Our time sense between two successive intervals depends on which interval is held constant

How sharp is our sense of time? This is often investigated in terms of the smallest difference in the duration of two time intervals that can be detected with a given accuracy, usually 75%. This difference threshold is often determined by presenting two successive intervals, holding one of them constant (the standard interval, St), varying the other (the comparison interval, Co), and having observers report which interval seemed the longer.

Perhaps surprisingly, the difference threshold depends in two ways on the presentation order of St and Co, that is, whether the first interval is held constant and the second is varied, or vice versa. Firstly, there is a time-order error: For the two intervals to appear equally long, there has to be a slight duration difference – often in favor of the first interval – between them. Secondly, the relative positions of St and Co in the pair determine the impact a change in Co has on the observer's tendency to report it as longer than St. This is the standard-position effect. Due to these two effects, a given difference between St and Co yields different degrees of accuracy depending on their order of presentation. These effects are observed also for other types of stimuli, and must be taken into account in assessing stimulus discriminability.

Here, we studied duration comparison across interval types and standard durations, using the sensation-weighting model to describe and interpret the results. This model says that stimulus comparison does not mean simply subtracting one magnitude from another and reporting the outcome. Instead the experienced difference between two stimuli is the difference between two compounds, one for each stimulus, where the sensation magnitudes of the stimulus and of a so-called reference level are weighted together. This usually makes the two stimuli differently important for the response, and causes the standard-position effect and the time-order error. Often, the first-presented stimulus gets the smaller weight, which is thought to be an adequate adaptation to some of its information being lost from memory.

In our first experiment, we used four types of time intervals: auditory (filled with a 1000-Hz tone or empty, bounded by click sounds) or visual (red LED, filled, i.e., continuous, or empty, bounded by brief flashes). For each interval type, two presentation orders (St–Co, Co–St) and two standard durations (100 ms, 1,000 ms) were used. Between the compared intervals was an empty interval of 900 ms. The standard-position effects were mostly negative (i.e., smaller difference thresholds for the order St–Co than for Co–St), indicating that the second interval was of greater importance for the response than the first. However, exceptions to this were the filled-auditory and empty-visual 100-ms standards, for which opposite effects were obtained, indicating a greater importance of the first interval than of the second. In our second experiment, we used filled auditory intervals, with four standards between 100 and 1,000 ms. Standard-position effects were negative for standards of 100 and 1,000 ms, but positive for 215 and 464 ms.

Our main finding is that depending on the interval type and the standard duration, standard-position effects occur that can go in either direction. These effects reflect a flexible relative stimulus weighting, which seems to be due to an adaptation to stimulus conditions, aimed at maximizing sensitivity to informative changes in the stimuli. Our results shed some light on how our information-gathering system works, and also highlight the fact that measuring our ability to detect stimulus differences is not as straightforward as might be thought.

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Publication

Time-order errors and standard-position effects in duration discrimination: An experimental study and an analysis by the sensation-weighting model.
Hellström Å, Rammsayer TH.
Atten Percept Psychophys. 2015 Oct