Chapter 3

Assessing Duration Discrimination: Psychophysical Methods and Psychometric Function Analysis

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1 Introduction

An important aspect in timing and time perception research is investigating the ability to perceive and compare temporal intervals, that is, the study of duration discrimination (Bindra & Waksberg 1956; Grondin 2010; Matthews & Meck 2016). Just as in every perceptual domain, a central problem in this field is how the relation between physical stimulus input (e.g., a tone lasting for 500 ms) and the sensation evoked by this input (the perceived duration of this stimulus) can be quantified. The scientific study of this relation is called psychophysics (Fechner 1889; Gescheider 1997).

One fundamental issue in psychophysics is the measurement of the difference threshold (just noticeable difference, JND; difference limen, DL), or in other terms, discrimination sensitivity. It is often loosely defined as the minimal physical difference between two stimuli (e.g., a 500 ms vs. a 550 ms interval) that a participant can just notice. A second important concept in psychophysics concerns the magnitude of the sensation evoked by a given stimulus. Typically, this sensation magnitude is determined by identifying the physical magnitude of a stimulus that is judged to be equal to the magnitude of another stimulus defined as the standard stimulus. For example, one might pinpoint that an auditorily presented temporal interval must be 480 ms to appear as having the same duration as a visually presented standard interval of 500 ms duration. This point along the duration dimension is termed the point of subjective equality (PSE), and just as in the example above, it often does not correspond to the point of objective equality (POE), which indexes physical equality with the standard stimulus.

Although these definitions appear simple, the experimental determination of these indices of discrimination performance can be quite cumbersome. For example, PSE can be influenced by perceptual and decisional biases, and this may even depend on the specific procedures employed for data collection. For example, when a participant is asked to compare the duration of two
successively presented identical intervals, there may be a general tendency (i.e., bias) to judge the second presented duration as longer than the first presented one. Another major problem is that discrimination performance randomly fluctuates from moment to moment. For example, sometimes a given physical difference between two stimuli is perceived, while sometimes this difference is not perceived. To overcome such obstacles, 19th century researchers already invented various psychophysical tools for measuring discrimination performance, such as the method of constant stimuli (Hegelmaier 1852; Renz & Wolf 1856).

In this chapter, we review several of these tools and methods that are especially useful for measuring duration discrimination performance. Numerical examples are provided to illustrate these psychophysical procedures. In the first section, we introduce the standard psychometric function for comparative judgments and its associated parameters. We discuss various experimental paradigms, which are typically used to collect such data for assessing discrimination performance. In the second section, we present data collection and analysis methods based on equality judgments. For each type of judgment, we introduce several parametric and non-parametric procedures for computing indices of discrimination performance from these data, including exemplary Matlab scripts implementing these procedures (see book’s GitHub repository). In the final conclusion, we briefly review several advanced toolboxes available for assessing discrimination performance.

2 Comparative Judgments

Several of the experimental paradigms, which are typically employed in timing research, involve comparative judgments. Specifically, these judgments require that participants decide whether a given stimulus duration is longer or shorter than a certain target duration. For example, in the so-called reminder task, the participant receives two successive durations in each experimental trial. One of the two durations is the target duration that is kept constant across a block of trials. This duration is traditionally called the standard or reference duration $s$ (Guilford 1954; Woodworth & Schlosberg 1954). The other duration varies randomly from trial to trial and is usually called the comparison or test duration $c$.

In most experiments, several different comparison durations are used, some larger than $s$ and some smaller than $s$. Typically, between 6 and 12 different values of $c$ are arranged symmetrically around $s$. It is convenient to index these