RETROSPECTIVE, AND PROSPECTIVE CONSIDERATIONS ON PSYCHOPHYSICAL MEASUREMENT EMANATING FROM TIME PERCEPTION STUDIES

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Abstract

Retrospective, What kind of invariances should we look for, and where? Can we catch the lack of invariance by parameter values? The empirically obtained linearity between standard and set ratio in ratio setting in general and in duration reproduction in particular leads uniquely to a power function describing the relation between stimulus and sensation—an example of invariance. Applying the parallel-clock model (H. Eisler, 1975) makes the determination of the parameter values possible without the observers having to use numerals. The parameters should not only be regarded as fitting constants; they carry information about time-structuring behavior, as in, e.g., group differences, experimental conditions, and individual differences—which otherwise could be seen as simply lack of invariance (H. Eisler, Eisler, and Hellström, 2008).

Prospective. (1) Nonlinear psychophysical dynamics deals not only with the end result of a sensory process but also attempts to follow the building-up of a sensation (over time). (2) A close connection between brain processes and psychophysical variables seems imminent. Empirically obtained breaks in the psychophysical function for duration are in line with Thatcher and John's (1977) assumption that time experience is built up from iterative neural loops (see Eisler, 1996). Furthermore, a recent discovery of number neurons (Dehaene, 2003, Nieder & Miller, 2003) promises fast advances in psychophysics.

Introduction

First a few more or less self-evident remarks. What we are looking for are invariances, men we have to distinguish between invariances as to the *form* of a function and as to its parameter values. When context effects can be accounted for by different parameter values the main invariance, the one of the function, is kept.

Worth considering is also the contribution of the researcher relative to the observer's in erecting a subjective scale. An ordinal scale is based only on the observer's behavior (a > b) and logic. In my opinion this is quite different from "indirect" scaling, based on observers´ discrimination. To obtain a scale the researcher piles discrimination units on top of each other, which seems to me rather arbitrary. There the researcher's contribution is largest. Furthermore, there is an arbitrariness as to the interpretation of data. In pair comparison, e.g., Thurstone's model builds on differences. However, the judgments can be considered evoked by ratios as well, resulting in another scale, or by a faculty in the observers to just judge ">" without using neither differences nor ratios. In H. Eisler (1980) I showed a number of possible data-equivalent representations in another context.

In direct scaling methods (hopefully resulting in ratio scales) one might argue whether the acceptance of an observer's behavior at face value should be considered as a contribution of the observer. There are a number of—as to my knowledge—unsolved problems like are there biased judgments? If so, is the bias in the sensation or in the judgment, or is this a meaningless question?

Finally, are the observers really doing what they are supposed to do? I shall give examples of this not being the case in connection with time perception.

Retrospective considerations

Recently Dehaene (2003) claimed that "the Fechner-Weber-Stevens debate was never fully resolved". I found this statement distressing; not only does a wealth of empirical evidence show the ubiquitous power function relating subjective scales to their physical counterpart, but there is also at least one compelling theory. Let me remind that from the empirically obtained linearity between set ratios and standards a power function of the form $\Psi = \kappa(\Phi - \Phi_0)^{\beta}$ can be uniquely derived (H. Eisler, 1974). Note that the proof shows that only the *form of the function* (power function) is invariant.

One of the criticisms leveled against direct scaling is how the observer uses the number system. This shortcoming is obviated by means of the *parallel-clock model* for duration scaling using the method of reproduction (H. Eisler, 1975). The model constitutes also an example of disobedient observers. The observer is not using any memory where the standard duration is stored, in order to produce an equally long duration from this memory. No memory is involved; instead the observer monitors the subjective equivalents of the difference between the total duration (from the start of the standard) and the reproduction. When this difference equals the reproduction the observer experiences that the reproduction equals the standard. From the point of view of the researcher s/he is halving the total duration, which makes determination of the parameters β and Φ_0 possible. Furthermore, there is a particular twist to the psychophysical functions for duration**.** The psychophysical function for duration typically exhibits a break for most observers, which divides the function into two segments. These two segments differ by the values of either or both parameters κ and ϕ_0, whereas β□ is not influenced. The single break in the *psychophysical function* entails two breaks in the *raw data plot* (that is, three straight lines). The parallel-clock model imposes strong restrictions on the data: the two outer lines must be parallel, and the abscissa of the left break, has to have the same value as the ordinate of the right.

Just in passing: another example of the observers not doing what they are supposed to do is in a bisection experiment where the observers´ task is to classify durations as "short" or "long" according to two anchors. H. Eisler (1975, 1981a, 1981b) pointed out that the observers always judge two successive durations in the vein of reproduction, that is total time from the first duration until the end of the second, and the second duration. In the next judgment the second duration takes the place of the first and the new-presented duration becomes the second, and so on. This means that only two consecutive durations are judged; the observers neglect the anchors**.**

Context effects are often seen—not without a feeling of resignation—as lack of invariance. However, the values of parameters succeed very often to specify context effects. They might also allow a deeper insight into the perceptual processing mechanisms. To see them only as constants to be fitted implies throwing away possibly interesting information. In time perception I have often been dejected by that the result of some comparison or manipulation is given only as "A yields a significantly shorter duration than B" rather than specifying which parameter (β, κ, Φ_0) lies behind a difference (see H. Eisler et al., 2008). For instance decreases β for duration with loudness. Accordingly, using a parametrical description provides a valuable tool for psychophysical research in general, not only for time perception. An attempt at parametrization can we also find in Hellström's sensation weighting model (see H. Eisler et al., 2008).

Prospective considerations

Psychophysics has mostly been interested in the end product of a possible perceptual process, but there are theories that attempt(ed) to deal with what one could call the history of a percept. One example is the old German Aktualgenese, and another example the well-known random walk model developed by Link (1992).

The new and important approach in psychophysics is the application of nonlinear dynamics, that is, of “chaos theory” (see Gregson, 1988, 1992). Interestingly, the chaos theory was successfully applied in a study by H. Eisler, Eisler and Gregson (1995) in which an unexpected cusp was found when subjective width of rectangles was plotted against physical shape (see also H. Eisler, 1965).

Recent research literature shows that development and research activity in psychophysics focuses attention on neuropsychology. Evoked potentials have been used a long time, with high resolving power as to time but low in brain location. PET and fMRI are high in location, but show poor resolving power as to time. I hope for a physiological method that combines high resolving power of both location and time simultaneously.

Also a recent discovery of number neurons (Dehaene, 2003; Nieder & Miller, 2003) promises fast advances in psychophysics.

Finally, I am inclined to interpret time perception as primarily governed by biological clocks. I want to wind up with a hypothesis (Thatcher & John, 1977), according to which time experience is built up from iterative passages through neural loops (not from neural oscillations). I expanded this hypothesis by stating that each new passage of the loop accumulates a new subjective time unit.

Furthermore, each passage through the loop takes more (physical) time, resulting in an exponent β for duration < 1 (an average is about .85, see H. Eisler, 1976). The break in the psychophysical function is interpreted as a "device" to maximize accuracy, like changing the range of a voltmeter from, say, 0 - 1 to, say 0 – 10 volts. This may be expressed differently (see Teghtsoonian, 1973) or in terms of gain control. The parameter describing this “device” is κ, which can be considered as a unit. The breaks mentioned are characterized by different κ values of the two segments.

As a future step towards the understanding of how the brain keeps time, the neurophysiological hypothesis of neural loops deserves attention (see A. D. Eisler & Eisler, 2009; A. D. Eisler, Eisler & Montgomery, 2004). Thus, it would be interesting to study the neurophysiological processes of timing mechanisms in general within the framework of the parallel-clock model (see H. Eisler et al., 2008).

Another interesting issue is that it seems that blind people respond to the same circadian rhythm as sighted people. It is argued that the reason is the social cues following time of day information (Pauley, 1981; see also A. D. Eisler, 2003). It would be interesting to study congenitally blind children´s subjective time in comparison with sighted children of the same age. Strategies such as these should provide valuable insight into the biological basis for the human sense of time, but also development in psychophysical research and experimental strategies.

Generally, these considerations and reflections may open a future path for study of time perception, but also for study of other perceptual continua.

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