Preliminary findings on some effects of very fast sequential input rates on perception

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A study was made of the effects of presenting to the visual system a string of very fast sequential inputs, employing a computer-based CRT display system. The results showed that for either 5 or 10 inputs (i.e., all Xs, random letters, letters forming a word, or small line segments) approximately the first half of these sequentially presented inputs were not perceived, if display order was irregular and display input rate was fixed at certain values between clear simultaneity and clear sequentiality.

This report presents preliminary qualitative findings on some effects on perception that occur when the visual system is presented with a string of very fast sequential inputs. This problem has received little attention. However, some work has been done very recently by Bliss, Crane, Link, & Townsend (1966) with the tactual system, and by Bruner (1966), Fraisse (1966), Julesz (1964), McFarland (1965), and White (1963) with the visual system.

Method

Since it was desired to present a string of inputs, five or 10 elements long, sequentially at a very rapid rate, a computer-based CRT display system was employed. This system consists of a PDP-7 digital computer coupled to two CRT display consoles. Input sequences were programmed for display on a Master (Type 340) CRT and also appeared on a Fairchild slave display. This method was necessary since the 340 CRT is equipped with a P7 phosphor with a very long decay time, while the P24 phosphor of the Fairchild slave display has a decay time on the order of a few microseconds.

Several five and 10 letter sequences, as well as a 10 element sequence consisting of 10 dashes or line segments, were selected for presentation on the Fairchild display. These input sequences displayed each successive letter or element in adjacent spatial positions on the display. The input sequences and input display orders that were examined are given in Table 1. Two types of orders, regular and irregular, were employed. With the regular orders the display sequence was always progressive from left to right or right to left (i.e., 1-5, 5-1, 1-10, or 10-1), while with the irregular orders the display sequence jumped irregularly from element to element (e.g., with the sequence "chair" and the order 42513, "i" was displayed first, but in the fourth position, "h" was displayed second, but in the second position, "r" was displayed third, but in the fifth position, etc.).

At the shortest exposure time examined for five element sequences, each element and each interval between elements was fixed at approximately 200 microseconds. For 10 element sequences, the equivalent time was 300 microseconds. A total of 1800 or 5700 microseconds were required to display the entire five or 10 element sequences, at the shortest exposure time, which we shall call one display cycle, and increases in exposure time shall be referenced to number of display cycles; thus, two display cycles equal 3.6 and 11.4 msec. or 400 and 600 microseconds per element and per interval, etc. The 200 and 300 microsecond values are approximate, since execution of program instructions rather than computer clock time was employed to set exposure time. Variations about these mean values are small, probably not exceeding 50 microseconds.

Since little previous work was available to provide guidelines for the present study, a phenomenological and qualitative approach was adopted. Two observers watched all of the sequences given in Table 1, starting at one display cycle and proceding upward in steps of two display cycles to 150 display cycles and an additional 18 observers watched most sequences over various portions of the range from one to several hundred display cycles.

Results and Discussion

All observers reported the following observations: (1) With both the five and 10 element sequences presented in either regular or irregular orders, at one display cycle up to about four display cycles, all elements are perceived clearly as occurring simultaneously. (2) At approximately 25 to 50 display cycles the major and most striking finding of the study appears. At this rate, all elements are perceived for all regular orders with a strong and very rapid flow of movement from left to right (1-5 and 1-10) or right to left (5-1

Table 1. Input Sequences and Input Orders Employed in the Study

Orders	Sequences XXXXX	JBXDF	CHAIR	BEACH
Regular	1-5 5-1	1-5 5-1	1-5 5-1	1-5 5-1
Irregular	42513 31254 14352	42513	42513 31254 14352	25143
	XXXXXXXXXX	SOMERSAULT		---------
Regular	1-10 10-1	1-10 10-1		1-10
Irregular	69210158374 75921104386 24681097531	69210158374 75921104386 24681097531 10864213579		75921104386 24681097531

and 10-1), but for all irregular orders an entirely unexpected event begins to occur. For all irregular orders, except 24681097531 and 10864213579 which will be discussed later, the first element presented in the sequence disappears from the display followed shortly, as the number of display cycles is increased slightly further, by the second element presented, so that, for example, "chair" appears c-a-r with the order 42513 (dashes in the sequence indicate the position of the letters that were not perceived) and "chair" appears as c--ir with the order 31254, or the sequence "xxxxx" appears as -xxx- with the order 14352, etc. With the 10 element sequence 69210158374, the first, second, and third elements disappear so that, for example, "somersault" appears as so-e-sa-lt, and with the 10 element sequence 75921104386, the first, second, third, fourth, and fifth elements disappear so that "somersault" appears as s-m--s--lt, or the 10 dash sequence appears as -a-aa-aa--, "a" referring to those positions in the sequence where dashes were absent, i.e., where no dashes or line segments were perceived. In sharp contrast, with the 10 element sequence 24681097531 or 10864213579, no elements disappear over the entire range of display cycles examined even though extensive jumping from element to element is present. What is perceived, after the simultaneity stage, is a flow of simultaneous movement inward from both ends of the sequence towards the middle with the order 24681097531 or the reverse, a flow of simultaneous movement outward from the center to the two ends with the order 10864213579, and this effect persists until a value of approximately 140 display cycles (i.e., almost 800 msec.) has been reached, when perception of the jumps from one side of the sequence to the other begins to appear. (3) Finally, with those irregular orders in which elements disappear from the display, as the number of display cycles is increased still higher all the elements are again perceived, occurring in an easily detected sequential order. It should be noted that these effects are apparently so strong that they occur under the following variations in conditions which were examined: (1) observed at a few inches from the display or a few feet, (2) observed head-on or from the side, (3) with letters 1/4 in. high up to 1 in. high, and (4) room illumination normal or relatively dark. Only if an observer fixates directly on the location of a missing element and so tunnels his vision as to exclude almost all other elements can a missing element be detected.

In brief, the findings suggest that with certain irregular orders of presentation and certain display input rates considerable "blanking" or masking of items presented early in the sequence will occur. As to the underlying mechanism producing such sequential blanking a number of possibilities might be considered. For example, metacontrast (Raab, 1963) should be examined as a possible explanation, since in many of the display orders examined those elements that are not perceived are followed temporally and enclosed spatially by later elements which might provide the conditions necessary for metacontrast to operate. However, with the sequence "xxxxx" and the order 14352, the perception is -xxx- and here the first and last elements are not enclosed spatially by later items and yet they are not perceived. Also, with the 10 dash sequence and the order 75921104386, the first five of the 10 dashes presented are not perceived, and it is difficult to assume that the very slight contour interference which might occur at the boundaries of these dashes or line segments could produce such large masking effects. Also, with the sequence "somersault" and the display order 10864213579, all letters are clearly perceived and yet the first letter presented (i.e., the second "s") is followed temporally and enclosed spatially by the second and third letters presented (i.e., "r" and "a"), which in turn are followed temporally and enclosed spatially by the fourth and fifth letters presented (i.e., "e" and "u"); conditions it would seem which should produce maximum metacontrast, and yet none occurs.

The appearance of simultaneous movement from the center out with the display order 10864213579 or from the ends in with the display order 24681097531 suggests that display orders having a spatial-temporal organization resulting in coherent movement "gradients" (all regular display orders, such as, 1-5, 5-1, 1-10, 10-1, etc., would have such properties) may provide the conditions necessary for all sequence elements to be perceived. In contrast, display orders that do not allow for such spatial-temporal organization of coherent movement gradients may result in sequential "blanking" of those sequence elements that do not fall along such movement gradients.

References

Bliss, J. C., Crane, H. D., Link, S. W., & Townsend, J. T. Tactile perception of sequentially presented spatial patterns. *Percept. & Psychophys.*, 1966, 1, 125-130.

Bruner, J. S. Personal communication, 1966.

Fraisse, P. Visual perceptive simultaneity and masking of letters successively presented. *Percept. & Psychophys.*, 1966, 1, 285-287.

Julesz, B. Some recent studies in vision relevant to form perception. *Bell Tel. Lab. Rep.*, 1964.

McFarland, J. H. Sequential part presentation: A method of studying visual form perception. *Brit. J. Psychol.*, 1965, 56, 439-446.

Raab, D. H. Backward masking. *Psychol. Bull.*, 1963, 60, 118-129.

White, C. T. Temporal numerosity and the psychological unit of duration. *Psychol. Monogr.*, 1963, 77, No. 12, 1-37.