stable pollutants (*5*) could alter natural algal communities by suppressing sensitive species and permitting pollutant-resistant forms to become dominant. Polychlorinated biphenyls and DDT can occur in natural waters at concentrations comparable to those that altered the species ratios in our experiments, although concentrations found in nature are generally lower (*6*). Exposure to organochlorine compounds is probably greater than the concentrations in natural waters would indicate, however, because these substances are rapidly absorbed from water by organisms, including phytoplankters (*1*). In eutrophic environments, alterations of algal communities could further reduce an already decreased species diversity (*7*), aggravating problems of algal blooms and contributing to the general degradation of the ecosystem (*8*).

Many zooplankters graze selectively, often choosing their food on the basis of size or shape (*9, 10*). The dietary requirements of herbivores are not satisfied by all algal species, as indicated by the growth rates of oyster and clam larvae (*11*), the viability of barnacle nauplii (*10*), and reproduction in copepods (*12*). Hence, altering the species composition of a phytoplankton community could profoundly affect the health, distribution, and abundance of many animal populations higher in the food web (*8, 10, 11*).

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20 December 1971

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Information-Processing by Pigeons

Abstract. *Two pigeons matched to sample on the basis of color or line orientation when a sample consisted of a value for each stimulus dimension or a value for only one dimension. When the duration of the sample stimulus was varied to maintain constant performance, compound stimuli required more time than single elements.*

Most studies of stimulus analysis in animals impose focused-attention tasks which require the subject to attend to a specific stimulus feature (*1*). An alternative approach, adopted by Blough (*2*) and common in the literature of human information-processing, is to require the subject to divide his attention among a number of stimulus features. Lindsay (*3*) has demonstrated that in a divided-attention task stimulus duration is a critical determinant of performance. Despite suggestions (*4*) that stimulus duration may be a powerful variable in stimulus selection by animals, it has not been systematically examined. Using a psychophysical technique to measure the minimum stimulus duration necessary to maintain a constant performance level, we found that stimulus duration was longer under conditions of divided attention than of nondivided attention.

Two white Carneaux pigeons were maintained at approximately 85 percent of their free-feeding weights. Both were trained to match to sample in an operant conditioning chamber. The chamber was equipped with three Lehigh Valley pigeon keys, horizontally aligned on the front panel. Each was backed by an Industrial Electronics Engineers in-line stimulus projector. The food hopper was located directly beneath the center key. The chamber was located in a room in which sound was attenuated, and further sound attenuation and ventilation were provided by an air blower system. A PDP-8/L computer (Digital Equipment Corporation) controlled stimulus presentations and reinforcements, conducted on-line analysis, and reported data on a teletypewriter.

A white light projected on the center key signaled the onset of a trial; a single peck to the center key resulted in the immediate replacement of the white light by the sample stimulus. The sample stimulus consisted of one of two colors (red or blue) or one of two orientations (0° or 90°) of three white lines superimposed on a black background. After 5 seconds the center key was darkened and the two side keys were illuminated by the comparison stimuli, which were red and blue or 0° and 90° line orientations. A "match,"

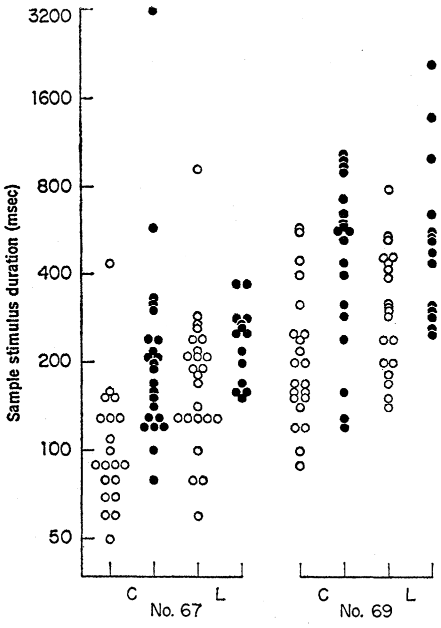

Fig. 1. Distributions of sample stimulus durations obtained from two birds under conditions of divided and nondivided attention. Each point is the result of a matching-to-sample session in which the duration of the sample stimulus was varied to maintain performance constant at 80 percent correct. The durations for matching color and line orientation are plotted separately for each bird (letters *C* and *L*, respectively). Closed circles represent divided-attention sessions, and open circles represent nondivided-attention sessions.

that is, a peck to the side key containing the sample stimulus, activated a food hopper which allowed the bird 1.5-second access to mixed grain (reinforcement); an incorrect response resulted in a 1.5-second blackout. A total of 224 trials (half color and half line orientation) were randomly presented during each daily session and were separated by intertrial intervals of 10 seconds. The data reported below are from the last 192 trials of each session.

After both birds stabilized above 90 percent correct on the "element" matching or nondivided-attention task described above, they were trained on a "compound" or divided-attention task. This training differed from the element matching only in that the sample in a given trial contained three white lines superimposed on a colored background. In half the trials the birds were still required to match on the basis of line orientation, and in half, color. Thus, the compound sample stimuli did not predict which of the two elements would later appear for matching, so that the birds were forced to attend to both stimulus dimensions. Once again both birds stabilized above 90 percent correct.

The experiment was concerned with the stimulus duration required to maintain some level of performance. Accordingly, we adopted a psychophysical technique in which performance was fixed at 80 percent correct and the duration of the sample stimulus was varied to maintain that performance. Our procedure was a modification of Taylor and Creelman's (*5*) PEST (Parameter Estimation by Sequential Testing). In PEST, some value of the independent variable (stimulus duration) is assumed to be just sufficient to maintain a particular performance. During a session the independent variable converges on that threshold value through a series of diminishing "up-and-down" steps; the momentary value changes when a Wald sequential likelihood ratio test (*5*) yields a decision of too many or too few correct responses relative to the expected performance value. Our modification involved using a double PEST during each session in which each bird was treated as two observers; one observer matched on the basis of colors and the other observer matched on the basis of line orientation. Within each pair of days during this phase of the experiment, compound and element matching sessions were randomly scheduled. Within each session, trials involving color and line orientation matching occurred equally often in a random sequence. During each of these sessions, the computer separately and independently "titrated" sample stimulus duration in the color and line orientation trials. Estimates of separate threshold durations were therefore attempted during each session for both line orientation and color trials.

Figure 1 depicts the distributions of sample stimulus durations recorded during the first 50 PEST sessions. The estimates of stimulus duration derived from compound sessions generally exceeded those derived from element sessions. Rank-sum tests (*6*) indicated that compound-element differences were significant for both line orientation ($P < .02$) and color ($P < .001$) matching for both birds.

Assuming that stimulus duration reflects the minimum amount of time necessary to process stimulus input, we view these results as evidence of a central information-processing channel of limited capacity. When channel capacity must be shared between two separate stimulus dimensions, a longer stimulus duration is required in order to process each dimension.

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7. PHS grants MH12485 and FR-7006-Biomedical Support Grant to D. A. Riley supported this research; we are supported by PHS training grants MH 10878 (W.S.M.) and GM01207 to the Institute of Human Learning (T.C.L.). We thank D. A. Riley and C. R. Leith for constructive advice and encouragement.

11 January 1972; revised 6 March 1972 ■

Splitbrain Monkeys: Cerebral Control of Ipsilateral and Contralateral Arm, Hand, and Finger Movements

Abstract. *The connections of the descending pathways in the monkey suggest that each hemisphere controls independent arm, hand, and finger movements contralaterally, but mainly arm movements ipsilaterally. This difference could be observed in splitbrain monkeys executing a visuomotor task with one eye covered, provided tactile guidance of the movements was largely prevented.*

The descending cortical and brainstem pathways to the spinal cord represent the main instrument by which the brain controls movements. In the rhesus monkey these pathways terminate on cells (i) the dorsal horn, (ii) the motoneuronal cell groups of the ventral horn, and (iii) the intermediate zone (Rexed's laminae VI to VIII in cat) (*1*, *2*) which contains the bulk of the spinal interneurons to the motoneurons. The fibers to the dorsal horn modulate mainly sensory transmission while the fibers to the intermediate zone especially influence motoneurons (*3*).

In the rhesus monkey the descending corticospinal fibers from each hemisphere terminate (Fig. 1) in the dorsolateral part of the intermediate zone contralaterally and in its ventromedial part bilaterally. In addition, many corticospinal fibers are distributed directly to contralateral motoneurons of distal extremity muscles (for example, those of wrist and fingers) (*4*). The descending brainstem pathways terminate mainly in the intermediate zone (Fig. 1). On the basis of their termination pattern they may be subdivided into two groups, (i) a lateral brainstem pathway which