Development of multisensory integration is site-specific

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INTRODUCTION

- The brain's powerful ability to integrate congruent signals across multiple sensory modalities is not an inherent capacity.
- Deprivation of visual-auditory experience (e.g., by rearing in darkness or omnidirectional masking noise) precludes the development of this neural process and its behavioral sequelae.
- This neural capability can be developed in compromised adults after repeated presentations of visual-auditory cues however the ability to use this integration to produce behavioral benefits has not been shown.

METHODS

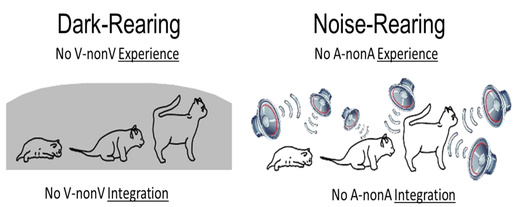

Fig.1: Experimental Cohort Rearing Conditions. The experimental cohort was composed of 1 adult dark-reared (DR) and 3 adult noise-reared (NR) cats (2 males, 1 female). DR animal was reared in a light-tight room within a week of birth and prior to eye opening. NR animals were housed from prenatal day 9 in the center of a room that had speakers mounted at ceiling level on all walls. The speakers produced a constant masking sound that suppressed perception of most patterned auditory stimuli.

- Animals were trained to approach a visual (50 ms LED flash) or auditory (50 ms broadband noise burst) stimulus at several locations (-60° to +60°, 15° increments) (Fig.1).
- Training continued until they reached 80% or greater accuracy at each location.
- Prior to testing, cue intensity was reduced to degrade performance to 30-40% correct.
- Animals were presented with spatiotemporal concordant cross-modal cues at a single location (e.g., -45°) or unimodal visual/auditory cues at the opposite location (e.g., +45°).
- Animals were intermittently tested with a standard battery of visual, auditory, visual-auditory, and catch trials to assess behavioral enhancement capabilities.

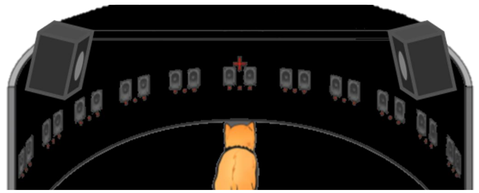

Fig. 2: Rearing Conditions and Perimetry Apparatus. The detection and localization task was performed in a perimetry apparatus with LEDs and speakers at locations spanning the central 180° of space in 15° intervals (only the central 120° was tested here, the 0° location was used for fixation only). Large speakers mounted above the device delivered background noise. (Figure adapted from Gingras et al., 2009).

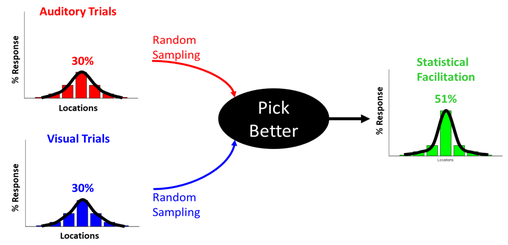

Fig. 3: Statistical Facilitation (SF) Model. SF model predictions were generated through a bootstrap procedure in which the responses on visual-alone and auditory-alone were randomly sampled and the "better" (i.e., more accurate) response was selected as the SF prediction. This procedure was repeated 10,000 times to generate sampling distributions for each response metric predicted by SF

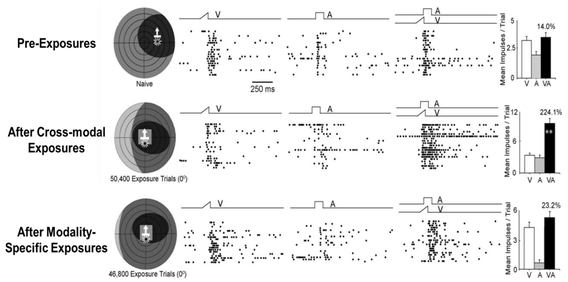

Fig. 4:The development of multisensory integration capabilities in superior colliculus neurons was noted after cross-modal exposures, but not after modality-specific exposure. The receptive fields and responses of a typical neuron from a dark-reared animal. Visual (V, black) and auditory (A, gray) receptive fields (shading) as well as the stimuli are presented. Each dot in a raster represents one impulse, and each row represents the response to one stimulus presentation. Summary bar graphs show the mean response (number of impulses) for each stimulus condition in the rasters. Numbers above the bars represent the percentage multisensory response enhancement. Figure adapted from Yu et. al., 2009.

RESULTS

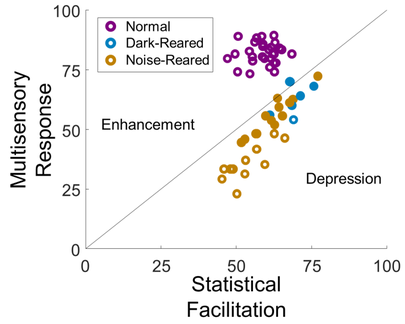

Fig. 5: Multisensory localization performance pre-exposures. Normally-reared animals (purple, N=4) showed robust enhancement above statistical facilitation, while dark-reared (blue, N=1) and noise-reared (gold, N=3) animals did not. Solid line represents line of unity. Filled circles represent non-significant difference.

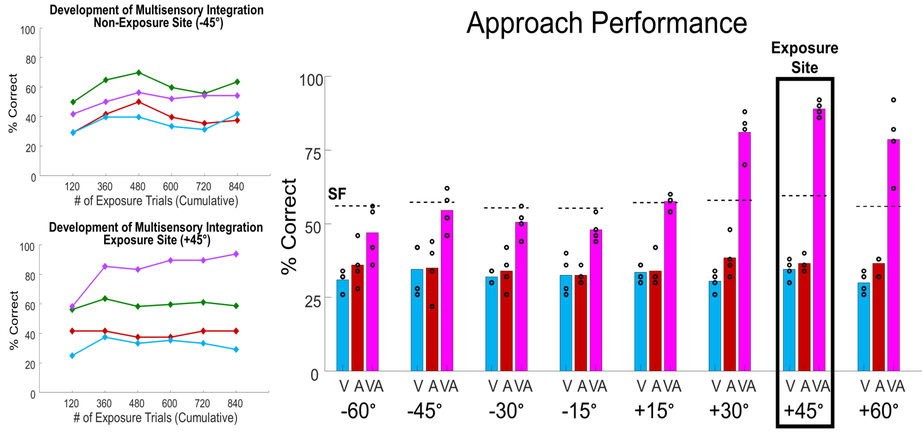

Fig 6. Multisensory enhancement was observed at not only the site of exposures but at the immediate adjacent locations as well. Open circles represent individual animal data. SF dashed lines represents statistical facilitation prediction. * = p< 0.05

CONCLUSIONS

1. Animals showed normal multisensory performance benefits at the training location and its immediate surround.
2. The site-specificity closely parallels the neural correlates previously observed in single superior colliculus (SC) neurons after similar rearing and training conditions.

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