RELATION OF EARPHONE TRANSIENT RESPONSE TO MEASUREMENT OF ONSET-DURATION

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Onset of catatonic symptoms only emerge in patients who are effectively treated with chlorpromazine, according to Schubert, et al. (1995). They suggest that the onset-delay of these symptoms can be predicted with a high degree of precision, and that the limit of detection approaches inaccuracy. The assumption that these symptoms are related to the treatment of schizophrenia is plausible, although further research is needed. These findings must be considered in the context of the limited nature of this study. However, the data provides valuable insights into the nature of these symptoms and their potential mechanisms.

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MEASUREMENT OF ONSET-DURATION*

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ABSTRACT
Measurements were made of the transient response of PDR-8 earphones. These data
indicate that the original estimate of the onset-duration of auditory stimuli can be revised
downward to 0.8 ms. Implicit in the results is a caveat on the faith one should have in the
output of commonly used earphones with short- or single-transient inputs.

Onset-duration, the duration below which
only cues derived from the onset of a stimulus
are effective, was first discussed by Tobias and
Schubert in 1959 when they attempted to esti-
mate its size in a study of binaural function.
They thought that, for stimuli shorter than the
onset-duration, changes in waveform should not
be perceptible. Although unable to predict a
precise value, they did estimate a maximum
limit of about 3 ms. To calculate the 3 ms, they
assumed that duration was the sole contributor
to the weighting of any stimulus segment,
although several other onset-weighting factors
must have been involved (primary among these
being the well-known on-effect and the effect
of time-since-onset on “binaural memory”).
However, these factors could not be taken into
account because of limitations in the available
data.

The next step involves finding the onset-
duration directly rather than in the indirect and
somewhat cumbersome fashion used by Tobias
and Schubert. Several techniques — some mon-
aural, some binaural — are possible. For in-
stance, differentially filtered noise bursts of
varying duration might be compared, but there
is a strong possibility that short bursts would
ring the filter for too long to allow proper
control of duration. The use of any filter there-
fore seems inadvisable in this sort of work.
(Indeed, if the onset-duration concept is cor-
rect, the perception of “sharp” and “dull” — that
is, high and low pitched — clicks results from
overly long acoustic stimulation, since any truly
short click should sound like any other on the
sharp-dull continuum.)

A more defensible approach, and the first one
used in this study, requires a binaural analysis
of the stimulus: two binaural conditions are
compared at a number of stimulus durations.

1 Tobias, J. V., and E. D. Schubert. “Effective Onset-
Duration of Auditory Stimuli,” J. Acoust. Soc. Am. 31,
of the Auditory Nerve,” Am. J. Physiol. 113, 478-504
(1935).

*The work reported here was performed at the Defense Research Laboratory of the Uni-
versity of Texas while the senior author was employed there as Research Scientist in the
Undersea Warfare and Acoustics divisions. The paper has been published in The Journal of
the Acoustical Society of America 34, 857-858 (1962).
EXPERIMENTS

It was postulated that subjects would make almost 100 percent correct differentiations between interaural correlation conditions of +1 and 0 for long noise bursts and chance differentiations for short bursts. The division between long and short must be the onset-duration. However, judgments were 100 percent correct for any noise-burst length. Phenomenologically, the +1 correlation stimuli were of course in the median plane; 0 correlation stimuli varied in azimuth, probably because of the random interaural time difference in onset. Judgments were necessarily easy on the basis of the localization.

In the second approach, the troublesome 0 correlation condition was not used; a −1 condition was substituted. Since only the rarefaction half-cycle of the waveform actually serves as a stimulus, some "jumping" of the perceived image (as occurred with 0 correlation) was expected, but instead only the commonly reported separation to the two earphones was noted for the −1 stimuli. Here too, judgments were 100 percent correct at any burst length.

However, these apparently negative results can be used to modify the original onset-duration estimate if some use is made of transducer response. If one assumes that an onset-duration exists and that it is of the order of 1-3 ms, it becomes obvious that the signal must not have been adequately specified for the shorter durations. The clear cause of the inadequacy is poor transient response of the earphones. Specification of the stimulus duration below which the phones refused to behave, then, should give a new upper limit for onset-duration.

The procedure was simple: oscilloscope trace photographs were made of PDR-8 earphone responses to two kinds of transient signals, rectangular current pulses and short noise bursts ("short" ranging from 0.09 to 10 ms). The phones were the ones used in the listening experiments although other phones were tried with similar results. Figure 1 shows the response of a phone to several lengths of rectangular pulse: 2, 1, 0.5, and 0.1 ms. At 1 and 2 ms, the acoustic pattern was the characteristic symmetrical double response — positive following the initial transient, negative after the release. The form of the response was the same for both pulse lengths. For 0.5 ms, the phone started to produce the same output but was unable to complete the first response before the second half started. The very early second half in the 0.1-ms case produced a waveform that looks quite different from any of the others.

In the two earphones there was an overdriving of the input circuitry by the figure of the waveforms; however, the transducer response was that of a matched filter.

The observations of the two earphones have been made with a gate of 1/10 of the waveforms, resulting in a switch to one other. These can be heard much more closely and the ringing can be made in 1/12 of the waveforms. Each 0.1- and 0.05-ms case beyond the 0.1-ms case was as follows:

In the +1 correlation, the amplitude was approximately one half.

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In all cases, the acoustic duration was well over a millisecond, and the shortest possible duration (found by measuring the positive part of the 1 or 2 ms waves) is at least 0.8 ms. Thus, even if the signal were an infinitesimally short transient, these phones would respond for nearly a millisecond.

The possibility that noise bursts might behave differently led to similar measurements on gated noise inputs. Figure 2 shows some typical results for noise bursts of 2, 1, 0.5, and 0.1 ms, switched with very short rise and decay times. The 2-ms samples varied from one another much as should be expected for random input, and the acoustic duration, exclusive of the 8-kc ringing, was 2 ms. The 1-ms samples were similar except for their duration which was perhaps 1/2 ms more than the 1 ms of electrical activity. Each of the 0.5-ms bursts actually extended beyond a millisecond acoustically, and the 0.1-ms bursts produced activity for 0.7-0.8 ms. In this last case, the phone seemed to behave almost as if it had been hit by short rectangular pulses of varying amplitude, which is what would be predicted.

CONCLUSIONS

It is now necessary to derive some information from these waveforms to allow a revision of the onset-duration estimate. First, it is worth noting that the contribution of the phone to the stimulus becomes relatively large for inputs of perhaps 1.5-ms duration or less. But the datum which is directly useful is the length (0.7-0.8 ms) of the click-like sound produced by very short noise bursts. In the situation in which stimuli are either interaurally in-phase short bursts or 180° out-of-phase short bursts, subjects can differentiate perfectly between the two conditions. Thus, the onset-duration if it exists must lie below 0.8 ms.

One further point deserves restatement. Since psychophysical experiments of this sort are designed, in effect, to discover interaural correlation problems which cannot be solved in any fashion by the binaural system, it is necessary to conclude that transduction by standard earphones cannot be used. Matched phones will simply add similarity to the stimuli at the two ears no matter what the electrical input may be. The more closely the phones are matched, and the shorter the duration of the electrical activity, the worse the problem becomes. Attempts to produce dichotic or incoherent short-duration stimuli are doomed to be confounded by the interaural similarities forced upon the stimulus by standard transducers.