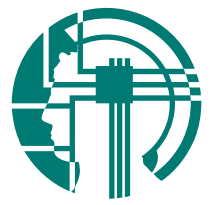# Multi-sensory interactions in perceptual and response selection processes

MAX-PLANCK-GESELLSCHAFT

MPI FOR BIOLOGICAL CYBERNETICS

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Introduction

To categorize complex stimuli such as familiar objects or actions, the human brain integrates information from multiple senses. At the behavioral level, multi-sensory integration (MSI) of congruent information facilitates detection, identification and categorization of objects in our environment. At the neuronal level, MSI has been associated with non-linear response enhancements (superadditivity) and suppressions (subadditivity) for bi-modal stimuli relative to their unimodal components. Audio-visual interactions have been observed in a distributed subcortical and cortical system encompassing putative 'unisensory' regions as well as higher-order association areas. Yet, the types of information that are integrated within these regions remain unclear ranging from low-level (spatial-temporal) to higher-order (content related) perceptual information. Furthermore, multi-sensory interactions may emerge for decisional or executive processes.

Scientific Aims

1. To dissociate neural systems sustaining integration of low-level vs. higher- order audio-visual information independent of task context.

2. To identify multi-sensory interactions at the decisional (i.e. executive) level irrespective of stimulus levels.

Experimental Design

1. Levels of Stimulus Feature Integration:
• "High+*Low* Level" design allows the detection of integration sites of low-level (spatial-temporal) *and* higher-order (content-related) information.
• "High Level Only" design allows detection of integration sites specifically of higher-order information by controlling for low-level features.
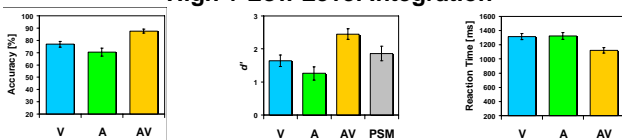
2. Task Context:
• "Active Categorization Task" – decisional processes: high.
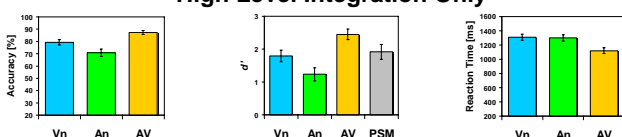• "Passive Target Detection Task" – decisional processes: low.
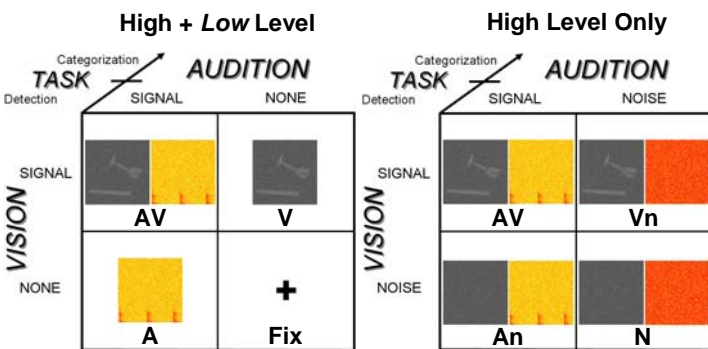
Stimuli: Movies of tools and musical instruments embedded in white noise.

Behavioral Results

High + *Low* Level Integration

High Level Integration Only

fMRI Acquisition and Analysis

• Data acquisition:
  - SIEMENS TimTrio 3T scanner, GE-EPI, TE=40ms, 38 axial slices, TR = 3.08s, voxel size 3x3x3 mm.
  - 21 subjects: 4 sessions 242 volumes each.
• Data Analysis:
  - SPM5, Event-Related Analysis (HRF, temporal derivative).
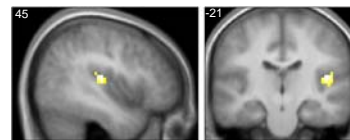 - Random Effects Analysis, 2nd Level ANOVAs to enable Conjunction Analysis, $p<0.05$ corr. at cluster level.
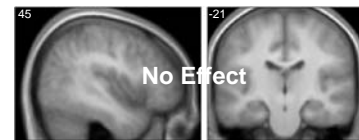
fMRI Results

1. Effect of Level of Stimulus Feature Integration
Conjunction analysis across tasks.

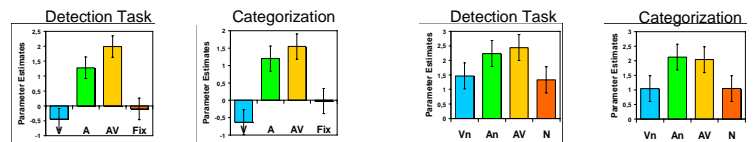**a. Super**additive audio-visual interactions:

Direct comparison: High + *Low* Level > High Level Only

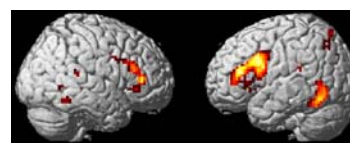**b. Sub**additive audio-visual interactions: none.

2. Effect of Task Context
Conjunction analysis across stimulus levels.

a. Superadditive audio-visual interactions: none.
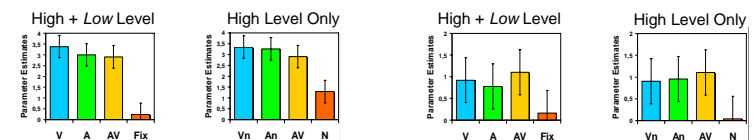
b. Subadditive audio-visual interactions:

Direct comparison: Categorization > Target Detection

Summary & Conclusions

• Superadditive audio-visual interactions in Heschl Gyrus (HG).
  - Only for High + *Low* stimuli irrespective of task.
  ➢ "Automatic" integration of low-level audio-visual features.

• Subadditivity in the inferior frontal sulcus (IFS), the intraparietal sulcus (IPS), in the insula (INS) and inferior temporal gyrus (ITG).
  - Only for categorization task irrespective of level of stimulus feature integration.
  ➢ Interactions at decisional (i.e. executive) level.

Multi-sensory interactions can emerge at multiple levels, with HG involved in "automatic" integration of low-level audio-visual features and IFS, IPS, INS and ITG reflecting multi-sensory facilitation of response selection.