Abstract for MODVIS 2018

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# The Channel Capacity of Visual Awareness

We know less than meets the eye. We often fail to notice salient information even when it is entirely visible in the field of view. Such failures of awareness result from attention to competing information. Limited capacity serves as an axiomatic correlate of visual attention, but often the content is not specified and the limits are not quantified.

Response time hazard rates for visual target detection have recently revealed and quantified a channel capacity for visual awareness, measurable in *bits/s*. Shannon's (1948) Fundamental Theorem states that any given communication channel has a maximum rate of transmission, imposed by the maximum rate of variation in its physical states. Accordingly, the brain mechanisms of conscious visual awareness may operate at similarly limited rates. Evidence for this idea was discovered by Lappin, Morse, & Seiffert (2016). Conscious detection of visual target motions was found to occur at a rate invariant with the rates of both visual input and response output. Moreover, the process of awareness operated in parallel with visual integration of motion signals, concurrently and independently.

A simple linear system described by a dimensionally balanced equation accounted for 98% of the variance in RT hazard rates in our first main experiment:

$$h(t) = V(t) \bullet B^{-1} \bullet C,$$

where $h(t)$ is the observed hazard rate (*bits/s*) at any time $t$ following stimulus onset; the temporal function $V(t)$ describes the time course of visual information produced by the target motion signal, $0 \leq V(t) \leq 1$; $B$ ($\geq 1$) quantifies the complexity of the background scenario, proportional to the number of independent objects demanding attention ($n$ = 1-12); and $C$ is the channel capacity parameter, in *bits/s*. The temporal growth of motion information, $V(t)$, and the number of visually monitored background objects, $B$, exerted mutually independent selective influence on the observed hazard rates, $h(t)$. Temporal variations in observed hazard rates reflect the temporal process of visual signal acquisition, $V(t)$; while factors $B$ and $C$ are time-invariant, scaling the maximum output rate for a given task environment. A single capacity parameter, $C \cong 25$ *bits/s*, was invariant with wide ranges of input workloads and output response times.

Recent experiments have extended the investigation to more predictable spatiotemporal patterns, to target information involving transient changes rather than temporally extended motions, and to more difficult target discrimination tasks. These experiments investigate the following hypotheses: (1) Visual *awareness* of information operates in parallel with sensory signal acquisition. (2) The rate of visual awareness is limited by a quantifiable channel capacity, measurable in *bits/s*, invariant with the rates of both input and output. (3) Questions: Does conscious awareness of input information operate prior to or concurrently with decisions that act on that information? Does awareness operate independently of decision processes?

This research illustrates the analytical power of several aspects of the *Systems Factorial Technology* developed by James Townsend and colleagues.