# Behavioral Benefits of Multisensory Integration Require Multisensory Experience

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## INTRODUCTION

- In the normal adult, multisensory integration enhances detection, localization, and orientation behaviors.
- These are believed to depend on individual neurons in the midbrain superior colliculus (SC), which integrate congruent cross-modal signals to enhance the physiological salience of the initiating events.
- Experience with visual-auditory stimuli is required for neurons to develop this integrative ability - If reared in a room with omnidirectional masking noise (or noise-rearing) they do not develop it.

## METHODS

- Animals were reared from birth in an omnidirectional (noise-reared group, n=3) or a normal housing environment (normally-reared group, n=2).

Experiment 1

- Animals were trained to approach a visual (50 ms LED flash) 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 tested with randomly interleaved: visual, auditory, visual-auditory, and catch (no stimulus) trials.

Experiment 2

- Animals were re-trained to approach an auditory (50 ms broadband noise burst).
- Animals were re-tested with randomly interleaved: visual, auditory, visual-auditory, and catch (no stimulus) trials.

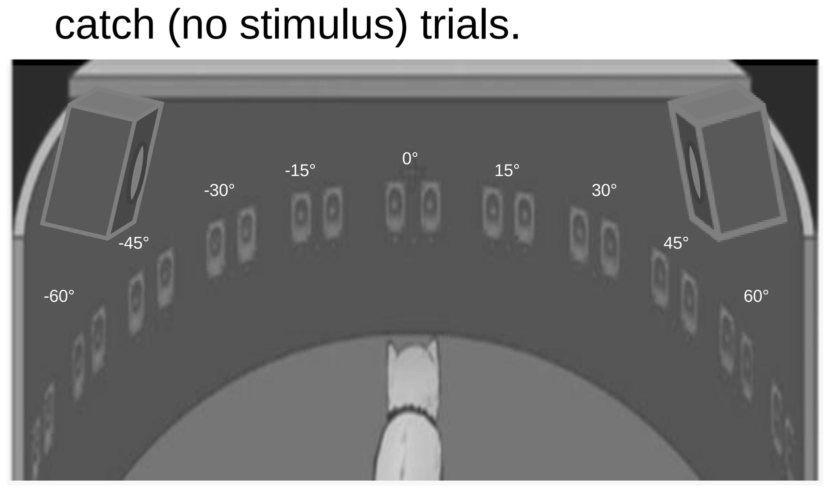

**Fig. 1: Perimetry Apparatus**. The detection and localization task was performed in a perimetry apparatus with LEDs and speakers at locations spanning the central 180° of space in 15° intervals (only the central 120° was tested here, the 0° location was used for fixation only). Each stimulus location contained a complex of two speakers and three LEDs at 2 cm separations. Large speakers mounted above the device delivered background noise. (Figure adapted from Gingras et al., 2009).

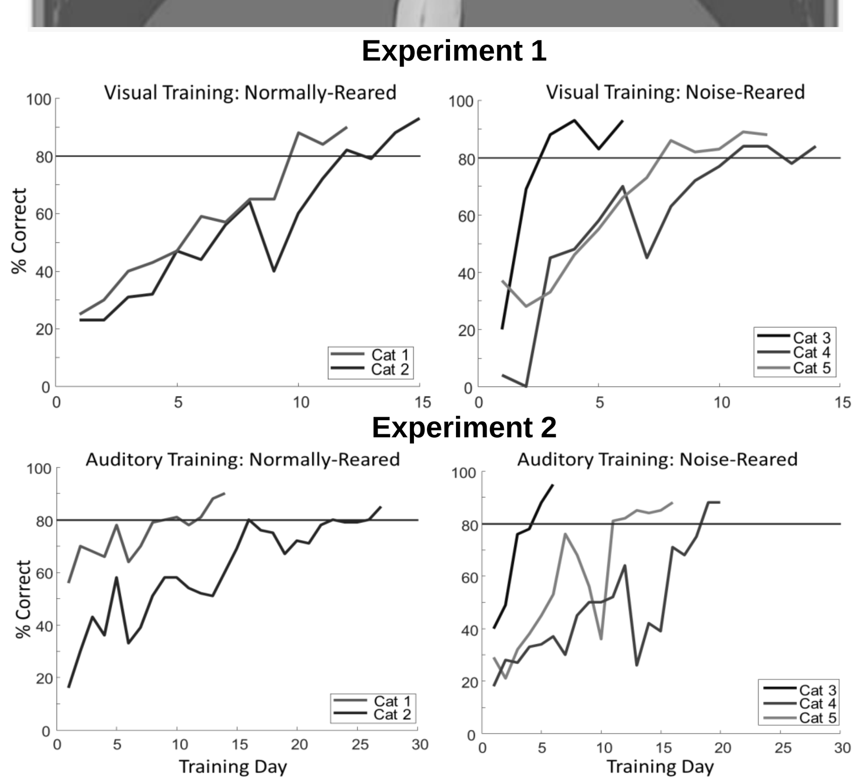


**Fig. 2: Training Performance.** Animals of both cohorts quickly learned to orient and approach visual (prior to Exp. 1) and auditory stimuli (prior to Exp. 2). Each animal's performance is plotted individually (Cat 1-5). Both normally-reared and noise-reared animals learned the visual (top) and auditory (bottom) tasks rapidly, and there were no significant intergroup differences.

## RESULTS

### Visual Reduction Performance

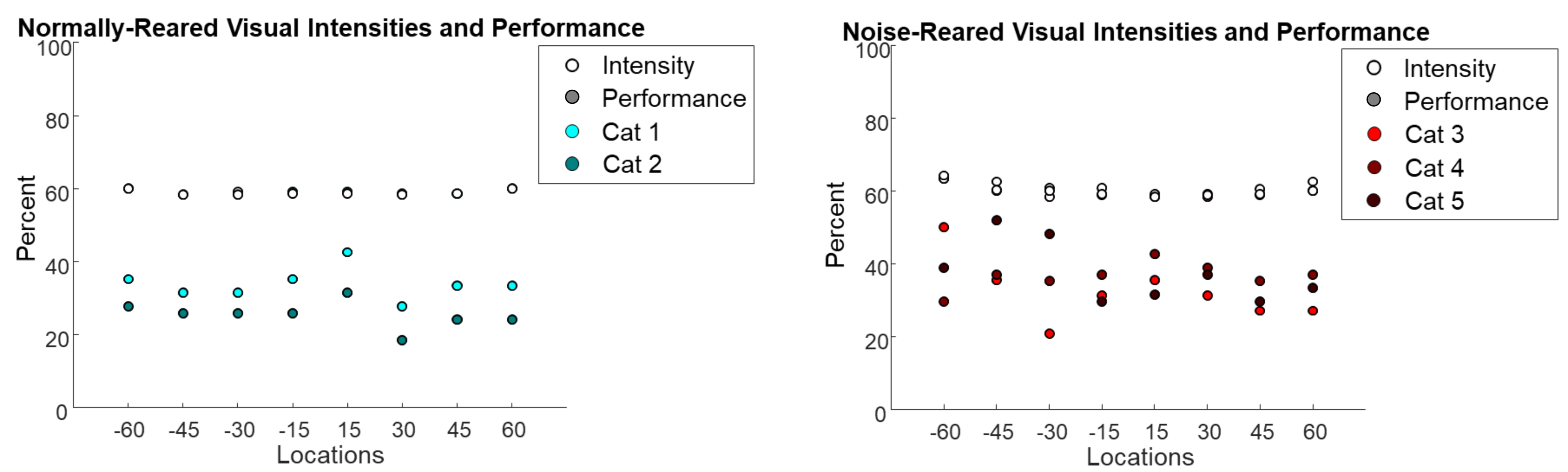


**Fig. 3: Visual Reduction was similar between groups.**

### Experiment 1

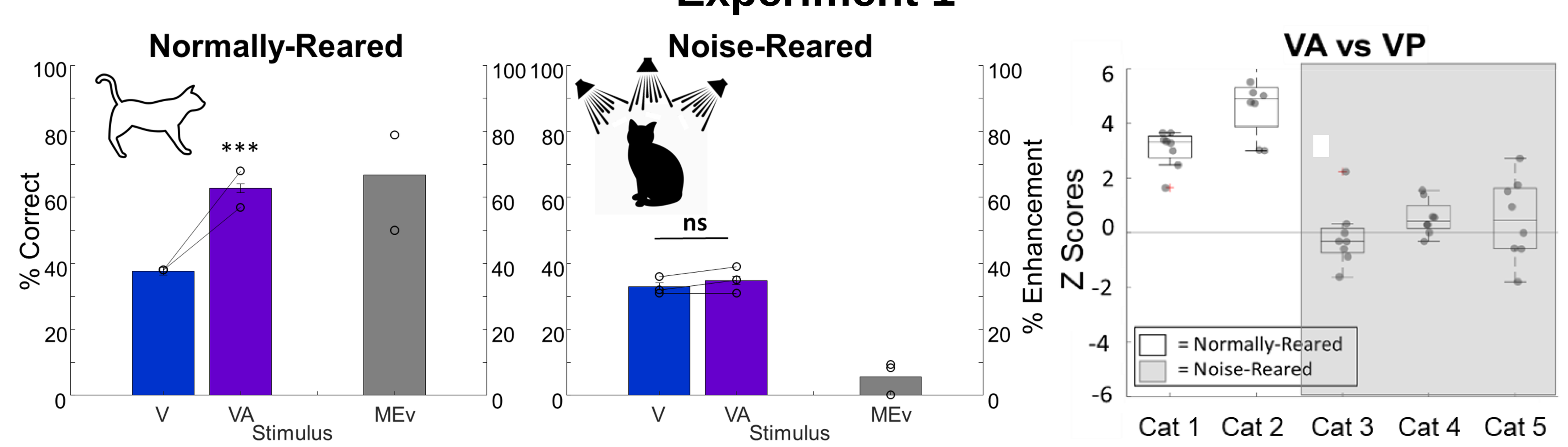


**Fig. 4: Auditory stimuli failed to enhance visual localization performance in noise-reared animals.** Bars show that coupling a novel auditory stimulus with the visual target stimulus (V) to create a cross-modal target (VA) significantly enhanced group multisensory performance (MEv) in normally-reared animals, but not in their noise-reared counterparts. Open circles represent individual animal data with lines connecting their unisensory and multisensory performance. Z scores in boxplots for each location and each animal (grey dots) show multisensory, relative to visual, localization performance. The multisensory performance of normally-reared animals was always significantly enhanced. In contrast, the multisensory performance of noise-reared animals (in grey shading) was often no better than their visual performance. ***=p<0.001, ns=not significant.

### Auditory Reduction Performance

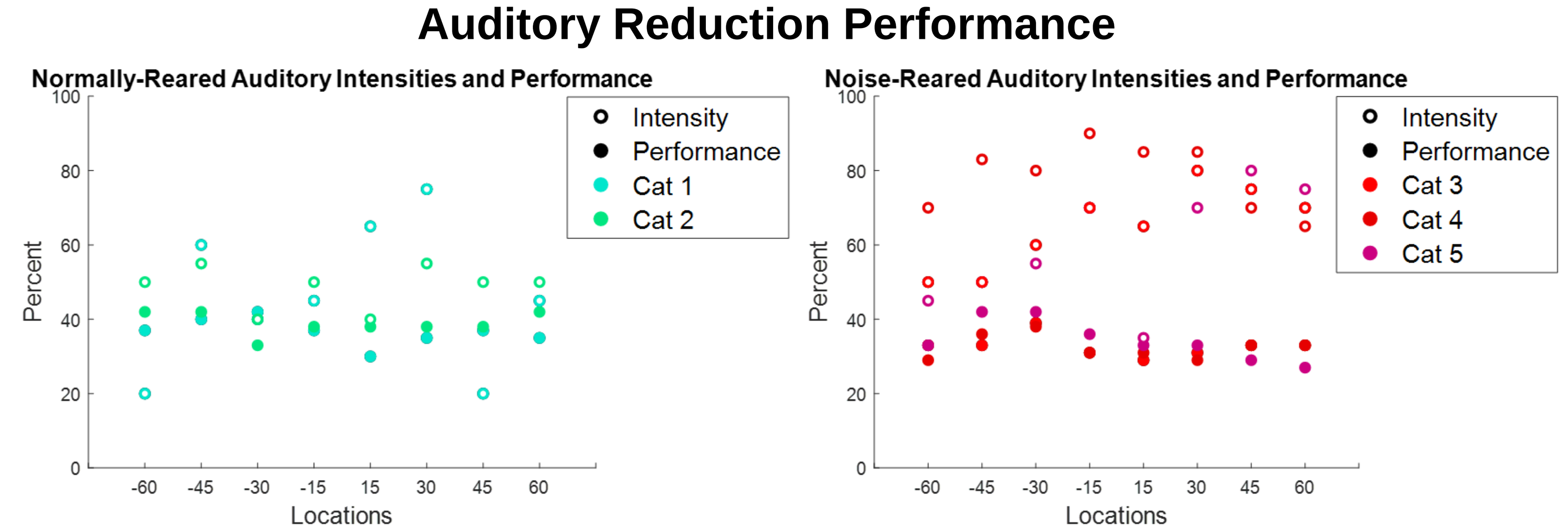


**Fig. 5: Auditory Reduction was similar between groups.** There was no significant difference in the reduction needed for the same reduced responses (Δ group=15.6±7.37, location intercept=4.37, cat intercept=4.14; p=0.058). The omnidirectional noise during rearing appeared to have no direct deleterious effect on the ability of noise-reared animals to use auditory information to make detection/localization decisions.

## RESULTS

### Experiment 2

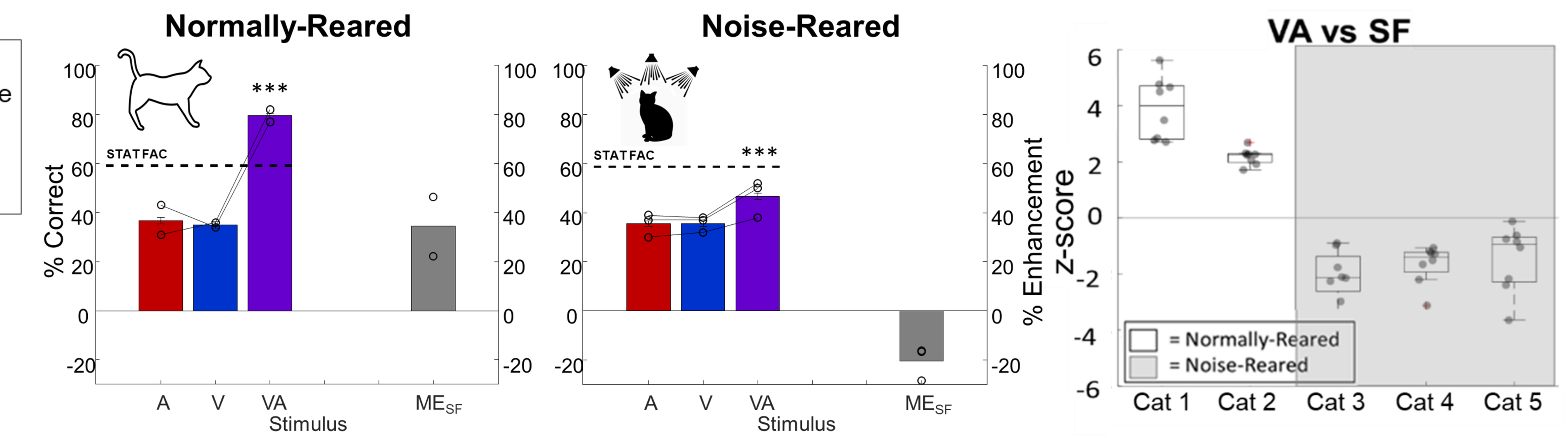


**Fig. 6: Noise-reared animals failed to show multisensory enhancement when both visual and auditory stimuli were targets**. Conventions are the same as Fig. 3, albeit here the referent is statistical facilitation (SF). A: The multisensory performance in normally-reared animals significantly exceeded SF. B: In contrast, the multisensory performance of noise-reared animals failed to reach SF predictions. C: Z scores show the contrasting performance of the groups: enhancements in normally-reared and depression in noise-reared (grey shading) animals. $ME_{SF}$ = Multisensory Enhancement over Statistical Facilitation. ***=p<0.001.

### Performance Across Testing Period

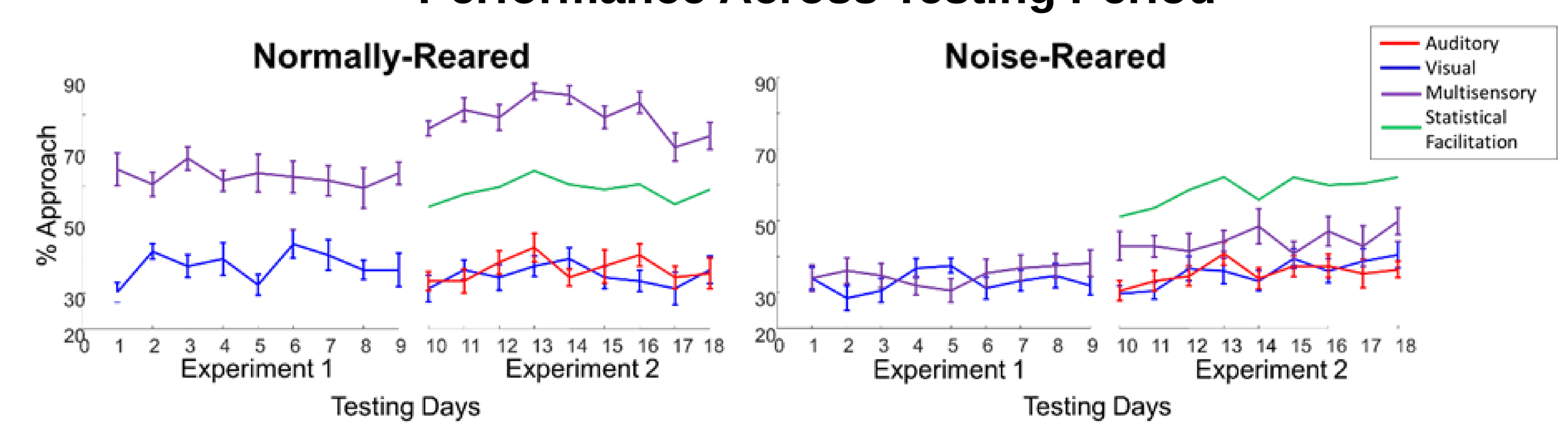


**Fig. 7: Group performance was stable over the testing period.** Shown are visual (blue), auditory (red), and multisensory (purple) localization performance and SF predictions (green, Exp. 2). There was relative within-experiment performance stability over testing sessions (albeit noise-reared animals showed a gradual increase in response to the visual stimuli in Exp. 2). However, following explicit auditory training between experiments both cohorts showed an increase in correct multisensory approach responses.

## CONCLUSIONS

1. Noise-rearing does not impair the ability to localize auditory cues.
2. Noise-reared animals lack multisensory integration capabilities in a visual localization and redundant target task.
3. Normally and noise-reared animals showed increase approach to cross-modal cues when trained in both modalities.
4. Multisensory exposures over testing period was not enough to develop multisensory integration in noise-reared animals.

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