Abstract

Investigating the Pacemaker Component of the Human Timing System

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Humans have a remarkably accurate perception of time, where two durations can be discriminated which differ by a hundredth of a second. Despite this sensitivity, many non-temporal characteristics of stimuli can affect perceptions of their duration. For example, the modality that an interval is presented in can affect duration judgements, where sounds are judged longer than lights of the same physical duration (the modality difference). In addition, an interval presented as a continuous stimulus, such as a tone, will generally be perceived as longer than a period of silence delineated by two beeps (the filled-duration illusion). Furthermore, an interval preceded by a short burst of click sounds (a click train) will be perceived as longer than the same interval preceded by a period of silence.

A dominant theory in the timing field, Scalar Timing Theory, has been invoked to explain each of these effects. It has been suggested that the pacemaker of an internal clock ticks at a faster rate during the former than the latter conditions, leading to a greater number of ticks accumulated in a given interval of time. This leads to proportionately greater judgements of duration. Though this explanation has been applied widely, there are a number of implicit predictions and assumptions that remain to be tested. This thesis aims to investigate these assumptions through three closely linked objectives.

The first objective sought to test the suggestion that the pacemaker largely determines performance in estimation and temporal difference threshold tasks. However, performance did not correlate between tasks when intervals were presented as sounds, lights, or vibrations, though the classic modality effect was replicated. In addition, the modality in which a participant performed best in (perhaps indexing the condition of their fastest pacemaker rate) often differed between tasks. However, this was expected to be the same modality in each task, if estimates and thresholds are both driven by pacemaker rate. These tests were repeated using filled and empty intervals, which led to results similarly inconsistent with the pacemaker explanation.

The second objective questioned whether click trains, which affect temporal performance in several other timing tasks, would lead to significantly lower temporal difference thresholds. It was found that click trains did not affect thresholds, though it would have been logically consistent with the pacemaker explanation for them to have done so. A computational model of the threshold task was devised, which fully embodied Scalar Timing Theory. The model was used to simulate the effect of the filled-duration illusion and click trains on thresholds, and found that Scalar Timing Theory suggests click trains would lead to significantly lower thresholds in only around 10% of cases.

The third and final objective sought to investigate whether the effect of click trains on temporal estimates is due to an increase in physiological arousal. While click trains did not lead to the usual increase in estimates compared to silence, pupil dilation was found to significantly increase during this stimulation. In addition, heart rate change was found to correlate with participants' estimates. Though not a clear picture, there are suggestions that pacemaker rate may be linked to physiological arousal.

In sum, the pacemaker was found to reasonably account for several well-known effects in the timing literature, but researchers may wish to note that this model alone cannot wholly account for all effects, and several inconsistencies were uncovered.