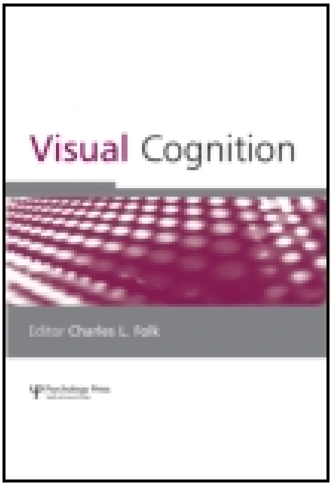

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A taxonomy of directional motion judgement based on informational content: Evidence from a deficit following bilateral parietal brain damage

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Hollingworth, A. (2007). Object-position binding in visual memory for natural scenes and object arrays. *Journal of Experimental Psychology: Human Perception and Performance*, *33*, 31–47. doi:10.1037/0096-1523.33.1.31

Orhan, A. E., & Jacobs, R. A. (2013). A probabilistic clustering theory of the organization of visual short-term memory. *Psychological Review*, *120*(2), 297–328. doi:10.1037/a0031541

A taxonomy of directional motion judgement based on informational content: Evidence from a deficit following bilateral parietal brain damage

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In the study of visual motion perception, two sets of distinctions play a central role. The first is between continuous (modal) and apparent (amodal) motion stimuli (Ramachandran & Anstis, 1986). The second is between lower- and higher-level motion systems that process different visual information (Battelli et al., 2001; Lu & Sperling, 1996).

There are important disagreements about the characterization of these systems. The first concerns the "high-level" (HL) system. It is widely accepted that observers can make directional change judgements by comparing an object's positions over time. But there is disagreement about whether these computations

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produce genuine motion percepts, or more segmented percepts. This is outside the current scope, and we refer to HL motion for simplicity.

The second disagreement concerns the information utilized by the lower-level (LL) system. Some have argued that this system depends only on motion energy (Lu & Sperling, 2001)—luminance change—whereas others argue that it depends on luminance counterchange, or a combination of the two (Hock, Schöner, & Gilroy, 2009).

Finally, an important question concerns the relationship between the two sets of distinctions. Does perception of continuous stimuli rely on the LL system, and the perception of apparent motion rely on the HL system?

We report the results from a patient case study addressing these latter two questions.

CASE HISTORY

JKI is a 51-year-old right-handed male. He suffered a stroke in 2003, resulting in extensive bilateral parietal damage. Broadly, JKI's deficits involve an inability to accurately report object locations in the left visual field (LVF), as well as symptoms consistent with simultanagnosia or extinction. His perception is largely intact in the RVF (Ma, Nino, Flombaum, & McCloskey, 2013). For current purposes, these deficits led us to expect directional judgement impairment in the LVF for stimuli that require a position comparison system, but not for stimuli that could activate an LL system via transients. We expected little or no deficit in the RVF.

APPARENT MOTION PERCEPTION

We tested with two kinds of stimuli (Figure 1a). In each sequence, four grey filled circles appeared successively, progressing horizontally. In addition to Standard Apparent Motion (SAM), in which each circle disappeared at the onset of the next, we presented a Stay-On (SO) condition, in which each circle remained in view while subsequent circles were presented. We varied the duration between onsets from 17 ms to 533 ms (with 13 durations). The logic is that via temporal summation, an LL system should produce stronger signals when briefer durations separate events. JKI reported the direction (left or right) of a sequence, and also whether his subjective percept involved "smooth" or "segmented" events.

Overall, JKI's directional judgements were nearly perfect in the RVF (SAM: 99.2%, SO: 99.4%). But in the LVF he showed significant impairment with longer stimulus durations (for both stimuli). To analyse these results statistically, we utilized his subjective reports in the RVF, identifying durations at which LL signals become weak. Specifically, he reported "smooth" motion perception over 90%

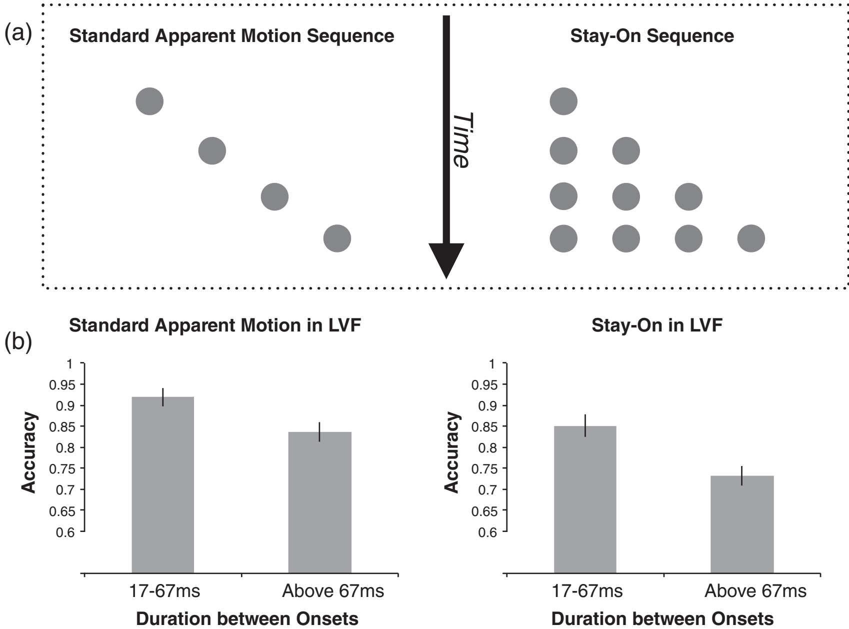

Figure 1. (a) Schematic depiction of stimulus sequence used in "Apparent Motion" experiments. (b) Directional judgement accuracy of patient JKI.

of the time for RVF stimuli with durations between 17 and 67 ms, after which he made increasing "segmented" reports. (A similar pattern obtained in the LVF.) His directional accuracy was unrelated to subjective reports (and close to perfect) in the RVF. In the LVF, we thus compared direction report accuracy for stimuli with durations below and including 67 ms and stimuli above (Figure 1b). He performed significantly better for the stimuli with brief durations (SAM $p = .033$; SO $p = .006$).

Further evidence of an intact LL system, and a dependence on that system for making accurate judgements obtained via significant correlations, in the LVF, between the likelihood that he made a correct judgement, and the likelihood that he reported that trial as subjectively "smooth". (Because of a pronounced bias to report rightward motion, the relevant statistic concerns the correlation for leftward motion, $p = .023$.) Thus, he was more accurate when a stimulus seemed to activate LL detectors, producing a smooth percept. These effects suggest that short duration amodal stimuli can be perceived accurately via a LL system, whereas longer duration stimuli require a HL comparative mechanism.

Finally, JKI's performance also suggests that the LL system relies on luminance counterchange. If JKI can only make accurate judgements via the LL system, then removing information utilized by this system should impair performance further. SO motion removes luminance counterchange while sparing directional luminance change. JKI performed significantly more poorly with SO motion than with SAM ($p < .001$), supporting a role for counterchange in the perception of motion.

SLOW CONTINUOUS MOTION

To further investigate JKI's HL impairment, we tested him with continuously moving stimuli, with interest specifically in slow motion. In this task, a grey circle moved a fixed distance of 1.39°. The speed at which it moved varied by trial; we utilized two fast speeds (1.95°/s and 0.97°/s), and four slow speeds (0.19°/s, 0.24°/s, 0.32°/s, and 0.49°/s). In the RVF, JKI's directional performance was nearly perfect (98.6%). In the LVF, he showed a speed-dependent impairment with a significant difference between the two fast and the four slow speeds (95.8% vs. 66.7%, $p < .01$). The fixed distance resulted in slow-moving stimuli that were present for longer durations. If a LL motion system prefers faster transients (for temporal signal summation), then this deficit can be understood by the failure of slow, continuously moving stimuli to activate that system. Slow continuous motion perception may rely on HL systems to make comparative position judgements.

CONCLUSION

JKI's pattern of impairment supports two conclusions. First, the severity of his impairment for stimuli without counterchange (SO) suggests that a counterchange detection system is capable of low-level detection (Hock et al., 2009). Second, the results suggest that modal/amodal or apparent/continuous may only be accurate descriptive terms at the level of the stimulus. Mechanistically, motion systems should be distinguished by their informational dependence on transients or establishing spatial relationships among segmented events.

REFERENCES

Battelli, L., Cavanagh, P., Intriligator, J., Tramo, M. J., Hénaff, M., Michèl, F., & Barton, J. S. (2001). Unilateral right parietal damage leads to bilateral deficit for high-level motion. *Neuron*, *32*, 985–995. doi:10.1016/S0896-6273(01)00536-0

Hock, H. S., Schöner, G., & Gilroy, L. (2009). A counterchange mechanism for the perception of motion. *Acta Psychologica*, *132*(1), 1–21. doi:10.1016/j.actpsy.2009.06.006

Lu, Z. L., & Sperling, G. (1996). Three systems for visual motion perception. *Current Directions in Psychological Science*, *5*(2), 44–53. doi:10.1111/1467-8721.ep10772720

Lu, Z. L., & Sperling, G. (2001). Three-systems theory of human visual motion perception: Review and update. *Journal of the Optical Society of America*, *18A*(9), 2331–2370.

Ma, Z., Niño, J., Flombaum, J., & McCloskey, M. (2013, May). *Shared mechanisms for representing the sides of the visual world and the sides of objects: Evidence from a localization deficit*

following parietal brain damage. Paper presented at the annual meeting of the Vision Sciences Society, Naples, FL.
Ramachandran, V. S., & Anstis, S. M. (1986). The perception of apparent motion. *Scientific American*, *254*(6), 102–109. doi:10.1038/scientificamerican0686-102

The relationship between saccade velocity, fixation duration, and salience in category learning

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Information in our visual environment enters the processing stream through a series of fixations punctuated by saccades. Patterns of a participant's eye movements can indicate his or her perceived salience of parts of the environment, or the endogenous priority to attend certain elements of the visual space. Previous work has shown interesting interactions between low-level visual attention, and higher-level processing. For example, research has shown that that fixation latencies to task relevant items are be longer than fixations to irrelevant parts of the environment (Blair, Watson, Walshe, & Maj, 2009), and reports from van Zoest and colleagues (van Zoest, Donk, & Theeuwes, 2004; van Zoest, Hunt, & Kingstone, 2010) indicate that saccades under conscious control are slower than those that are automatically deployed. In this study, we measured the influence of salient distractors on eye movements during learning in a category learning task (measured by fixation durations and saccade speeds), thus exploring the influence of salience and task knowledge in parallel.

The category learning task was relatively complex in that it required the participant to learn which features were important in predicting category membership, how to combine the features to make a correct category decision, and how to optimize their time and energy by making fixations only to information that informed their category decision. To this end, we explore how

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