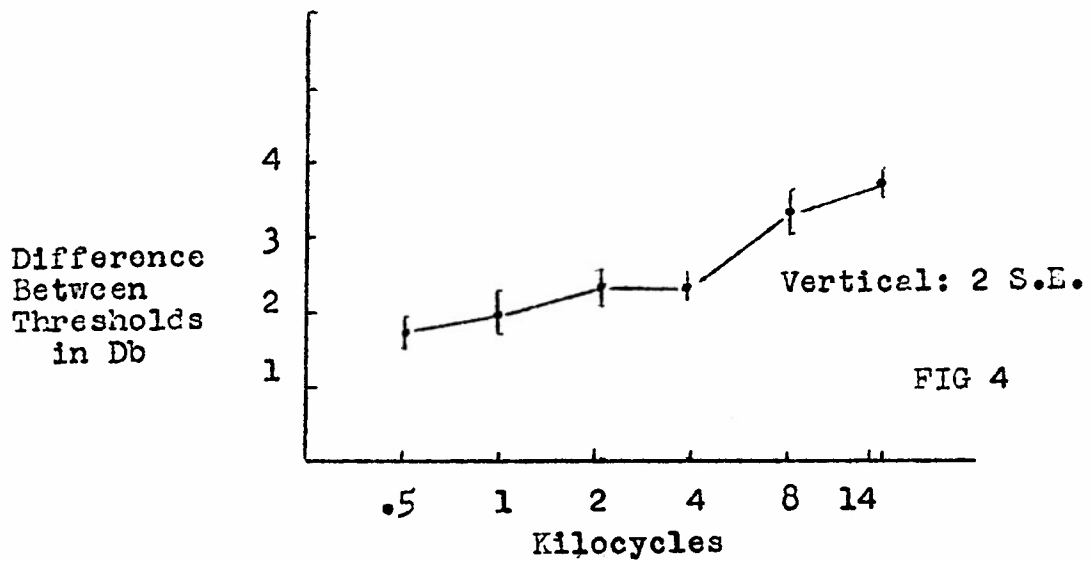
On the other hand, there may be a tendency for the introduction of a mask to decrease the zone in which a tone cannot be identified. Fig. 6 shows on the ordinate the width of the zone for 8 kc in quiet and in 5 different mask intensities, 10, 20, 30, 40, and 50 db. Four of the 5 differences in masking are smaller than the difference in quiet. It is more than likely that this is related to recruitment--to the fact that a tone 5 db over its 50% detection point in a noise is much louder in millisonnes than that same tone 5 db over its 50% detection point in quiet. If it sounds louder in a mask, it could reasonably be better assigned a pitch-quality.

Another bit of evidence on the same line is our finding that as the mask grows louder, the psychometric function steepens. Q decreases fairly regularly from 1.9 db at 10 db mask to 1.25 at 50 db.

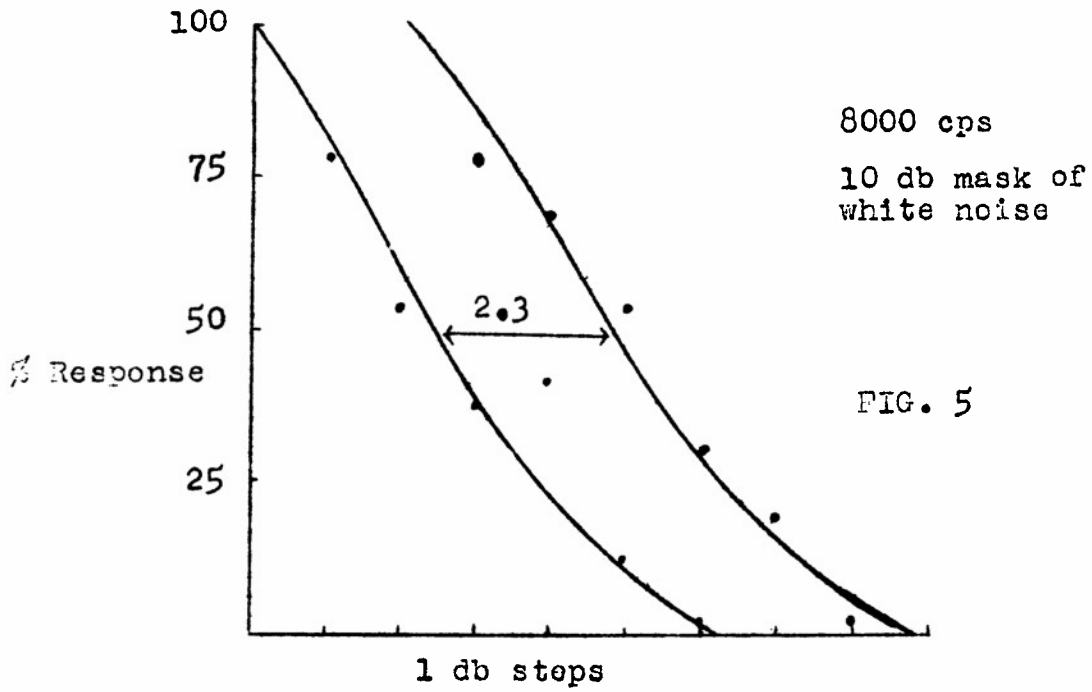
We do not suppose that there is any sharp emergence of a pitch-quality as a tone is increased from subthreshold strength to audibility and above, nor do we suppose that, once a pitch-quality can be ascertained 50% of the time, there is no further refinement of the pitch-quality as the tone becomes even louder. This is probably a fairly gradual process. Our own present purpose was served when we had determined the general intensity-range above detectability where a pure tone could be recognized as having a pitch. No doubt a careful observer could use criteria which would enable him to fix one or more thresholds in addition to the two studied here.



Left-hand curve: "Nothing" to "Something"
 Right-hand " : "Something" to "Pure tone"

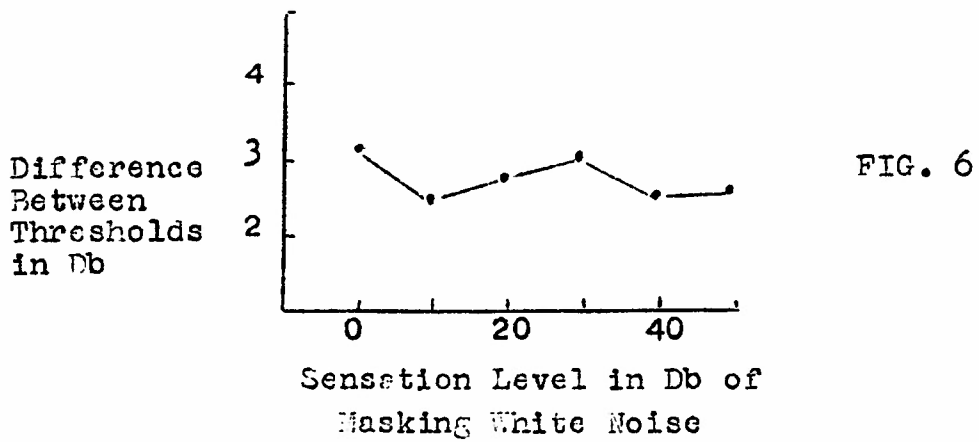


Zone of Detectability as a
 Function of Frequency



Left-hand curve: "Nothing" to "Something"

Right-hand " " : "Something" to "Pure tone"



Whether or not a pitch-quality was actually present cannot, of course, be proved objectively on the basis of this data alone. All we have done is to document the precision of a certain criterion; that criterion need not necessarily be one of pitch. The problem becomes one of finding how well the perceived tone can be identified as to pitch. For this purpose we wish to know the differential pitch thresholds at these very low loudness levels. If pitch discrimination can be achieved there, we have objective evidence for some pitch-quality.

So far, inherent fluctuations of the absolute threshold of detectability of the order of 2-3 db have prevented us from collecting conclusive data on pitch discrimination at the loudness levels below 5 db; but we have data on a more stable point, the 50%-detectable point of a pure tone in a constant white noise surround. Here we find that discrimination becomes progressively poorer as the intensity of the tone above the background is decreased, and that discrimination finally reaches a minimum at a point asymptotic not with the 50%-detectable point, but 2-3 db above this point. But this is just the region at which the pitch-quality studied here is becoming apparent, and the correspondence indicates that the threshold introduced here is in all probability a pitch phenomenon, since the beginning of a true pitch quality and also of pitch discrimination occur at about the same loudness.