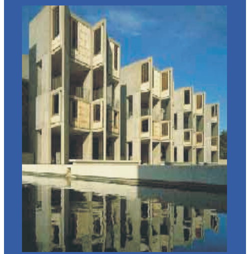

Cued associative recall:
Novel pairings of visual motion to color or to auditory tones improves motion discrimination in noisy environments

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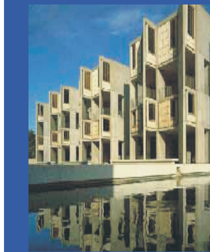


BACKGROUND

Recently, we showed that macaque MT neurons respond selectively to stationary shapes once animals have learned to associate these stimuli with particular directions of motion (Schlack & Albright, 2007).
It remained unclear from these studies whether such neuronal plasticity could also influence visual motion perception. Here we ask:

-> Do subjects use cues that they learn to associate with visual motion to disambiguate motion directions in noisy environments?

-> Does associative plasticity also occur if motion is paired with stimulus features other than shape, such as color or auditory frequency?

METHODS

Stage I TEST: Pre-Training Motion discrimination thresholds

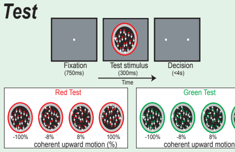
Stage II *TRAIN: Pair Visual Motion + Color or Auditory Frequency*
Color: mean= 13 days (7-19); mean= 80 repeats (29-120)
Auditory: mean= 16 days (10-21); mean= 113 repeats (84-122)

Stage III TEST: Post-Training Motion discrimination thresholds

TASK

Color-Visual Motion Pairing

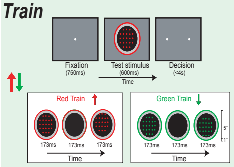
Test



-Motion direction discrimination: 2AFC
-Test stimulus coherence:
(+/- 100%, +/- 77%, +/- 54% +/- 33% +/- 8%)
-Measure behavior for red and green trials

-Orthogonal judgement & response
Judge: up/down
Eye Movement: right/left

Train



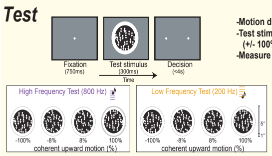
-Motion direction discrimination:
2AFC (pair color + motion direction)
-Displacements:
23-50% of the row size
11 stimulus speeds (0.47-1.03^{o}/s)

GROUP I: pair red + up/ green + down

GROUP II: pair green + up/ red + down

Auditory Frequency-Visual Motion Pairing

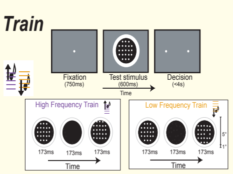
Test



-Motion direction discrimination: 2AFC
-Test stimulus coherence:
(+/- 100%, +/- 77%, +/- 54% +/- 33% +/- 8%)
-Measure behavior for high and low trials

-Orthogonal judgement & response
Judge: up/down
Eye Movement: right/left

Train



-Motion direction discrimination:
2AFC (pair auditory+ motion direction)
-Displacements:
23-50% of the row size
11 stimulus speeds (0.47-1.03^{o}/s)

GROUP I: pair high frequency + up/ low frequency + down

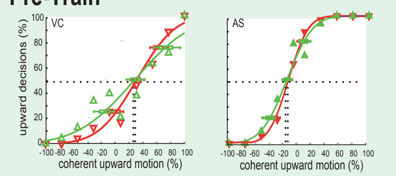
GROUP II: pair low frequency + up/ high frequency + down

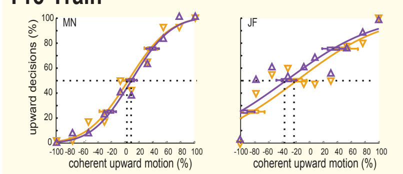
Motion direction discrimination is influenced by the learned association

Color-Motion Pairing

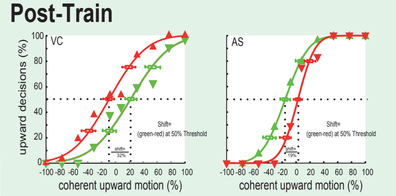
Auditory-Motion Pairing

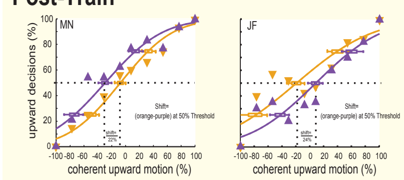
Pre-Train



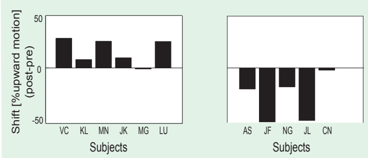


Post-Train



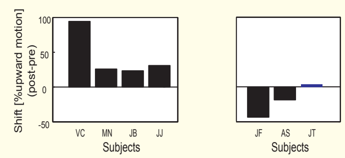


Summary Across Subjects Post-Pre



Pre-Train: 30 repeats total (4800 trials); Post-Train: 33 repeats total (5280 trials): mean ~ 5 repeats/subject;160 trials/repeat

Summary Across Subjects Post-Pre



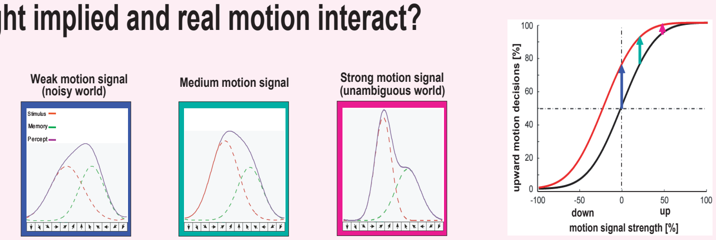
Pre-Train: 30 repeats total (4800 trials); Post-Train: 33 repeats total (5280 trials); mean ~ 5 repeats/subject; 160 trials/repeat

-> Subjects' motion direction discrimination performance after training was influenced by the learned color or auditory frequency pairing.

-> The direction of the shift in the psychomertic function depended on the learned association (rank sum: color+motion p=0.0034; auditory+motion p=0.028).

-> We found no significant changes in the slope of the psychometric functions before vs after training.

How might implied and real motion interact?

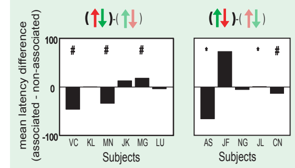


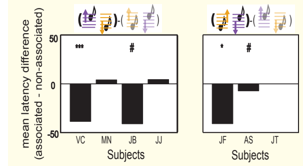
Reaction times tend to be faster for associated stimuli

Color-Motion Pairing

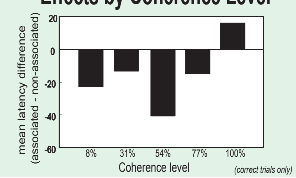
Auditory-Motion Pairing

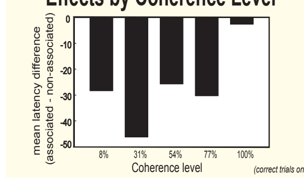
Summary Across Subjects Associated - NonAssociated





Effects by Coherence Level





-> Reaction times tended to be faster (more negative) for associated vs non-associated combinations. Although several subjects showed individually significant effects, there was no overall significant effect across subjects (ranksum p>0.05).

-> Latency benefits for associated stimuli tended to be strongest at medium coherence levels, when there was some detectable motion signal in the stimulus, not at the lowest (8%) coherence levels when subjects were most uncertain. These effects were not significant (Kruskalwallis p>0.05).

These results suggests that subjects were not simply responding reflexively to a particular color or tone.

CONCLUSIONS

-> As predicted by our physiological findings in area MT of macaques (Schlack & Albright, 2007), subjects can use cues they learn to associate with visual motion to disambiguate motion directions in noisy environments.

-> We find associative plasticity if visual motion is paired with features other than shape, i.e. color or tones.

-> Our findings extend previous work showing that the learning of naturally occuring associations between static images and visual motion can evoke responses in motion sensitive brain areas (Kourtzi & Kanwisher, 2000; Krekelberg et al., 2007; Lorteije et al., 2007) and influence perception (Lorteije et al., 2007; Winawer et al., 2008).

-> Our findings are also in line with studies of cue recruitment showing that the visual system can be trained to use newly learned cues to construct visual percepts (e.g., Haijiang et al., 2006).

-> These results are unlikely to solely result from motor bias; motor output was orthogonal to judgments of visual motion direction and latency analyses suggest that judgments were not simply reflexive responses to a particular color or tone. Our future work will consider the role of response bias and feature-based attention in this paradigm, as well as changes in early human visual cortical areas.

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