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Article (Accepted Version)

Dyson, Benjamin James (2017) Serial dependence in audition: fast, free and feature-less? Trends in Cognitive Sciences, 21 (11). pp. 819-820. ISSN 1364-6613

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Serial dependence in audition: Fast, free and feature-less?

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Keywords

Serial dependence

Auditory processing

Repetition effects

Event file theory

Predictive coding

In light of the recent forum paper on serial dependence in the visual domain [1], consideration is given to how the auditory system deals with sequential processing. A review of historic and contemporary literature shows potential differences in the expression of auditory and visual effects and remind us that while multiple modalities ultimately work together they may be tailored towards processing different properties of the environment.

The idea that the nature of sensory input, the resultant computations and eventual response required by a previous moment impacts on the processing of the present moment has a long lineage in experimental psychology. Historical observations regarding ‘repetition effects’ (e.g., [2]; see [3] for an interim review) were consolidated into Event File Theory [4] where stimulus, processing and response all leave echoes to influence future performance. Similar sentiments were also expressed in episodic memory accounts of cognitive performance [5] and embody much of what is current described in terms of serial dependence. Predictive coding accounts (e.g., [6]) arguably represent the next stage of serial dependence model by incorporating a Bayesian framework.

[1] provide an overview of the way in which visual information is integrated across multiple points in time: this can hinder in the case of proactive interference but can help in the case of perception (see [7] for a similarly double-edged discussion of the adaptive, and occasionally maladaptive, process of memory distortion). The integration of events across time is probably derived from the fact that our environment is relatively static in terms of the number and nature of objects within it (despite these objects modulating in space and time). In other words, our environmental history has taught us to expect continuity. To wit: “the recent visual past is typically a good predictor of the future” ([1], p. 494).

Although [1] acknowledge that these carry-over mechanisms might extend to other modalities, it is important to consider whether the same constraints identified in the visual literature are present elsewhere. Indeed, it is possible to argue that since audition is inherently temporal given the transitory nature of acoustic input (e.g., [8]), serial dependencies in audition should be much more robust. In particular, question marks hang over the necessity of attention, task-relevance and temporal lag on observing serial dependence effects in audition.

Mismatch negativity (MMN) is a neural component originating in primary auditory cortex, maximal approximately 200 ms after stimulus delivery, and functions as an automatic change detector for sound (see [9] for a review). Participants can be passively listening, asleep or foetal but will still generate MMN when there is a discrepancy between the incoming stimulus and what was expected based upon the previously presented stimuli. This mismatch takes an impressive number of forms, including single features, combinations (conjunctions) of features, or, the violation of rules abstracted from a set of stimuli that do not share common features (e.g., as the pitch of the tone rises, the loudness of the tone decreases). This is not to say that the processes of serial dependence cannot be influenced by attention, but strongly suggests that perceptual serial dependence is not contingent on attention in the auditory domain.

Behavioural data from the auditory domain also challenge the idea that serial dependency is only applied to aspects of the environment that have previously been attended. In a case where an auditory stimulus is categorized according to one task-relevant dimension but also varies on a second, task-irrelevant dimension, serial dependence on the irrelevant dimension is exhibited when the task-relevant dimension is kept consistent across consecutive trials

[10]. This reflects an across-trial mechanism similar to the within-trial mechanism described in Load Theory [11]. When perceptual demands are low (e.g., imperative feature is maintained) irrelevant aspects of the environment are more likely to be accommodated, where when perceptual demands are high (e.g., imperative feature is changed) irrelevant aspects of the environment are less likely to be accommodated. Finally, the observation of both auditory and visual inhibition of return [12], where previously activated locations are negatively weighted in favour of new locations following long rather than short delays between events, appear to contradict the idea put forward by [1] that delays increase the attraction between events, making computational mimicry more likely.

In summary, the notion of serial dependency is a fundamental and long-standing aspect of information processing. Differences in the way audition and vision reuse information from the past may be in part a function of the way in which the modalities are tailored towards temporal and spatial information.

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