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Notes and Comment

Processing differences between memory search and foveal visual search

MARTIN GAGNON, PATRICK CAVANAGH,
and LOUIS LAURENCELLE
Université de Montréal, Montréal, Quebéc, Canada

Recently, Chiang and Atkinson (1976) investigated individual differences and the interrelationships in performance between memory search and visual search. Both tasks involve encoding and comparison processes: it is likely that in memory search the slope of the reaction time (RT) vs. list length function reflects at least the comparison processes, while in visual search the slope may be related to both encoding and comparison processes. Comparing the observed slopes across individual subjects, Chiang and Atkinson found no differences between the slope for memory search (MSLOPE) and that for visual search (VSLOPE); the same was true for the intercepts of the RT functions in the two tasks. Moreover, MSLOPE and VSLOPE were significantly correlated and the regression coefficient of their relation was close to one.

Given the high degree of similarity between the results in the two tasks, Chiang and Atkinson concluded (p. 668, paragraph 3) that it was possible that the same comparison process subserves the recognition response in both. In the present note, we report a similar study in which the two tasks were compared across different types of stimuli. Our results indicate that the similarities seen between the two tasks may be limited to certain experimental conditions and that, under other conditions, significant processing differences are apparent.

As an index of the similarities of the processes reflected by the slopes of the two tasks, we analyzed the relationship between their slopes for both positive and negative responses (averaged over subjects) across three types of stimuli: numbers, letters, and symbols. If the same comparison process is involved in both tasks, we would expect, at first glance, that the regression coefficient between the two slope measures would be close to one. If, in the visual search task, the slope also reflects encoding processes and the encoding processes are influenced by stimulus type in the same manner as the comparison process, we would then expect the regression coefficient mapping MSLOPE onto VSLOPE to be greater than one. On the other hand, if the encoding processes represented in the slope of the visual search task data are not influenced by stimulus material, the regression equation mapping MSLOPE onto VSLOPE should have a coefficient of one but an intercept significantly greater than zero.

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METHOD

Four male graduate students at the Université de Montréal served as subjects. For their participation, they were paid $36 each plus $1 bonus for each session with less than 10 errors or too long RTs.

The experiment involved: (1) two tasks-a memory search task in which the presentation of a memory target list of varying size was followed by a memory test, and a visual search task where the presentation of a visual target was followed by a visual test list of varying size; (2) three types of stimuli used in both tasks—letters, digits, and simple symbols; (3) three list sizes—two, three, or four elements of one stimulus type; and (4) two types of responses—positive or negative.

Each subject was submitted to two sessions for each of the six possible combinations of task and stimuli, in a random order. The schedule required four sessions a day for 3 consecutive days, with at least 1 h between each session (about 15 min for each session). One day before the experimental sessions began, a practice session was presented which included the six possible combinations.

Each experimental session began with 20 practice trials, followed by 216 randomized test trials with a 30-sec rest in the middle of the session. The following restrictions were imposed on the 216 test trials: (1) positive and negative trials were to occur equally often, (2) each list length was to occur equally often within each response, and (3) on positive trials, the memory test (or visual target) was to appear equally often at each serial position for a given list length.

The stimuli sets were: letters, F, G, H, L, M, Q, R, T; digits, 2 through 9; and symbols, +, =, ∼, >, ⌐, ↑, Ψ, ∩. Test and target stimuli were presented horizontally on a CRT with two end delimiters (the same height as the stimuli which were presented simultaneously when more than one was presented). A maximum visual angle of 3.20° (including the delimiters) was subtended by the display: each element subtended .43°, and the center-to-center spacing was .64° of visual angle.

Each trial proceeded as follows. (1) Presentation of the target or target list for a duration determined by the subject. (2) After a 250-msec delay, the test or test list was presented for 200 msec. From the beginning of the test presentation, the subject had 1,200 msec to give his response. (3) Immediately after the response (or the 1,200-msec time limit), a feedback was given on the CRT for 500 msec: (a) TROP LONG, (b) MAUVAISE REPONSE, or (c) OK with the response time. (4) The next trial followed immediately.

After each session, the experimenter told the subject how many errors he had made, whether he had won a bonus, and his mean RT. If the subject had more than 15% errors (32 wrong responses or too long RTs), he repeated the same session; if two repetitions were required in the 12 sessions, the subject was rejected (no subjects failed more than one session). A DEC PDP-12 controlled the experiment while the subject sat in an adjacent room.

RESULTS AND DISCUSSION

The medians for negative responses and the means of the medians of each serial position for positive responses were used for the data analysis. Only correct responses were analyzed: errors and too long RTs (over 1,200 msec) represented 4.78% of all trials. Each of the subjects repeated one session.

The combination of the two tasks, three types of stimuli and two types of responses produced 12 different RT functions. All the sums of squares associated with list size were combined for an analysis of the linearity of these 12 functions. Each of the linear components was significant [$F(1,36)$, all significant to $p < .01$], while none of the residual components reached a significance level exceeding $p < .10$. Figure 1 shows the relation between the two tasks, for positive and negative slopes across three types of stimuli. The correlation coefficient is .922 [$t(4) = 4.71$, $p < .01$] and the regression equation is VSLOPE = 13 + .51 MSLOPE. The intercept is greater than zero [$t(4) = 2.92$, $p < .025$] and the regression coefficient is both greater than zero [$t(4) = 4.71$, $p < .01$] and less than one [$t(4) = -4.53$, $p < .01$].

The significant correlation between the memory search and visual search slopes point to some similarity in the processes influenced by list length in both tasks. Furthermore, as indicated by the nonzero intercept of the regression equation, some component of the slope-related processes in the visual search task appears to be independent of the variations of the memory search slope. This suggests that at least two processes are reflected in the visual search slope: one that covaries with the slope-related processes in the memory task and one that does not. Assuming that these two processes are, respectively, comparison and encoding, the observation that the regression coefficient in Figure 1 is less than unity indicates that the effect of list length on comparison stage duration does not arise from the same process in both tasks.

The simplest interpretation of our data therefore reveals two major differences between the tasks: first that the visual search slope reflects a significant encoding component (13 msec/item, the intercept of Figure 1) that is, of course, not present in the memory search slope; and, second, that the variation of comparison stage duration with list length must have *different sources* in the two tasks. These different sources might be, for example, retrieval of list elements from a sensory buffer in visual search vs. retrieval of a short-term memory buffer in memory search. A variety of other interpretations of the roles of encoding and comparison processes in the relationship seen in Figure 1 are possible; however, none of these appears to support the hypothesis that a common comparison stage component is the source of the RT slopes in both tasks.

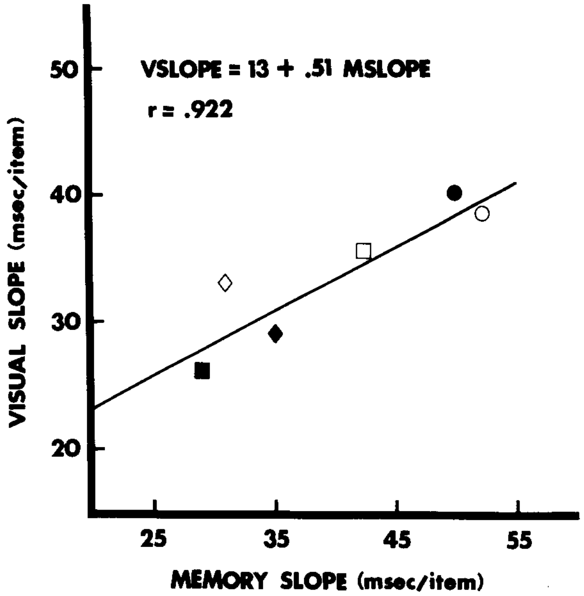

Figure 1. Visual search slopes as a function of memory search slopes: positive slopes in white, negative slopes in black; symbols, letters, and digits are represented, respectively, by circles, squares, and diamonds.

One exception is the possibility that the short delay between the offset of the target and the onset of the test (250 msec in our experiment vs. 2,000 msec in Chiang and Atkinson study) would differentially affect the memory representations of the target item or items in the two tasks, and would therefore also differentially affect the duration of comparisons. Available evidence concerning the effect of delay on memory and visual search slopes is, however, inconclusive. The RT slopes that we have calculated for experimental conditions equivalent to the visual search task in a study by Connor (1972) increase with delay in one of her experiments but decrease in the other. The RT slopes for conditions equivalent to the memory search task are greatest at short delays in both of her experiments, but the presentation time for the entire target list was only 200 msec. With such a limited exposure followed by a short delay, target list processing probably continues after the presentation of the test item, artificially increasing the RT slope. Clifton and Birenbaum (1970), using sequential list presentation, found no effect of delay on memory search slope.

A number of studies permit a comparison of visual and memory search rates, in particular those using, as did Connor (1972), all combinations of target and test list lengths (see Table 1). The RT slopes of the data for the conditions equivalent to the memory and visual search tasks (i.e., a single test item or a single target item, respectively) for all of these studies are

Table 1
Visual and Memory Search Rates and Experimental Conditions from Studies Using These Tasks or the Equivalent

Study	Materials	Delay	Slope: Memory* Positive	Slope: Memory* Negative	Slope: Visual* Positive	Slope: Visual* Negative
Briggs and Blaha (1969)	Random Figures	Fixed Set	31.0	34.0	39.6	59.0
Briggs and Johnsen (1973)	Letters	Fixed Set	28.3	35.0	18.0	31.3
Chase and Posner (Note 1)	Letters	2,000 msec	53.0**	53.0	37.0**	37.0
Connor (1972)	Letters	150, 500, and 2,000 msec	†	61.0	†	50.0
Nickerson (1966)	Letters	2,000 msec	76.4	66.4	65.8	60.4
Scarborough and Scarborough (1975)	Letters	2,000 msec	92.8	69.2	52.8	48.9
Schneider and Schiffrin (1977)	Letters or Digits	820 msec	35.1	54.5	9.0	12.1
Sternberg (Note 2)	Digits	4,000 msec	36.9	37.2	37.3	41.9

**Milliseconds per item. **Positive and negative slopes did not differ significantly and were not reported separately.*
†No positive response data presented.

presented in Table 1 along with various experimental parameters.

Data for conditions involving acoustic or visual confusion manipulations (Connor, 1972; Chase & Posner, Note 1), negative set items of a different category (e.g., digits vs. letters, Schneider & Schiffrin, 1977), or upper- and lowercase manipulations (Scarborough & Scarborough, 1975) were excluded. Despite the wide variation of experimental procedures, the calculated memory search and visual search slopes appear to be related [$r = .538$, $t(13) = 2.30$, $p < .05$]. The regression equation is VSLOPE = 16 + .48 MSLOPE; the regression coefficient is greater than zero [$t(13) = 2.30$, $p < .05$] and less than one [$t(13) = -2.50$, $p < .05$]; the visual search slopes are smaller than the memory search slopes [$t(14) = 2.40$, $p < .05$], but the intercept of the regression equation is not different from zero [$t(13) = 1.38$].

These data appear quite similar to those of the experiment we have reported here. An inspection of the effect of delay on the difference between the slopes in the two tasks in Table 1 does seem to suggest that the shorter the delay, the greater the differences between the slopes. However, as mentioned previously, no consistent effect of delay on slope is seen under controlled conditions (Clifton & Birenbaum, 1970; Connor, 1972).

A more direct explanation of the difference between the Chiang and Atkinson results and our own is possible. Their study measures slope variations across subjects; subject-to-subject changes in the slopes of the tasks may be very similar because *all* slope related factors are varying equally from one subject to the next. Manipulating materials (Figure 1) or experimental conditions (Table 1), on the other hand, appears to affect some slope-related factors but not others. Most significantly, it appears to show that different processes are responsible for the comparison stage contribution to the RT slope as a function of list length in memory search and visual search tasks. We are currently conducting more extensive studies to investigate these possibilities.

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