Attention is fast but volition is slow

A random scan is a quicker way to find items in a display than a systematic search.

How swiftly can the object of your attention be changed? Consider two ways to deploy attention: it can be commanded from place to place by a deliberate act of will, or it can run freely without specific instruction. Here we use a visual search task to show that deliberate movement of attention is significantly slower because of an internal limit on the speed of volitional commands.

Extensive research on visual search tasks such as finding the letter F in Fig. 1a has revealed that stimuli of this sort can be searched at a rate equivalent to one letter every 25–50 ms (ref. 1). The order of search, even of eye movements, is influenced by stimulus salience and eccentricity, but is otherwise random through the set of salient loci[2]. Why is there sparse evidence for systematic scanning of search displays? We argue that searching is free-running ('anarchic') because commanded, ordered deployment of attention is so much slower than anarchic deployment that it is faster overall to make many anarchic attentional deployments than fewer orderly ones.

In our 'command' condition, observers knew in advance where and when their attention needed to go. The 12 observers viewed each of 8 frames like those shown in Fig. 1a–d for 53 ms, followed by a mask which varied in duration from trial to trial. One target, a letter Y or N, was present on each trial. This target could appear only at position 1 (12 o'clock) on frame 1, position 2 on frame 2, and so on. If an observer deployed attention at the correct rate around the circle, attention would be on the target when it appeared (position 4 in Fig. 1d), otherwise the task was impossible. Observers were trained to move attention clockwise in time to a spatially uninformative tone. A 'staircase' procedure was used to measure the maximum speed that permitted 70% correct performance; software constraints limited the maximum rate to 80 ms per frame.

For comparison, observers were tested in a 'random anarchy' condition. Here, the Y or N was present on all frames but moved among three locations (different on each trial) between frames. Attention freely sampled the display at random. Randomization thwarted any parallel accumulation of information and prevented observers from attending to a single location and waiting for the target to arrive[3]. We asked observers to fixate; the letters were large enough to read without fixation and, critically, the stimulus configuration was the same in the 'random anarchy' and 'command' conditions. Any eye movement or other perceptual limitations in the 'command' condition would also apply to 'random anarchy'.

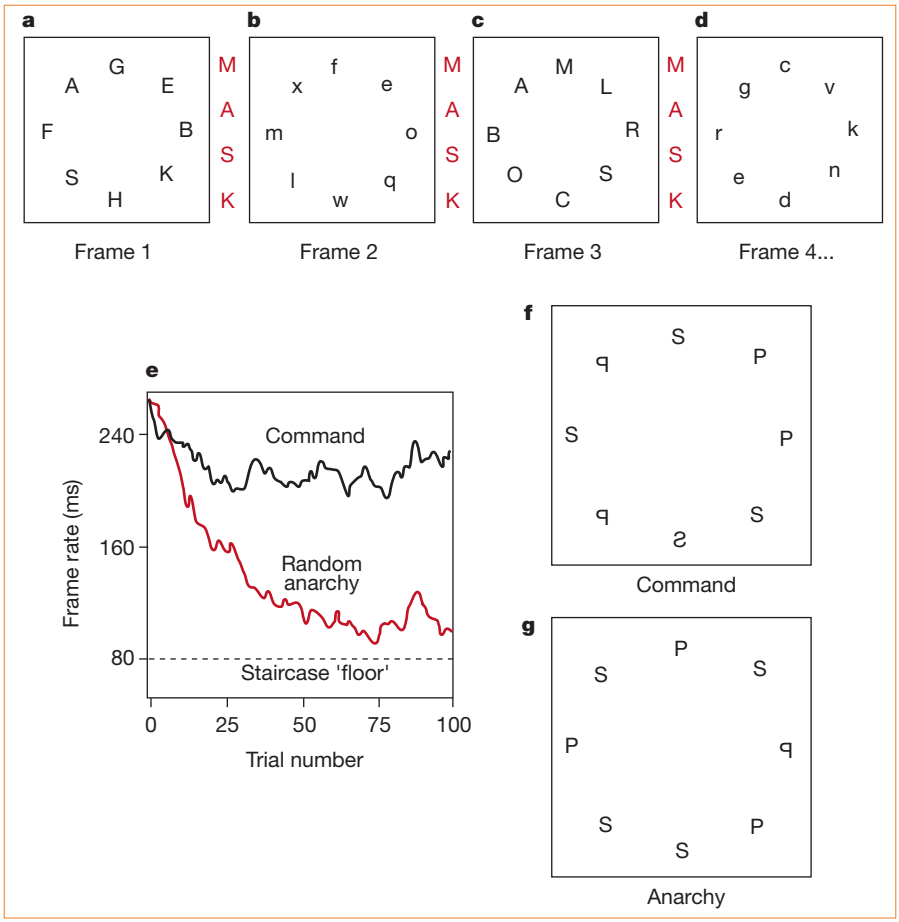

Figure 1 'Commanded' search is slower than 'anarchic' search. **a–d,** Four of eight frames in a 'command' condition trial. A 'Y' or 'N' can appear only at position *N* on frame *N* (position 1 corresponds to 12 o'clock). Here the target is in frame 4. Masks separate the frames. 'Random anarchy' uses the same stimuli, with a Y or N present in a random location on each frame. **e,** Staircase test results show that 'command' is much slower than anarchic deployment of attention. **f,** A static 'command' paradigm: search clockwise from the top to identify the first mirror-reversed letter. **g,** Static 'anarchy': find the only mirror-reversed letter. Again, commanded deployments are much slower than anarchic ones.

A control experiment with static letters confirmed that these stimuli are searched at a standard rate of 41 ms per item. The average minimum 'commanded' rate was 217 ms per frame, or 217 ms per item. 'Random anarchy' produced a 105 ms per frame rate, or 105–187 ms per item, depending on assumptions about visual search (Fig. 1e). This is conservative because of the 80-ms-per-frame limit. Other 'anarchy' conditions without this constraint yielded estimates of between 13 and 44 ms per item. Three other 'command' conditions yielded maximum rates of 206, 345 and 195 ms per item (Fig. 1f, g shows an alternative method).

Our measures of 'commanded' attention are therefore slower by up to an order of magnitude than any of our measures of anarchic attention. Our results indicate that visual attention may be deployed quickly and automatically by the salience of stimuli. Deliberate, volitional shifts of attention, however, can only be executed much more slowly, explaining why observers instinctively search unsystematically. Anarchy is faster than order in this case.

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