Neuronal responses to incongruent face-vocalization stimuli during an audiovisual non-match to sample task in the ventrolateral prefrontal cortex of the primate

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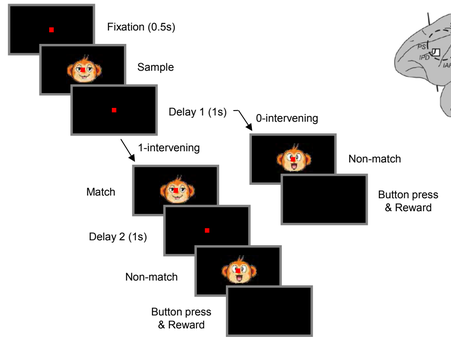
Introduction

Our previous work indicates that neurons in the primate ventrolateral prefrontal cortex (VLPFC) are multisensory and respond to combined audio-visual communication stimuli (Sugihara et al. (2006) J. Neuroscience 26:11138-11147). To further investigate the role of the VLPFC in sensory integration, we recorded single-cell activity in VLPFC (areas 12/47 and 45), while rhesus macaques performed a discrimination (non-match to sample) task with face-vocalization stimuli in which we altered either the auditory or visual track of the vocalization movie as the non-match stimulus.

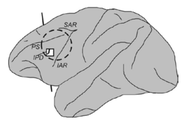
Methods

The trial begins when the animal fixates a central point on the computer screen. Then one of two sample movies is presented. After a 1s delay period, the second movie is played. If the second movie differs from the sample movie in either the auditory or video track, or both (non-match stimulus, 0-intervening trial), the animal indicates the detection of the non-match by pressing a button. If the second movie is identical to the sample movie (match stimulus, 1-intervening trial), another 1s delay follows before the non-match movie is presented. A trial is aborted when the animal breaks fixation during movie presentation or presses the response button before the non-match stimulus appears. One third of the trials in a block was composed of 1-intervening trials to prevent guessing or random responses. Single-neuron activity was recorded from the VLPFC of both hemispheres of a single monkey.

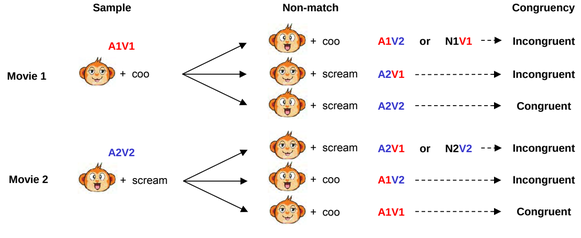
Non-match to Sample Task



Recording Site



Manipulation of Non-match Stimuli



Results

BEHAVIORAL PERFORMANCE. We performed132 recording sessions using modulated noise to replace the vocalization of the movie and 86 sessions where we switched the visual portion of the movie. The subject's performance was well above chance. In these two versions of the task 6.8% and 7.4% of trials were coded as incorrect. Including the trials in which the animal did not respond (no button press), the average error rate was 13.6% and 12.9%, respectively.

ANALYSIS OF NEURAL DATA. Since responses to the multisensory audio-visual stimuli occurred throughout the movie presentation, we tested several analysis windows around the time of movie presentation. Neural activity during non-match (NM) stimuli in the 0-intervening trials was analyzed with the following generalized linear model. Spike counts were converted into spike rate, if necessary.

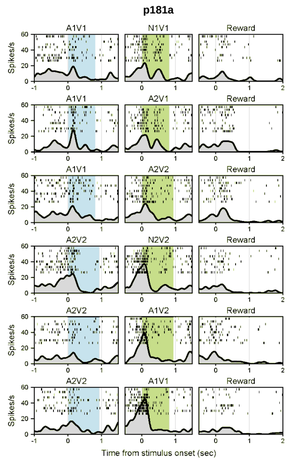
Model : NM activity = a0 + a1*MT + a2*NM1 + a3*NM2

MT: Movie type (0 : Movie 1; 1 : Movie 2)

NM1: Non-match type (congruency contrast) (-1 : Video (or Noise) switch 1; -1 : Audio switch -1; 2 : AV switch 0)

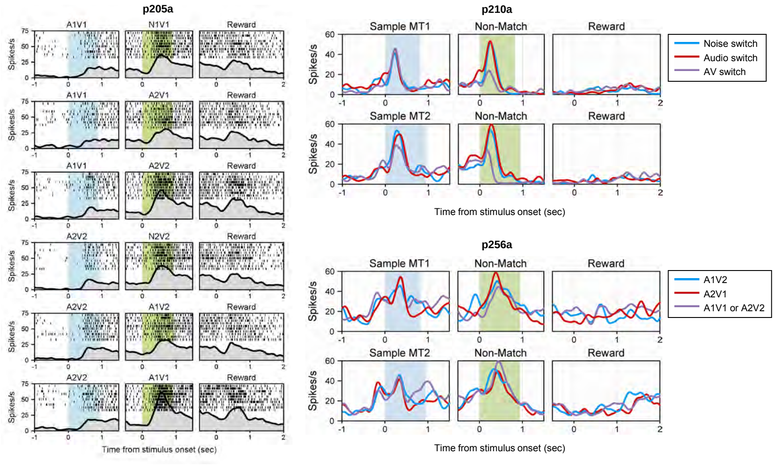
+ a4*MT*NM1 + a5*MT*NM2

Fig 1. Neuron with movie type effect



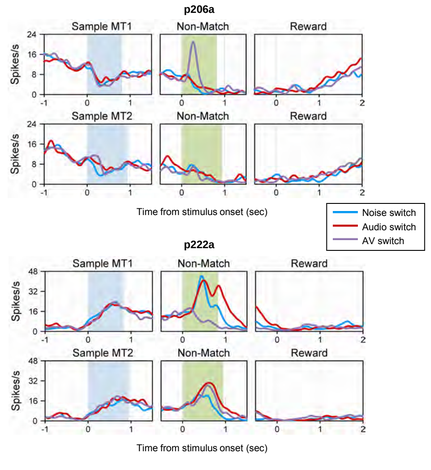
This is an example neuron in which coefficient a1 (sample movie type effect) of our model was significant. The activity during the non-match period (green background) was different depending on which sample movie type was presented but it does not seem to be affected by different non-match conditions.

Fig 2. Neuron with congruency effect



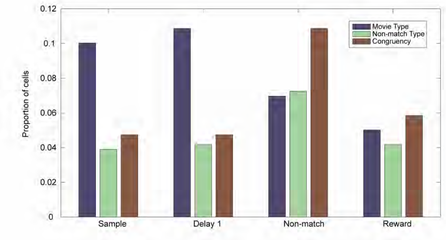
The effect of congruent / incongruent stimuli was tested by the NM1 term in our model. The peak activity of these neurons in congruent conditions are higher (p205a) or lower (p210a) than that in the conditions where the audio or video track was switched.

Fig 3. Neuron with interaction effect between movie type and congruency



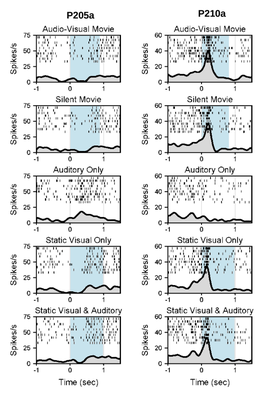
These are examples in which stimulus congruency had an effect for only one sample movie type. This effect is indicated by significance of coefficient a4.

Population Result



We computed the proportion of cells which showed significant effect (α=0.05) of the sample movie type (MT), non-match type (NM), and congruency contrast based upon our model. Since NM is coded with two variables, α level is corrected for each term to meet 5% criteria, but, for congruency contrast, the correction was not applied because it is an *a priori* test. The meaning of the effect of NM type may depend on whether the visual switch (A1V2, A2V1) or the audio-noise switch (N1V1, N2V2) was used, but since the coding scheme is the same, we combined the results (Number of cells N=337).

Comparison with previous work



We also tested neurons with a passive viewing task we used in our previous work. (Sugihara et al. (2006) J. Neuroscience 26:11138-11147). Some cells which were active in the non-match to sample task also showed audio & visual response in this passive task, but the multisensory response in the passive task was not significant, overall. The cell on the left pane shows a significant auditory effect, and the cell on the right pane shows a significant visual effect, but they are active only one sensory modality and there is no significant interaction between the auditory and visual responses.

Conclusions

1. Neurons in VLPFC respond during particular task epochs (sample, delay, non-match, reward periods).

2. Some neurons showed activity related to stimulus congruency or were affected by both stimulus and task factors.

3. Multisensory responses may be affected by the type of task used to assess them.

Acknowledgments

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