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# Probing perceptual asynchrony

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A striking visual phenomenon, colour–motion asynchrony, suggests that different attributes of the same stimulus can appear to occur at different times. When a green pattern moving upwards and a red pattern moving downwards are alternated every 250 ms, a synchronous change in colour and direction is only reported if the direction change precedes the colour change by about 100 ms. This intriguing finding has been interpreted to indicate that conscious perception of motion requires a longer processing duration than colour, owing to temporal processing differences in the modules specialized for each of these attributes. From this, comes the suggestion that different visual attributes are processed asynchronously in time and perceived asynchronously without compensation.

A recent paper by Nishida and Johnston challenges this 'processing-delay hypoythesis' on theoretical and empirical grounds [1]. They show that the colour–motion asynchrony is only seen at high alternation frequencies, typically for stimulus changes once every 250 ms. They also show that perceptual asynchrony cannot be ascribed to a differential processing delay between colour and motion that only occurs at high alternation rates. Subjects were presented two stimuli: one above the other, which could be both colour, both motion, or one of each. Crucially, one of the two stimuli would rapidly alternate (in colour or motion) while the other stimulus would alternate at a single point in time. Subjects could accurately perceive the synchronicity of a single alternation with respect to a change in embedded in a rapidly alternating sequence. Perceptual asynchrony only occurred when the task was to compare colour and motion attributes, both of which were rapidly changing.

Nishida and Johnston also showed that the perceptual asynchrony effect, which could be as large as 100 ms, is not reflected in a difference in reaction time to respond to motion compared with colour. Subjects were equally fast whether they were detecting a target direction embedded in a sequence of rapidly alternating direction stimuli or a target colour embedded in a sequence of rapidly alternating colours. In addition, Nishida and Johnston showed that perceptual asynchrony is not consistent across tasks. They asked subjects either to synchronize a button press with the downward movement of an alternating sequence, or to follow the upward and downward motion by moving a computer mouse. Subjects were accurate only when using the mouse – button presses typically lagged the downward movement of the stimulus by about 100 ms.

These peculiarities of the colour–motion asynchrony effect caused Nishida and Johnston to question the processing-delay theory of perceptual asynchrony and to advance the idea of a 'time-marker' theory of temporal binding. They propose that a relative timing judgement about two attributes, requires each event to be temporally tagged for subsequent comparison. The relative temporal perception of two events sometimes depends upon the relationship between the time markers used to represent each event. A colour change, which can be measured at just two points in time, will be tagged as a 'transition' whereas a direction change, requiring measurement at three points in time, will be tagged as a 'turning point'. Nishida and Johnston argue that asynchrony effects arise because, at higher rates, it becomes difficult to link temporal markers of a different type (transitions vs turning points), leading to a faulty temporal correspondence between colour and motion. Nishida and Johnston used colour–motion and colour–luminance displays to show that perceptual asynchrony crucially depends upon the temporal characteristics of different attributes rather than the attributes per se. These findings strongly question the idea that colour–motion asynchrony can be ascribed to a processing delay in the neural system specialized for motion processing. Furthermore, they force us to consider temporal coding of events as distinct from the representational coding of these events.

1 Nishida, S. and Johnston, A. (2002) Marker correspondence, not processing latency, determines temporal binding of visual attributes. *Curr. Biol.* (in press)