Multisensory behavior: competition precedes cooperation

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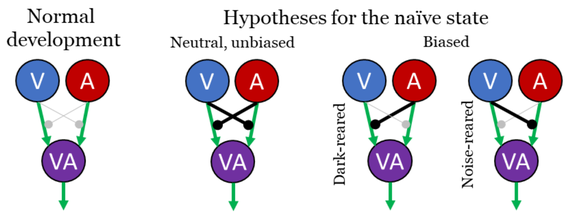
INTRODUCTION

- The brain's powerful ability to synergistically integrate congruent signals across multiple sensory modalities is neither innate nor genetically prescribed.
- When animals are reared without requisite multisensory experience, the multisensory responses of superior colliculus (SC) neurons and SC-mediated multisensory behaviors reflect a competition between the senses.
- Is this competition unbiased, or can it be biased by the unisensory experience of the animal?



METHODS

- Animals were reared from birth in an omnidirectional sound room (noise-reared, N=3), a light-tight dark room (dark-reared N=1) or a normal housing environment (normally-reared, N=2).
- They were trained to approach a visual (50 ms LED flash) or auditory (50 ms broadband noise burst) stimulus at several locations (-30° to +30°, 15° increments) in a perimetry apparatus (Fig. 1) until they reached >80% performance each training location.
- Responses were scored in 3.75° intervals (labeled 1-5) spanning adjacent stimulus locations (Fig. 1)
- Prior to testing, cue intensity was reduced to degrade unisensory performance to 30-40% correct in order to expose multisensory computations.
- Animals were tested with randomly interleaved: visual, auditory, visual-auditory (15° spatial disparity), and catch (no stimulus) trials between -45° and +45°.
- All training and testing of noise-reared animals was conducted in the presence of elevated background broadband noise (56 dB) and the dark-reared animal was tested in the dark.

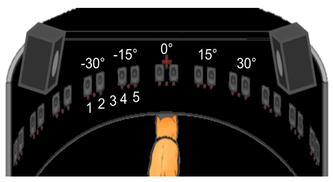


Fig. 1: Perimetry Apparatus. The detection and localization task was performed in a perimetry apparatus with LEDs and speakers at locations spanning the central 180° of space in 15° intervals (only the central 120° was tested here, the 0° location was used for fixation only). Each stimulus location contained a complex of two speakers and three LEDs at 2 cm separations. Large speakers mounted above the device delivered background noise.

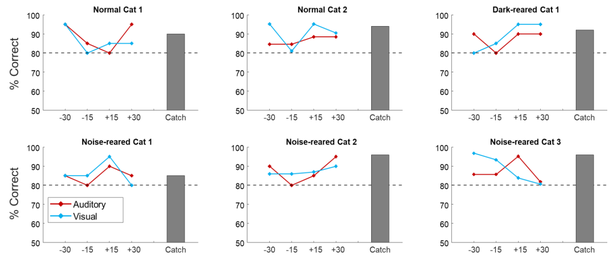


Fig. 2: Training Performance. Animals of all cohorts learned to orient and approach visual and auditory stimuli >80% (dashed line). Data averaged across 20 trials.

RESULTS

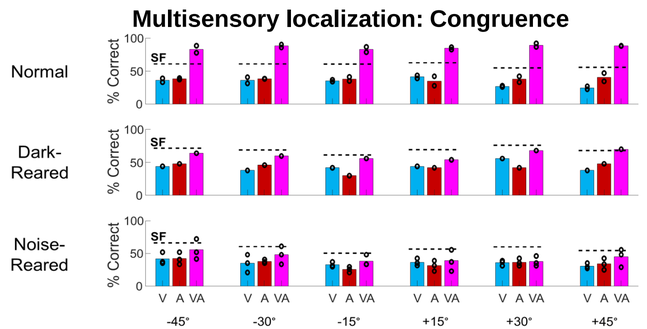


Fig. 3: Multisensory testing with congruent stimuli. Normally-reared animals (top) showed robust enhancement above statistical facilitation across tested locations. Dark-reared (middle) and noise-reared (bottom) did not show this enhancement and in many cases did not reach statistical facilitation (dashed line). Open circles represent individual animal data.

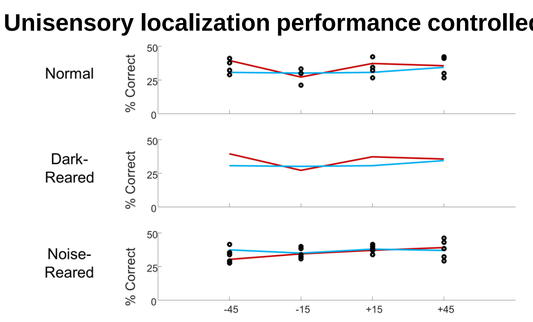
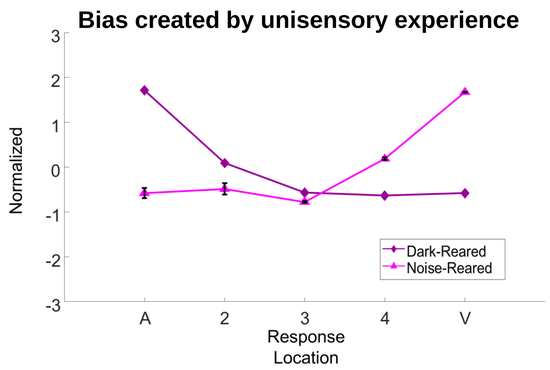


Fig. 4: Intensities of stimuli were reduced to ensure equal approach on modality-specific trials. Red and blue bars indicate responses on auditory only or visual only trials, respectively.



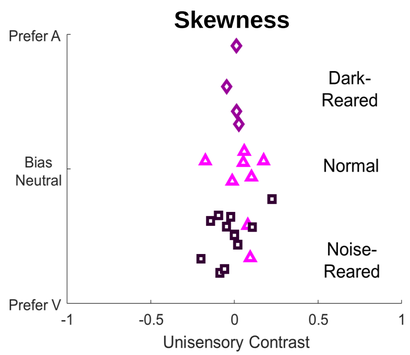


Fig. 5: Disparity testing revealed the presence of a bias due to unisensory experience. As predicted, the preferred modality was audition for dark-reared animals, and vision for noise-reared animals. Left: Normalized approach responses on multisensory trials are plotted for dark-reared and noise-reared animals. Error bars represent the standard deviation across animals. Right: The bias for each animal and tested location. ♦ represent dark-reared animals, ▲ represents normal animals, and ◘ represent noise-reared animals.

CONCLUSIONS

The competition between sensory modalities in the default multisensory computation is biased by unisensory experience.

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