Effects Of Intersensory Redundancy and Stimulus Contingency On Early Perceptual Learning

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Introduction

We recently demonstrated the powerful influence of stimulus contingency on the acquisition of auditory preferences in bobwhite quail neonates (Harshaw and Lickliter, *in submission*). In this study, chicks that were given less than 5-min of contingent exposure to a particular variant of a bobwhite maternal assembly call showed significant preferences for that call when tested 24 hours following exposure, whereas chicks given semi-yoked, non-contingent exposure did not. In comparison, chicks in previous studies (e.g. Lickliter and Hellewell, 1992), were found to require between 240 and 480 minutes of non-contingent exposure to a maternal call—or about 100 times more stimulation—to acquire significant auditory preferences.

A number of studies from our laboratories have also demonstrated a powerful effect of intersensory redundancy on attention, arousal, learning and memory, in both human and non-human embryos and neonates (e.g. Bahrick & Lickliter, 2004; Lickliter, Bahrick, & Honeycutt, 2002, 2004). Intersensory redundancy can be characterized as the experience of simultaneous, spatio-temporally contiguous stimulation in two or more modalities. The intersensory redundancy hypothesis (IRH) predicts that during early development intersensory redundancy facilitates the acquisition of learning about the amodal properties of stimulation, whereas unimodal stimulation facilitates the learning of non-redundant and modality-specific properties of stimulation (Bahrick, Lickliter & Flom, 2004).

Given the potent effect of stimulus contingency on perceptual learning, we were interested in whether stimulus contingency would interact with intersensory redundancy. We hypothesized that the effects of stimulus contingency would combine in an additive, linear manner with the effects of intersensory redundancy, such that a hierarchy of efficacy for engendering stimulus preference would be revealed: Redundant Contingent (RE-CON) > Unimodal Contingent (UNI-CON) > Redundant Non-Contingent (RE-NOC) > Unimodal Contingent (UNI-NOC). We thus predicted that unimodal exposure would be less efficacious than redundant bimodal exposure, that the greatest preferences would be seen in chicks provided with RE-CON exposure to a stimulus, and that the lowest preferences would be seen in chicks provided with UNI-NOC exposure.

Method

Day-old Northern bobwhite (*Colinus virginianus*) hatchlings were provided with individual, 5-min training sessions in a large circular arena (130 cm dia). Chicks in the CON conditions were played a single burst of a bobwhite maternal assembly call each time they distressed vocalized while in the arena. Chicks that provided with RE-CON and RE-NOC exposure were exposed both to a bobwhite maternal assembly call and a 60 watt light-bulb, positioned above the speaker emitting the call, made to flash in synchrony with the notes of the call with a Chaney color organ circuit. Each chick provided with NOC exposure was individually yoked to a chick from either corresponding CON condition. Each chick in the RE-NOC condition was thus yoked to a chick from the RE-CON condition and each chick in the UNI-NOC condition was yoked to a chick in the UNI-CON condition, producing a fully yoked design.

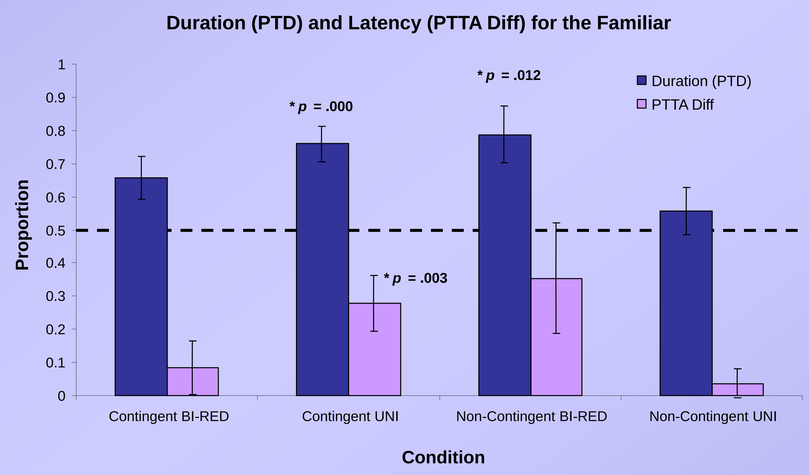
24 hrs following exposure, chicks were again placed in the arena and were provided with individual 5-min simultaneous choice tests between the familiar and an unfamiliar bobwhite maternal assembly call. Chicks were scored for latency and duration of approach. Any chick failing to spend at least 10 seconds in one of the approach areas was scored as a non-responder and a chick was only scored as showing a preference for a particular call if the chick spent at least twice as much time in one area as it did in the other. Duration scores were converted into proportion of total duration (PTD) scores (duration for the familiar divided by total duration for both calls) and latency scores were converted into proportion of trial elapsed prior to approach (PTTA) difference scores ($PTTA_{unfamiliar} - PTTA_{familiar}$). PTD scores were compared to .50 (chance) and PTTA difference scores were compared to zero using single-sample t-tests against $\alpha = .05/4 = .0125$ (utilizing a Bonferroni correction). Between group comparisons were made using Mann-Whitney *U* tests, evaluated at $\alpha = .05$.

Results

- Significant deviations from chance responding were found in duration (PTD) scores for chicks that received RE-CON ($p = .012$), UNI-CON ($p = .000$), and RE-NOC ($p = .006$) exposure to a maternal call and in latency (PTTA difference) scores only for chicks that received UNI-CON ($p = .000$) exposure.

- Replicating our previous results (Harshaw & Lickliter, *in submission*), chicks provided with UNI-CON exposure to a maternal call showed significantly greater PTD scores than chicks provided with UNI-NOC exposure ($Z = -2.19$, $p = .014$).

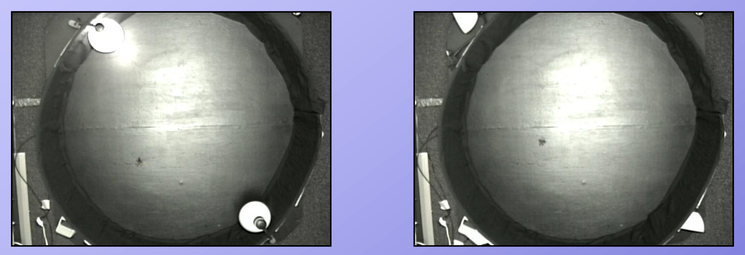
- Chicks given RE-NOC exposure also showed significantly greater duration (PTD) scores than chicks given yoked, UNI-NOC exposure ($Z = -1.96$, $p = .028$).



- Chicks that received UNI-NOC exposure showed the lowest preferences for the familiar call, however, contrary to our full hypothesis, the greatest preference for the familiar call were seen in chicks that were provided with RE-NOC exposure. These preferences (PTD and PTTA difference scores) were not, however, significantly different from chicks given UNI-CON and RE-CON exposure ($Z = -.50$, $p = .62$, and, $Z = -1.16$, $p = .25$, respectively).

- Chicks that were given UNI-CON exposure showed significantly larger PTTA difference (but not PTD) scores than chicks given RE-CON exposure ($Z = -1.77$, $p = .039$).

Testing/Training Arena



Conclusions

- The hypothesized notion of a simple linear, additive interaction between intersensory redundancy and stimulus contingency was shown to be false. The relationship between the two processes thus appears to be far more complex:

  - Intersensory redundancy appears to facilitate learning under conditions of non-contingent stimulus exposure—the RE-NOC chicks had significantly greater PTD scores than UNI-NOC chicks—but not under conditions of stimulus contingency.

  - The decreased preferences seen in RE-CON chicks compared to UNI-CON chicks (although not significant) may either be the result of "overshadowing" or else the result of the specificity of learning under conditions of intersensory redundancy. It may thus be necessary to a) give chicks bimodal-redundant rather than a unimodal auditory choice tests 24hrs following exposure and/or b) re-run these conditions with two non-species-typical stimuli that have distinct rhythms to shed light on this finding.

  - Chicks in the RE-CON condition (and thus also in the RE-NOC condition) heard the call on average of 23.6 times during training, compared to 28.1 times for UNI-CON and UNI-NOC chicks. It is unknown why responding was inhibited during RE-CON versus UNI-CON sessions; however, it is conceivable that the addition of the light provoked higher levels of arousal in chicks in the RE-CON condition. Given that chicks in the RE-NOC condition were yoked to RE-CON subjects, it is interesting that these chicks showed preferences just as high as chicks given UNI-CON exposure.

  - To achieve a fair comparison between the effects of UNI- versus RE-CON stimulation it will be necessary to run an additional condition in which RE-NOC chicks are cross-yoked to UNI-CON chicks, thus ensuring that chicks in the two conditions receive exactly the same number of stimulus exposures.

  - This study opens up a number of interesting questions, including the possibility that the dynamics of intersensory redundancy effects on learning may vary dependent upon whether or not stimuli are contingent upon the behavior of the organism under study.

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