*THE LOCAL ORGANIZATION OF BEHAVIOR:
DISSOCIATIONS BETWEEN A PIGEON'S BEHAVIOR
AND SELF-REPORTS OF THAT BEHAVIOR*

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The purpose of the experiment was to study the relation between what an organism does in a setting that demands temporal patterning of behavior and what it reports it has done. More specifically, a pigeon produced two classes, shorter and longer, of temporal patterns of key pecks (interresponse times) on a center key. Occasionally, a symbolic matching-to-sample probe arranged on side keys asked the pigeon whether its most recent pattern was a shorter or longer one. The longer reinforced pattern was always three times as long as the shorter one and the two patterns were reinforced equally often. Absolute duration of reinforced patterns was varied. In some conditions, interresponse-time distributions on the center key were bimodal, indicating a clear behavioral adaptation to the contingency, yet a bird did not report very well by appropriate side-key responding what its most recent interresponse time had been. In other conditions, the interresponse-time distributions were less clearly bimodal, yet a bird reported more accurately its previous interresponse time as shorter or longer. Thus, there was a dissociation between how well behavior on the center key conformed to the schedule requirement and how well a bird reported what it was doing on the center key. In addition, as absolute duration of the reinforced patterns was increased, a bird categorized its most recent pattern less well even as its preference for the shorter pattern increased dramatically. These results were interpreted as an example of the phenomenon of dissociation between tacit knowledge and knowledge.

Key words: interresponse times, differentiation, discrimination, dissociation, key peck, pigeons

When behavior adapts to a reinforcement contingency, thus conforming more closely to that required for reinforcement, we can say that the organism in a sense "knows" something about the contingency, even though it might be unable to describe verbally what it knows. Such knowledge may be called tacit knowledge (Polanyi, 1969), prelinguistic knowledge (Rorty, 1979), or referred to as "knowing how" as opposed to "knowing that" (Rorty, 1979; Wittgenstein, 1953). In this sense, much of the experimental analysis of behavior deals with the broad issue of an organism's tacit knowledge about the way environmental events such as reinforcers depend on its behavior. In many cases, behavior itself provides some of the environmental context in which other behavior is adaptive (Skinner, 1957). It may prove useful to consider this kind of adaptive

behavior that is under discriminative control of other behavior as a kind of self-report. That is, it may prove useful to consider this kind of adaptive behavior as one kind of measure, or even definition, of an organism's knowledge about its own behavior. In this sense, one can also study the issue of what an organism knows about its own adaptive behavior. If the subject happens to be a normal adult human, for example, the subject simply can be asked to report verbally what the contingency is, or what his or her own recent behavior has been. The relationship between behavior and a subject's verbal characterization of that behavior has been an interesting and fruitful, although exceedingly controversial, object of philosophical and scientific study (e.g., Jacoby & Dallas, 1981; Nisbett & Wilson, 1977; Rorty, 1979; Wittgenstein, 1953). In particular, the relationship between tacit knowledge and knowledge has for a long time played an important role in epistemology, philosophy of mind, and philosophy of science (Wittgenstein, 1953) and is a rapidly expanding area in the field of cognitive development, where the study of "metamemory" in

This research was supported in part by NIMH Grant 16928. I would like to thank Stephen J. Hutton for his outstanding work in helping to conduct this research. Send reprint requests to Charles P. Shimp, Department of Psychology, University of Utah, Salt Lake City, Utah 84112.

children consists in some measure of correlating a child's behavior in memory tasks with the child's verbal description of that behavior (Brown, 1975).

There would seem to be no reason why the study of the relationship between tacit knowledge and knowledge must depend either on conventional verbal behavior or on the use of human subjects. The purpose of the present experiment is to exploit a recently developed method for the study of this relationship in which a pigeon displays adaptive behavior and is asked to report what it knows or remembers about that behavior (Nelson, 1974; Shimp, 1981; for related methods see also Commons & Nevin, 1981; Kramer, 1982; Maki, 1979; Zirix & Silberberg, 1978). The basic method works as follows: A pigeon pecks on a center key and patterns of pecking are reinforced in a manner that produces a behavior stream consisting of shorter and longer behavioral patterns (inter-response times). Occasionally, the pigeon is presented with a symbolic matching-to-sample test with red and green side keys. A peck on a green side key is reinforced provided the previous pattern on the center key was a shorter one, and a peck on a red side key is reinforced provided the previous pattern was a longer one. Thus, the pigeon displays adaptive behavior on the center key and thereby displays a kind of tacit knowledge about the reinforcement contingency for center-key responding. It also displays knowledge by reporting on the side keys what it knows about what it has just done on the center key. The procedure accordingly permits one to examine the relationship between tacit knowledge and knowledge.

Data obtained to date suggest a remarkably simple relationship between these two types of behavior: Tacit knowledge about the contingency develops only when knowledge is also displayed. That is, a bird's behavior on the center key is adaptive when and only when it can also report on the side keys that it knows what it does on the center key (Nelson, 1974; Shimp, 1981). The present experiment was designed to use this same basic method to investigate further the relationship between tacit knowledge and knowledge.

METHOD

Subjects

Five White Carneaux pigeons were maintained at 80% of their free-feeding weights,

plus or minus 10 g. The subjects had served previously in a variety of experiments on short-term memory for visual stimuli and most recently in an experiment using the present procedure with retention intervals inserted between a pattern and subsequent matching-to-sample test (Shimp, 1981). Water and grit were always available in the home cages, where there was a 12-hr light-dark cycle.

Apparatus

Five standard three-key Lehigh Valley Electronics pigeon chambers were interfaced to a DEC PDP 12/30 that arranged all experimental contingencies and recorded the resulting data. A minimal force of roughly .15 N was required to operate the keys. White noise and ventilator fans helped to mask extraneous sounds.

Procedure

The procedure consisted of two parts, a shaping contingency to establish and maintain two behavior patterns and a probe contingency to measure discrimination of the most recently emitted of these two patterns. These contingencies are described separately.

Shaping contingency. This contingency was similar to that of earlier experiments in which two temporal patterns, a shorter and a longer, were concurrently reinforced (e.g., Hawkes & Shimp, 1974; Shimp, 1968). Before the present experiment began, however, the simple delivery of a reinforcer had been replaced by the more complex probes to be described below, so that the shaping contingency was used here simultaneously to maintain the desired baseline behavior and to arrange probes (see Shimp, 1981, for details of the original pre-training). Food was delivered only after side-key responses in the probes described below. During the shaping contingency the house-light was on and the center key appeared white. This contingency had two parts: a variable-interval schedule to arrange a distribution of minimum interprobe intervals and a pattern-selection procedure to assign each of the probes arranged by the variable-interval schedule to a particular one of two patterns (see below). These two features of the shaping contingency are described separately. (1) *Variable-interval Schedule.* A single variable-interval schedule arranged a probe with a probability of .05 every 1.0 sec so that the mean interprobe

interval, as arranged by the schedule, was 20 sec. When a probe was arranged, the variable-interval timer stopped and the probe remained available until a key peck terminated the selected pattern. No additional probe could be arranged until a previously arranged one was delivered. (2) *Pattern-selection Procedure*. The durations of the pairs of patterns for each condition are displayed in Table 1. Each probe arranged by the variable-interval schedule was assigned to one of the two patterns. The assignments were random in the sense that each pattern was equally likely to have a probe assigned to it and one assignment did not depend on the previous one.

Probe procedure. Symbolic matching-to-sample probes were designed to measure a pigeon's discrimination of its most recent pattern, i.e., a shorter or longer class of interresponse times. In general, this procedure worked as follows. A key peck initiated a probe provided that the variable-interval schedule had timed out and that the key peck terminated an interresponse time falling in the class chosen by the pattern-selection procedure (see above). The center key went out and red and green side keys appeared immediately after the peck initiating the probe. A bird was required to peck the green key if the previous interresponse time belonged to the shorter class and to peck the red key if the previous interresponse time belonged to the longer class. The details of this procedure were as follows. (1) *Test Phase*. Red and green appeared on the side keys, with the position of a particular color varying randomly from one test to another. A peck on the green key turned off the side keys and initiated reinforcement provided the most recent pattern had been a shorter one, and a peck on the red key initiated reinforcement provided the pattern had been a longer one. After reinforcement, the center key again appeared white and the houselight was again turned on. A peck on the incorrect color initiated a correction procedure. (2) *Correction Procedure*. A choice of the incorrect key was followed by a 5-sec correction interval, during which the keylights were off but the houselight was on. After the 5 sec elapsed, the side keys appeared again with the same assignment of colors to positions. This correction procedure continued to recycle until a correct response produced reinforcement and ended the test. This procedure, coupled with tests that were delivered equally often after

shorter and longer patterns, ensured that reinforcement was delivered equally often after pecks to a particular color and position.

Experimental conditions. Table 1 summarizes how the durations of the two reinforced patterns were varied while their relative duration was maintained at a constant ratio: The longer reinforced pattern was always three times longer than the shorter reinforced pattern. Additionally, the width of the longer reinforced pattern was always three times that of the shorter pattern.

Miscellaneous details. Reinforcement consisted of 1.5-sec access to the same mixed grain that provided that subject's daily diet. During reinforcement, all lights in the chamber were off except for one directly over the food hopper. The duration of each session was one hour and sessions were conducted at the same time six days a week. Experimental conditions typically lasted a standard 15 or 20 days, as described in Table 1. There was no programmed visual or auditory response feedback at any time.

RESULTS

Figure 1 shows three relative-frequency distributions of interresponse times. These curves are averages over all five pigeons and are for

Table 1
Experimental Conditions

Condition Number	Lower and Upper Bounds of Reinforced Inter-response Times (sec)		Duration between Lower Bounds (sec)	Number of Days
	Shorter	Longer		
1	1.5, 2.0	4.5, 7.0	3.0	15
2 ¹	2.0, 3.0	6.0, 9.0	4.0	15
3	2.5, 3.5	7.5, 10.5	5.0	20
4	3.0, 4.0	9.0, 12.0	6.0	20
5	3.5, 5.0	10.5, 15.0	7.0	20
6	4.0, 6.0	12.0, 18.0	8.0	20
7	5.0, 8.0	15.0, 24.0	10.0	20
8	6.0, 9.0	18.0, 27.0	12.0	20
9	2.0, 3.0	6.0, 9.0	4.0	25
10	1.0, 2.0	3.0, 6.0	2.0	15
11	0.6, 1.2	1.8, 3.6	1.2	20
12	2.0, 3.0	6.0, 9.0	4.0	20

¹Between Conditions 1 and 2 was a condition, unrelated to the present series of conditions, with the same reinforced patterns as Condition 1 but with a retention interval of 6 sec between the termination of a pattern and the matching-to-sample probe.

Fig. 1. The relative frequency of an interresponse time as a function of its length for Conditions 11 (top), 3 (middle), and 7 (bottom). Each panel is for the last day of a condition and is an average over all five pigeons. The reinforced patterns in each condition are indicated by brackets. The longest category is for interresponse times in that category or any longer one. Note that the bin width in the bottom panel is .25 sec and is .1 sec in the top and middle panels.

the last day of each of three different conditions (3, 7, and 11). As in corresponding previous experiments, the average curves well represented individual curves (e.g., Shimp, 1981). The three conditions were selected to include a pair of relatively short reinforced patterns (.6 to 1.2 sec and 1.8 to 3.6 sec), a pair of moderate-length reinforced patterns (2.5 to 3.5 sec and 7.5 to 10.5 sec), and a pair of relatively long reinforced patterns (5.0 to 8.0 sec and 15.0 to 24.0 sec). The curve at the top for the shortest reinforced patterns is bimodal whereas the other two curves are not perceptibly so, although in a later two cases the effect of the reinforcement of longer interresponse times is still apparent. The frequency of interresponse times longer than the shorter reinforced class is clearly greater than it would have been had there not been a longer reinforced class. In general, these curves conform to expectations built up from numerous earlier experiments on two classes of reinforced interresponse times and suggest merely that there was nothing unusual about the baseline stream of interresponse times in the present experiment (Shimp, 1968, 1970, 1981).

Figures 2, 3, and 4 show results from the side-key probes. The relative frequency of a peck to the correct side key was calculated for each of the last five days in a condition and then the mean and standard error for these five numbers were calculated. The relative frequency of a correct response in the test probes excludes all correction responses; only the first choice on a trial is included.

Figure 2 shows the relative frequency of a correct choice as a function of the duration of the two reinforced patterns, measured by the lower bound of the shorter reinforced pattern. The figure shows the likelihood of correct responses separately for those probes after shorter and longer patterns. On the whole, correct responses were no more likely after shorter than after longer patterns. There is remarkable agreement displayed across the curves for the different subjects. In all cases, the curve is an inverted U: A pigeon did not so well categorize the pattern it had just produced (i.e., peck the correct side key) when both reinforced patterns were quite short or quite long, as it did when the patterns were of intermediate duration. Recall that the interresponse-time distributions were bimodal for the shortest pairs of reinforced patterns but not for the longest pairs

Fig. 2. The relative frequency of a correct response in symbolic matching-to-sample probes as a function of the absolute durations of the two reinforced patterns, for probes after shorter patterns (unfilled symbols) and for probes after longer patterns (filled symbols). Triangles and squares refer to first and second replications, respectively. Vertical lines represent plus and minus one standard error.

of reinforced patterns. This bimodality suggests that in a sense the shorter interresponse time was more discriminable from the longer one when both were rather short than when both were either intermediate or rather long. Yet, Figure 2 indicates that a bird reported more accurately what it had just done when the pair of reinforced patterns was of intermediate duration and the interresponse-time distribution was not clearly bimodal. In general, bimodality of the curves in Figure 1 is not correlated with how well a bird reported what it had just done as displayed in Figure 2.

The replications can be seen from Figure 2 to have been adequately successful.

Figure 3 compares a bird's preference for one

pattern over another in the baseline behavior on the center key with the accuracy with which the bird identified in the probes the pattern it had most recently produced. Intuitively, one might expect that the magnitude of preference for one of two alternatives might be smaller when a subject less readily discriminates between the two alternatives (see, e.g., Baum, 1974). Curiously, Figure 3 shows a very different picture. First, note that for all birds preference for the shorter pattern, indicated by the dashed lines, increased monotonically as both patterns became longer. (Recall that their relative length was always the same.) This increased preference for the shorter pattern is to be expected (Hawkes & Shimp, 1974). Second,

Fig. 3. The relative frequency of a correct response in symbolic matching-to-sample probes, averaged over probes after shorter and longer patterns (left axis) and the relative frequency of shorter patterns (right axis), both as a function of the lower bound of the shorter reinforced pattern. Triangles and squares refer to first and second replications, respectively. Vertical lines represent plus and minus one standard error.

note that an intuitively contradictory picture emerges when this result is compared to the extent to which a bird could identify which pattern it just produced. The solid lines in Figure 3 are the averages of the curves in Figure 2 and clearly show that for neither the shortest nor longest pair of patterns was discrimination as good as for moderate pairs of patterns. Accordingly, there is a dissociation between strength of preference between alternatives (dashed lines) and the discrimination of those alternatives (solid lines). Consider in some detail four cases including the three conditions in Figure 1. When the two alternatives were both relatively short, namely .6 to 1.2 sec and 1.8 to 3.6 sec, the birds produced bimodal interresponse-time distributions, which suggests that they could clearly discriminate between the two alternatives. They also correctly discriminated the two in the test probes on the average 67% of the time and were essentially indifferent between them: Average preference

for the shorter pattern was .52. In short, both the temporal patterning and the probe behavior suggested a bird could tell the difference between the two patterns, but a bird did not significantly prefer one over the other. For the moderate-duration pair, 2.5 to 3.5 sec and 7.5 to 10.5 sec (Condition 3), the interresponse-time distribution was not bimodal, which suggests that the subjects could less well discriminate the difference between the shorter and longer patterns, yet on the average they correctly reported what they had just done 89% of the time and average preference for the shorter pattern was .84. Here temporal patterns suggested poor discrimination, probe performance suggested good discrimination, and one pattern was substantially preferred over the other. For a longer pair, 5 to 8 sec and 15 to 24 sec (Condition 7), the interresponse-time distribution again was not bimodal, the average probability of a correct probe response was .74, and preference for the shorter pattern in-

Fig. 4. The relative frequency of a correct probe response as a function of the relative frequency of shorter patterns. Triangles and squares refer to first and second replications, respectively. Vertical and horizontal lines represent plus and minus one standard error.

creased further to .93. For the longest pair, 6 to 9 sec and 18 to 27 sec, the probability of a correct response declined still further to .61 and preference increased still further to .96. Here the data indicate strong preference for engaging in the short pattern rather than the long pattern of interresponse times, yet the probes indicated the birds could not very well tell the difference between the two patterns.

Figure 4 describes the same results as Figure 3 but from a different perspective: It directly plots the probability of a correct probe response against the degree of preference for the shorter pattern. Figure 4 clearly shows that as preference for the shorter pattern increased, accuracy of reporting the most recent pattern first increased and then sharply decreased.

DISCUSSION

The present results may be said to give two different perspectives on what a bird knows

regarding a situation demanding adaptive behavior. First, interresponse-time distributions reveal varying degrees of adaptation to the demands the reinforcement contingency places on the temporal patterning of behavior. One can say that this adaptation represents tacit knowledge about the temporal patterning on which reinforcement depends. Second, the side-key choice behavior obtained here can be said to be a kind of nonverbal commentary by the organism on the topic of its own adaptive behavior.

One of the oldest controversies in scientific psychology has of course been the relation between what an organism does to adapt to the world and what it knows about what it does. At times, for example, this controversy has centered on the role of conscious awareness in the formation and maintenance of habits (James, 1890), on the nature of conscious behavior (Epstein, 1980), on the nature of knowledge (Rorty, 1979), on the development of cognitive

processes (Brown, 1975), and on an excessively broad range of other philosophical and theoretical issues (e.g., see Wittgenstein, 1953).

It has been noted before that ordinary conditioning techniques can be applied to this same controversy (Epstein, 1980; Israel, 1978; Lloyd, 1980; Skinner, 1969). The present experiment simply extends this idea further, to nonverbal organisms. Previous results obtained with the present method supported a very simple interpretation, namely, that the temporal patterning of behavior reveals adaptation to a reinforcement contingency to the extent to which an organism can report what its own temporal patterning is (Shimp, 1981, 1982). The present results suggest a different picture, one consistent with much, but not all, of a vast literature on the relation between a human subject's behavior and his verbal self-report of the behavior (Jacoby & Dallas, 1981; Nisbett & Wilson, 1977). The result obtained here is that what one does and what one "says" one does are two different things. When knowledge of the reinforcement contingency on the center key was at its highest level (i.e., when bimodality was most clearly apparent), a bird's reports on the side keys indicated that it did not know so well what it was doing on the center key. Furthermore, when preference for the alternatives on the center key was most extreme, a bird's reports on the side keys indicated that it could not very well tell the difference between the two alternatives. It is not clear how to explain these results, but the search for an explanation should prove interesting.

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Received September 30, 1981

Final acceptance August 23, 1982