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Temporal discrimination learning by pigeons

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Abstract

Memory for time by animals appears to undergo a systematic shortening. This so-called choose-short effect can be seen in a conditional temporal discrimination when a delay is inserted between the sample and comparison stimuli. We have proposed that this temporal shortening may result from a procedural artifact in which the delay appears similar to the intertrial interval and thus, produces an inadvertent ambiguity or 'instructional failure'. When this ambiguity is avoided by distinguishing the intertrial interval from the delay, as well as the samples from the delay, the temporal shortening effect and other asymmetries often disappear. By avoiding artifacts that can lead to a misinterpretation of results, we may understand better how animals represent time. An alternative procedure for studying temporal discriminations is with the psychophysical bisection procedure in which following conditional discrimination training, intermediate durations are presented and the point of subjective equality is determined. Research using the bisection procedure has shown that pigeons represent temporal durations not only as their absolute value but also relative to durations from which they must be discriminated. Using this procedure, we have also found that time passes subjectively slower when animals are required to respond to the to-be-timed stimulus.

Keywords: Choose-short; Instructional ambiguity; Single-code/default coding; Subjective timing; Temporal discriminations; Timing

In a temporal discrimination, pigeons learn that following the presentation of a stimulus (sample) for a relatively short duration (e.g., 2 s) a response to one test or comparison stimulus is correct (rewarded) and following the presentation of the same stimulus for a relatively longer duration (e.g., 10 s) a response to a different comparison stimulus is correct. Pigeons can acquire such a discrimination quite easily (Spetch and Wilkie, 1983). If one inserts a delay between the offset of the sample and the onset of the comparison stimuli, one can assess the pigeons' memory for the sample duration. Surprisingly perhaps, the typical finding with increasing delay has been that accuracy on trials involving the shorter sample remains high with increasing delay but accuracy on trials involving the longer sample declines rapidly as the delay increases. In fact, accuracy on long-sample trials typically declines below 50% (chance). This effect that has been reliably found in several studies has been referred to as the *choose-short effect* because at relatively long delays the pigeons respond almost exclusively to the comparison stimulus associated in training with short samples.

The choose-short effect has been attributed to the subjective shortening of the memory for the duration of a stimulus with the passage of time (Spetch and Wilkie, 1983). With increasing delay following the offset of the long sample, the remembered interval gets shorter and shorter until it approaches the duration of the short sample experienced on trials without a delay. Memory for the shorter sample also experiences subjective shortening but the effect of the shortening is not to make the sample appear more like the longer one. Instead, the pigeons continue to choose the comparison associated with the short sample because their memory for the short sample is always more similar to the duration of the short sample on trials without a delay than it is to the duration of the long sample on trials without a delay.

Later research discovered that a similar phenomenon occurred with manipulation of the intertrial interval (the time between trials). The longer the intertrial interval relative to that experienced during training, the more likely the pigeons would choose the comparison associated with the shorter sample during original training. This finding led to a revision of the subjective shortening hypothesis called the relative duration hypothesis (Spetch and Rusak, 1992). According to the relative duration hypothesis, the duration of the sample subjectively shortens with time since its offset but its duration is also judged relative to the interval immediately before the sample. That is, according to

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the relative duration hypothesis, memory for the sample duration is viewed against a background of the combined context of the intertrial interval and the delay. The longer the combined background, the shorter the sample is judged to be.

The notion that the memory of a temporal interval compresses with the passage of time seems reasonable perhaps in part because humans often lose some of the negative emotion associated with intervals initially judged to be very long. That long boring class experienced as an undergraduate may not seem as long when considered several years later. However, the magnitude of the effect found with pigeons after relatively short delays seems larger than would appear to be functional for an animal. For example, Spetch (1987) found that a 'long' duration of 8 s following a relatively short delay of 5 s was remembered by pigeons as being more similar to the 'short' duration of 2 s from original training than to the 8-s duration from original training. Although not being functional for an animal does not suffice as evidence against such a process, it should raise the possibility that some process other than subjective shortening might be involved.

To test an important prediction of the subjective shortening account, Kraemer et al. (1985) provided pigeons with three sample durations (short, medium, and long) and three comparison alternatives. They reasoned that if the sample durations were becoming subjectively shorter with the passage of time, with increasing delay on 'long' sample trials, the pigeons should begin to make errors by choosing the comparison associated with 'medium' sample durations and if still longer delays are experienced the 'long' samples should eventually lead to choice of the comparison associated with 'short' sample durations. In fact, when the pigeons began to make errors on long sample trials, virtually all of those choices were of the comparison associated with shortest duration even at very short delays. Kraemer et al. interpreted their results in terms of the individual coding of the three sample durations, and when the code for a sample was forgotten, the pigeons would revert to choice of the comparison associated with the shortest sample duration. However, a simpler explanation is possible.

1. The instructional ambiguity hypothesis

The procedures that have been used to study memory for sample duration have involved two important elements. First, generally, the pigeons are trained in the absence of delays so delays are a novel experience for them. Second, and more important, the intertrial intervals are generally quite similar in appearance to the novel delays. Thus, the procedure may create for the pigeon a somewhat ambiguous condition. If the delay is mistaken for an intertrial interval, its appearance could be viewed as the end of a trial (without the appearance of the comparison stimuli) and the appearance of the comparison stimuli could be viewed as the beginning of the next trial (without the appearance of a sample). If this were the case, it would not be surprising if on delay trials the pigeons tended to choose the comparison associated with the short sample. After all, the absence of a sample should be judged as more similar to the short sample than the long sample. Furthermore, the longer the delay, the more similar to the intertrial interval it should appear and the more likely the pigeons should be to choose the comparison associated with the short sample.

1.1. Intertrial interval-delay ambiguity

To test the hypotheses that ambiguity between the intertrial interval and the delay may have resulted in the choose-short effect, Sherburne et al. (1998) trained pigeons on a sample duration discrimination in which the intertrial intervals were lit for one group and dark for another. Following acquisition, the pigeons in each group were tested with lit and dark delays as well as lit and dark intertrial intervals. Results indicated that when the delay illumination matched that of the intertrial interval during training, the retention functions diverged, indicating the presence of a choose-short effect. However, when the delay illumination did not match that of the intertrial interval during training, the retention functions were parallel. Furthermore, the relation between the delay illumination and the intertrial interval illumination on test trials was not a factor. Thus, it was the characteristics of the intertrial interval *during training* that determined the relative slopes of the retention functions during testing. This result suggests that in duration sample matching, the conditions during the intertrial interval during original training had an instructional effect. That is, it identified the conditions that defined the end of the trial. On test trials, it was not the relation between the lighting conditions during the intertrial interval and those during the delay on the current test trial that produced the ambiguity but between the intertrial interval during training and that during the delay.

1.2. Novelty of the delay

Even when the ambiguity between the intertrial interval and the delay is reduced by differentiating the intertrial interval and the delays, pigeons may be uncertain as to the meaning of the delay. (For those who feel uncomfortable with the use of cognitive terminology such as meaning, instructions, and ambiguity, one can think of these effects on performance as resulting from a generalization decrement.) Although a generalization decrement produced by the novelty of the delay should not result in divergent retention functions, it might result in steeper retention functions than would be attributable to memory loss alone. However, this effect is characterized, it might be of value to separate performance deficits due to the novelty of test trials from those attributable to the retention of sample duration itself.

A possible way to reduce the decline in performance with increasing delay on duration sample matching trials produced by test-trial novelty is to train the pigeons with delays from the start. Dorrance et al. (2000) trained pigeons with delays of 0, 1, 2, and 4 s and distinctive intertrial intervals. To avoid possible floor effects they used the data from all sessions in which performance on 0-s delay trials was at or above 75%. In contrast to the steep decline in retention function typically found when delays are first introduced following training with 0-s delay trails, they found excellent matching accuracy at all of the delays. Apparently, the novelty of the delay does affect sample retention and the longer the delay, the great is this effect. When Dorrance, Kaiser, and