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Dark-Rearing Precludes the Auditory Enhancement of Visual Localization

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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 darkness (or omnidirectional masking noise) they do not develop it.

METHODS

- Animals were reared from birth in complete darkness (dark-reared group, n=X) or a normal housing environment (neurotypic group, n=X).
- Animals were trained to approach an auditory (50 ms broadband noise burst) or visual (50 ms LED flash) stimulus at several locations (-45° to 45°, 15° increments) (Fig.1).
- Training continued until they reached 80% or greater accuracy.
- 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. The testing environment was either fully lit (139 Lux), dimly-lit (0.16 Lux), or completely dark.

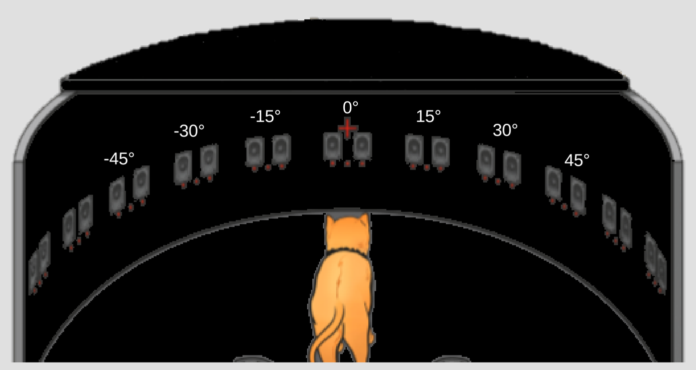


Fig. 1: Perimetry Apparatus. LEDs and speakers were spaced at 15° intervals from -105° (left) to 105° (right). .Only the left most LEDs and speaker in each group were used here. Animals had to approach the stimulus or remain still (NoGo) on catch trials to receive a food reward.

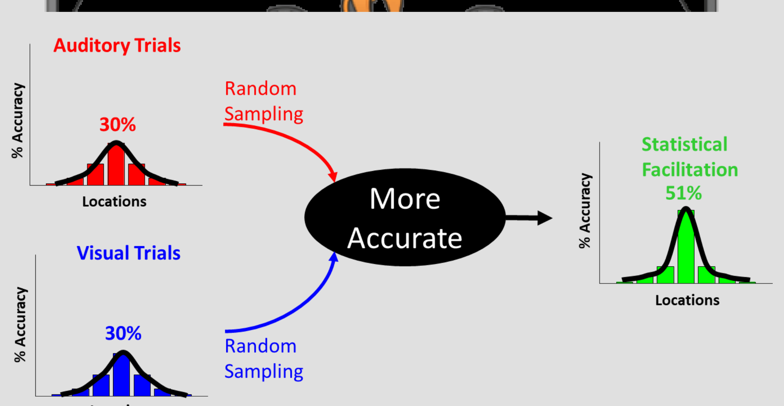


Fig. 2: Statistical Facilitation Model. Predictions for the multisensory responses were based on the premise that animals only respond to the "better" of the V and A signals on each trial but do not integrate them. Calculated separately for each animal/location. Responses on V-alone and A-alone trials were randomly sampled and the "better" (more accurate>less accurate, Go>NoGo) selected. This predicted a single multisensory trial outcome. The resampling was repeated to generate predicted sampling distributions for the % correct, incorrect, and No-Go responses.

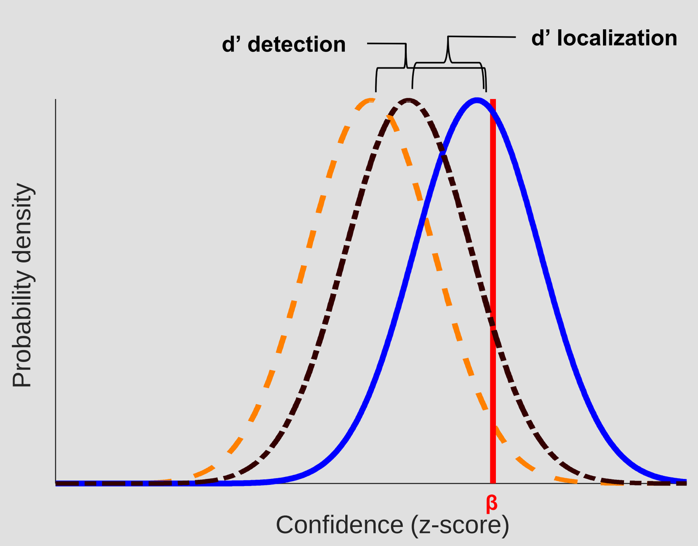
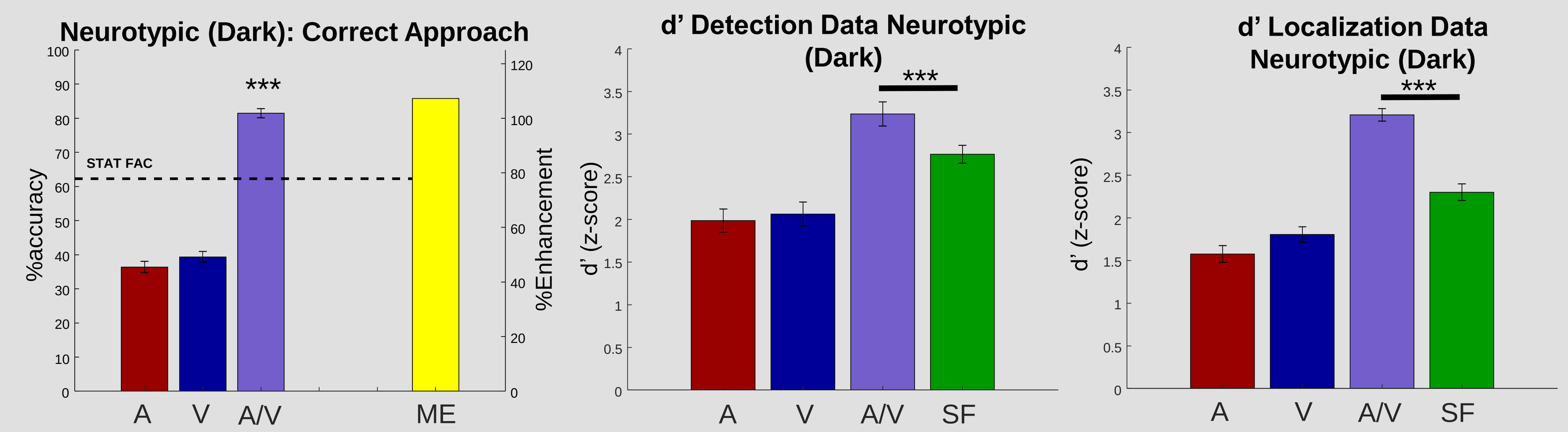


Fig. 3: Decision-Making Model. A signal detection / discrimination analysis was applied. Plotted are distributions indicating the animal's confidence that an orientation response should be made to a target . The orange curve represents the confidence distribution (z-score axis) for catch trials. The vertical red line indicates the criterion for an orientation response (β). The dash-dot black curve indicates the confidence distribution when the stimulus was presented at a non-target location. The blue curve indicates the confidence distribution for a stimulus at the target location. Discriminability statistics (d') are calculated for each comparison as illustrated.

RESULTS

Did dark-rearing preclude visual-auditory enhancement in overt localization behavior?



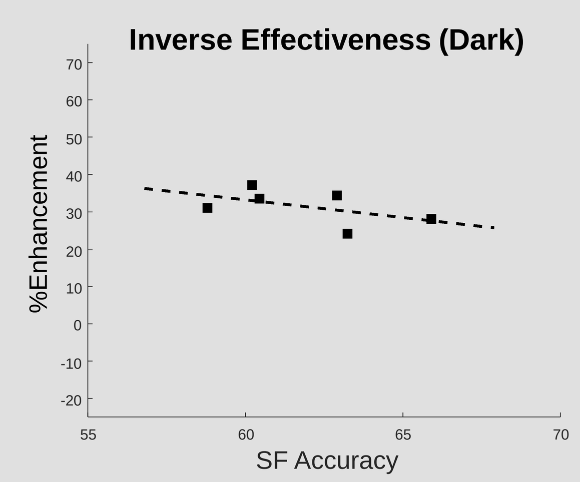
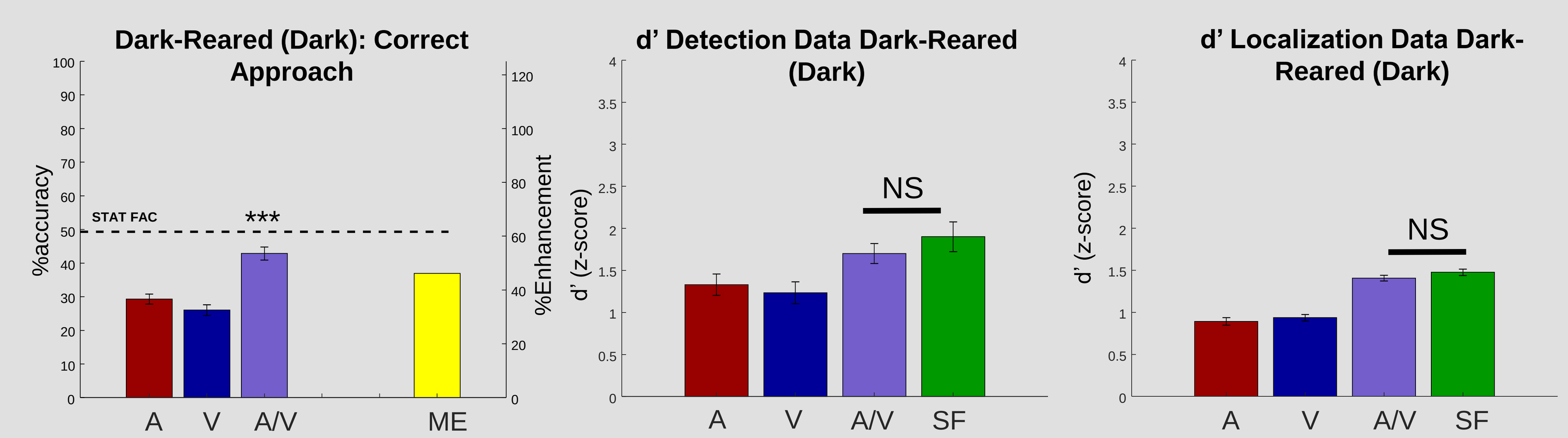


Fig. 4: Neurotypic Animals show robust multisensory enhancement in the dark. The cross-modal condition in neurotypic animals showed enhancement in their overall accuracy over the best unisensory (χ^2 test, p<0.0001) and over the statistical facilitation model (test, p<0.001). Neurotypic animals showed enhancement in their detection over the best unisensory (t test, p<0.001) and statistical facilitation (t test, p=0.0187). Neurotypic animals showed enhancement in their localization over the best unisensory (t test, p<0.001) and statistical facilitation (t test, p=0.001). Inverse effectiveness held true in these animals. The slope was -0.95 and the y-intercept was 90.2.



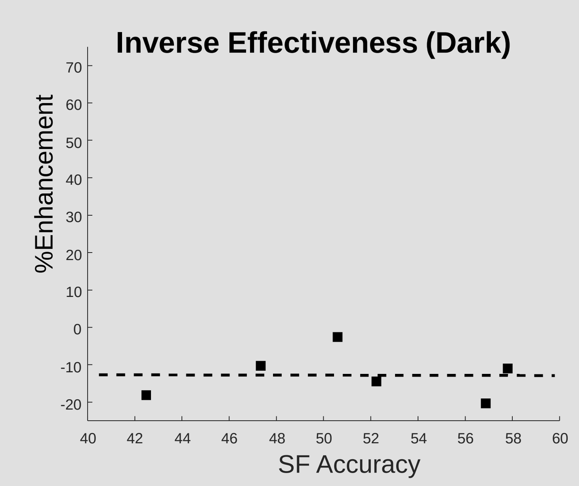


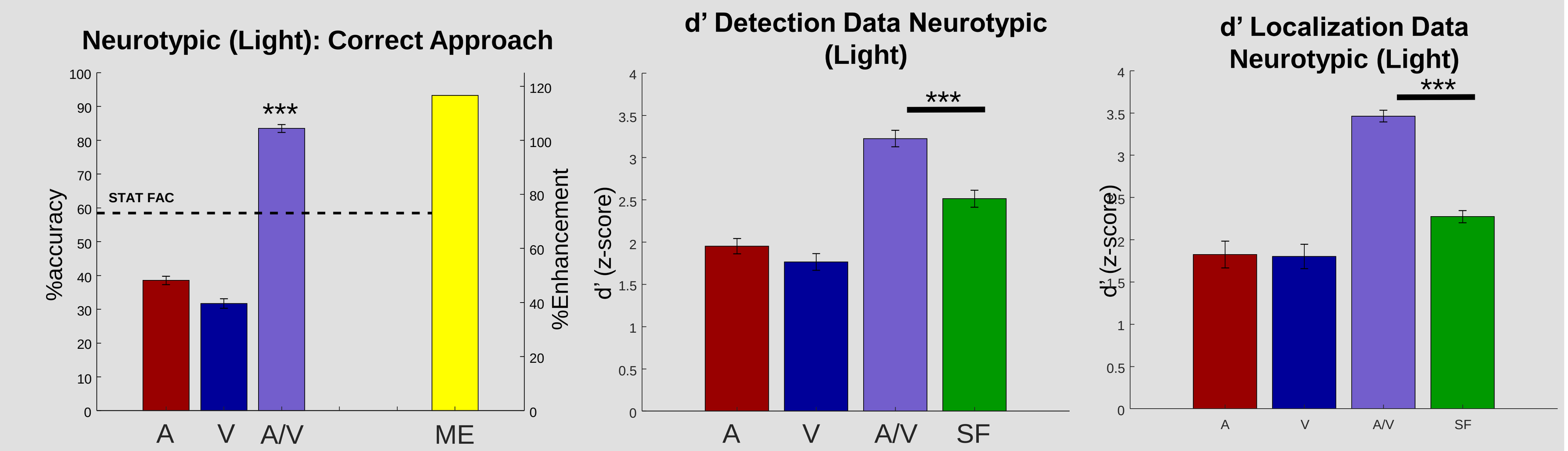
Fig. 5: Dark-reared animals show no multisensory enhancement in the dark. Dark-reared animals trained in the dark (N=2). The cross-modal condition in dark-reared animals showed enhancement in their overall accuracy over the best unisensory (χ^2 test , p<0.0001) but does not meet statistical facilitation model (test, p<0.0004). Dark-reared animals showed enhancement in their detection over the best unisensory (t test, p<0.001) and did meet statistical facilitation (t test, p=0.329). Dark-reared animals did show enhancement in their localization over the best unisensory (t test, p<0.001) but were no different than statistical facilitation (t test, p=0.310). Inverse effectiveness held true in these animals. The slope was -0.0097 and the y-intercept was -12.3.

CONCLUSIONS

Yes! Dark-reared animals do not show multisensory enhancement.

RESULTS

Did the Testing Conditions Matter?



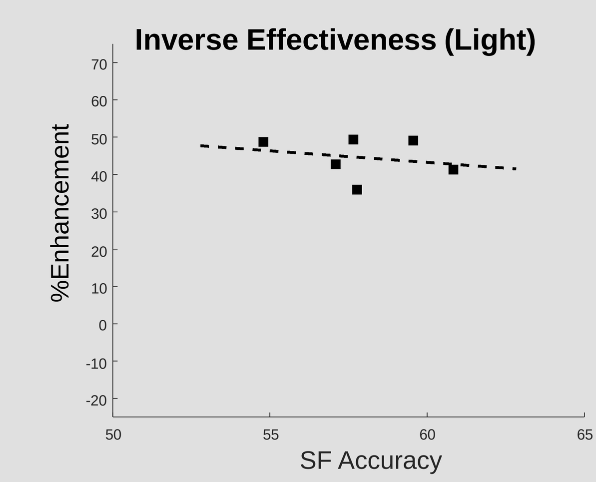
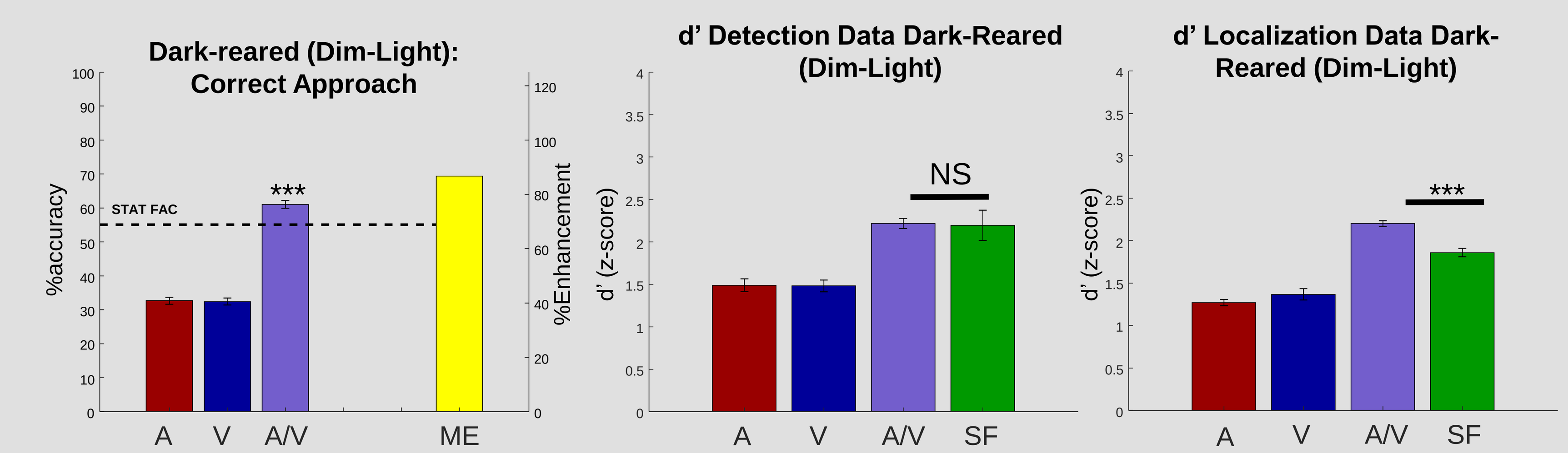


Fig. 6: Neurotypic animals show multisensory enhancement in the light. Neurotypic animals trained in the light (N=2). The cross-modal condition in neurotypic animals showed enhancement in their overall accuracy over the best unisensory (χ^2 test , p<0.001) and statistical facilitation model (test, p<0.001). Neurotypic animals showed enhancement in their detection over the best unisensory (t test, p<0.001) and statistical facilitation (t test, p=0.0013). Neurotypic animals showed enhancement in their localization over the best unisensory (t test, p<0.001) and statistical facilitation (t test, p<0.001). Inverse effectiveness held true in neurotypic animals. The slope was –0.62 and the y-intercept was 80.32.



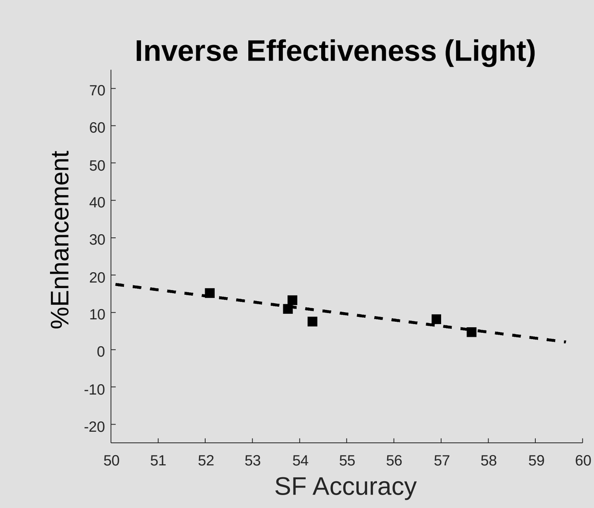


Fig. 7: Dark-reared animals show impaired multisensory enhancement in the light. Dark-reared animals trained in the light (N=4). The cross-modal condition in dark-reared animals showed enhancement in their overall accuracy over the best unisensory (χ^2 test , p<0.001) and over statistical facilitation model (test, p<0.001). Dark-reared animals did show enhancement in their detection over the best unisensory (t test, p<0.001) but were no different than statistical facilitation (t test, p=0.9065). Dark-reared animals showed enhancement in their localization over the best unisensory (t test, p<0.001) and statistical facilitation (t test, p=0.001). Inverse effectiveness also held true in these animals. The slope was -1.61 and the y-intercept was 98.5

CONCLUSIONS

Testing conditions did not affect multisensory enhancement for neurotypic animals. Dark-reared animals showed impaired enhancement in the light and dark.

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