Intersensory Redundancy Enhances Memory in Bobwhite Quail Embryos

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Introduction

We recently proposed an intersensory redundancy hypothesis (Bahrick & Lickliter, 2000), which hold that information presented concurrently and redundantly to two or more sensory modalities recruits infants' attention and promotes perceptual learning of amodal stimulus properties more effectively than does the same information presented to one sensory modality alone. Research findings from both animal embryos and human infants have provided converging support for this view (Lickliter, Bahrick, & Honeycutt, 2002; Bahrick, Flom, & Lickliter, 2002). For example, we found that quail embryos show significantly enhanced perceptual learning during prenatal development when amodal information (rate, rhythm, duration) available in a maternal call is presented redundantly to both the auditory and visual modalities as compared to unimodal (auditory) stimulation. Similarly, we found 3 and 5-month old human infants discriminate changes in the amodal properties of tempo and rhythm when presented redundantly to the auditory and visual modalities, but not under conditions of unimodal presentation. The present experiment examined whether the facilitative effect of intersensory redundancy would extend to the domain of memory. In keeping with our intersensory redundancy hypothesis, we predicted that quail embryos provided redundant audio-visual exposure to a maternal call would display enhanced memory for the familiar call relative to those provided only unimodal auditory exposure in the period prior to hatching.

Experiment 1

180 maternally-naïve embryos received intermittent (10 min/hr) exposure to either (1) no supplemental prenatal sensory stimulation, (2) unimodal auditory stimulation, or (3) temporally synchronized audio-visual stimulation during the 24 hr prior to hatching. The auditory event was an individual variant of a quail maternal call. The call consisted of a burst of 5 notes that displayed a complex rhythmic pattern and varied in duration and temporal patterning. Audio-visual redundancy was achieved by recreating the temporal patterning, rhythm, and duration of the notes in a synchronized flashing light. Following hatching, all chicks were individually tested at 48 or 72 hr of age in a simultaneous choice test between the familiar maternal call and an unfamiliar variant of the same maternal call. Results of testing revealed that only chicks which received redundant audio-visual exposure preferred the familiar maternal call 48 hr following the offset of stimulation. No group showed a preference for the familiar call by 72 hr of age (Figure 1). These results support the intersensory redundancy hypothesis by demonstrating that embryos provided intersensory redundancy displayed a preference for the familiar call at 48 hr, 24 hr longer than has been shown for embryos given only unimodal prenatal auditory stimulation (Lickliter & Hellewell, 1992).

Experiment 2

To further explore the impact of prenatal intersensory redundancy on memory, we repeated the methods of Experiment 1 but added a brief postnatal refamiliarization with the maternal call. Chicks were exposed to the familiar maternal call for 10 min at 48 hr

following hatching and tested at 72 hr for their preference between the familiar maternal call and the unfamiliar variant of the call. Embryos given no supplemental stimulation (controls) or unimodal (auditory) stimulation prior to hatching did not appear to benefit from the postnatal exposure to the maternal call. Neither group of chicks preferred the familiar call at the 72 hr test. In contrast, embryos provided redundant audio-visual exposure prenatally showed a significant preference for the familiar call at 72 hr following re-exposure to the call 24 hr earlier. Additionally, a separate group of chicks receiving prenatal redundancy and refamiliarized with the maternal call for 10 min at 72 hr following hatching significantly preferred the familiar call at 96 hr of age (Figure 2). Thus, a brief refamiliarization to subjects given redundant prenatal exposure reinstated memory for the maternal call for up to 72 hr beyond that of subjects given only unimodal prenatal exposure.

Discussion

Previous studies have found that intersensory redundancy can facilitate perceptual learning in animal and human infants (Bahrick & Lickliter, 2000; Bahrick, Flom, & Lickliter, 2002; Lickliter, Bahrick, & Honeycutt, 2002). The results of this study are the first to provide evidence that redundantly specified information is remembered longer and reinstated more easily than the same information presented unimodally. Subjects given prenatal unimodal exposure to a maternal call preferred that call at 24 hr, but did not appear to remember the familiar call at 48 or 72 hr following hatching. In contrast, subjects given redundant audio-visual exposure to a call + light recognized and preferred the familiar maternal call at 24, 48, 72, and 96 hr following hatching. Properties of sensory stimulation that are specified redundantly across multiple modalities appear to be attended to, learned, and remembered prior to modality-specific properties. More generally, this study represents a successful union between human and non-human animal research. We believe that the adoption of such a comparative, convergent operations approach can broaden the theoretical scope of developmental science by identifying basic themes or principles of development that potentially apply across species.

References

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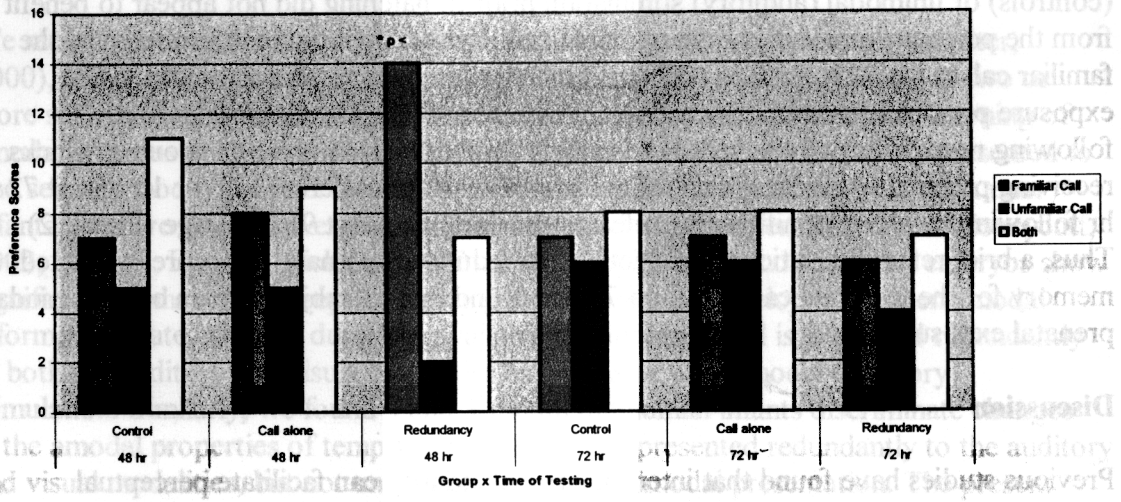
Preference Scores in Experiment 1



Preference Scores in Experiment 2