1Study information

**Title:**

An event-related potentials study of neural signals for perceptual decision making under uncertainty : A replication of O’Connell, Dockree, & Kelly (2012).

（作者）

The purpose of this study was to detect the neural signals evoked when subjects made perceptual decisions under four different conditions by separating the neural features of sensory evidence and evidence accumulation using a gradual target detection task. The results show that the CPP component is the neural signal that represents the accumulation of evidence in perceptual decision making.

**Hypothesis**

The experiment consisted of four different conditions. In the first condition, the participant continuously viewed a continuously flickering annulus, which gradually decreased in contrast, and responded with the right-hand button when the subject perceived the decrease in contrast; In the second condition, the task is the same as in the first condition, but instead of button responses, participant mentally count the number of circles that appear; In the third condition, the task was the same as in the first condition, but subjects were asked to stop focusing on the circle and instead pay attention to the changes in the background pattern; In the fourth condition, the visual stimulus was replaced with an auditory stimulus by having participants monitor a continuous tone for targets that were defined by a gradual drop in volume, the tone was envelope-modulated at 40Hz, When a decrease in volume is perceived, the participant responds by pressing the button with the right hand.

H1: We predict that all four conditions would evoke neural signals for sensory evidence: SSVEP/SSAEP. Sensory evidence decreases as visual/auditory stimuli diminish.

H2: We predict that the first condition would induce neural signals with evidence accumulation: LHB & CPP. The rate of accumulation of neural signals increases with response time and peaks at the time of making a response.

H3: We predict that the third condition would only evoke CPP. The change of neural signal is the same as in the first condition.

H4: We predict that the fourth condition won’t evoke CPP.

2Design Plan

**Stimulus**

Condition1: Seated 50cm from the monitor. White square background with 5\*5 pixels. An annulus ( inner radius = 1.14°, outer radius = 2.29° ) with 65% contrast on the background, the annulus is divided into 16 parts, two adjacent parts alternate in light and dark gray color. The annulus is flickering at 21.25Hz. In one trial: the contrast linear changes from 65% to 35% in 1.6s then linear changes from 35% to 65% in 0.8s. When a decrease in contrast is detected, participants use their right index fingers responding by pressing the button. The interval between each trial is randomized (4s、7.2s、10.4s). Each block has a total of 25 trials, with an interval of 7.2s between 9 trials, 4s between 8 trials, and 10.4s between 8 trials. A total of eight blocks were performed in this condition.

Condition2: The second condition has the same stimulus as the first condition. The difference is that participants do not perform a button response, but mentally counts the number of annuluses that appear in a block and reports the number at the end of each block. Each block consists of 23 to 27 trials

Condition3: [ To establish the extent to which the CPP was specifically elicited by task- relevant sensory information, participants performed two further blocks in which they were presented with the same flickering annulus but were asked to monitor the central fixation square for transient (100 ms) increases in size from 5 to 10 pixels (condition 3). Participants were asked to indicate these fixation targets with a speeded button press. Gradual decreases in the contrast of the sur- rounding annulus, identical to those defining the target in conditions 1 and 2, continued to occur, but were rendered irrelevant by the task instructions. Identical inter-trial intervals intermediated between gradual changes. Fixation targets were presented at random times between the offset of an annulus contrast change and 800 ms preceding the following contrast change. ] 、[ A final key characteristic of a true decision variable is that it should only be responsive to goal-relevant sensory information. To test this, we returned to the original version of our task and introduced an additional condition in which participants ignored the annulus and instead monitored a small square at fixation for sudden transient increases in size. ]

Condition4: [ We first translated our task into the auditory domain by having participants monitor a continuous tone for targets that were defined by a gradual drop in volume. The tone was envelope-modulated at 40 Hz. ]、[ A 9-cm diameter circular pattern with linearly increasing contrast from 0 to 100% from center to perimeter was flickered at fixation at 21.25 Hz during auditory performance to allow direct comparison with task version 1, but, again, its contrast was held constant at all times. ?]

**Study design**

The study uses a between-participants experiment design. Each condition contains 24 participants.

**Randomization**

For participants, they are randomly assigned to participate in one of the experimental conditions.

**Blinding**

Participants do not know the purpose of the experiment, and the experimenter knows the purpose and assignment of the experiment.

3Sampling Plan

**Existing data**

[ Registration prior to creation of data. ]

**Explanation of existing data**

**Data collection procedures**

Participants will be recruited through advertisements at NNU. Participants will receive 50 CNY as payment. Participants must be at least 18 years old and have a max age of 27 years. Participants should report of being right-handed, not suffering of epilepsy or other neurological disorders, and of not being under the effect of psychotropic drugs. Participants not fulfilling these criteria will not be tested.

**Data size**

96 participants with full data. Our goal was to collect at least 80 clean data sets from 96 participants.( at least 20 copies of each condition) .

Sample size rationale

4Variables

**Manipulated variables**

Between participants variables:

stimulus channel ( visual/auditory )、response mode ( keystroke/counting ).

Within participants variables:

Visual: Contrast ratio reduced from 65% to 35% ( condition1,2,3 )

Auditory: 30% reduction in sound level from 70dB ( condition4 )

Number of trials in each block varies randomly between 23 and 27 (condition2 )

**Measured variables**

RT ( condition1,3,4 )

Detection accuracy ( condition1,2,3,4 )

SSVEP/SSAEP、accumulated SSVEP/SSAEP: participants responded 1.2s before(-1.2s) to responding ( 0s ) (condition 1,3,4)

LHB: stimulus start（0-2）、beginning 1.2s before response (condition 1,2,3,4)

CPP: stimulus start（0-2）、beginning 1.2s before response (condition 1,2,3,4)

[ SSVEP (21.25 or 20 Hz depending on task version), SSAEP (40 Hz) and LHB (22–30 Hz, avoiding the SSVEP frequency) were measured using the standard short-time Fourier transform with a boxcar window size fitting exactly eight cycles of the SSVEP frequency and 50-ms step size. SSVEP was averaged over seven electrodes centered on standard 10–20 site Oz. SSAEP was averaged across three midline electrodes running posteriorly from standard site Fz. LHB was averaged over three electrodes around standard left-hemisphere motor site C3. ]

[ The CPP analysis consisted simply of averaging the single-trial waveforms, which were baseline-corrected relative to the 500-ms interval before target onset. CPP amplitude and latency measures were taken from the average of three electrodes centered on standard site CPz ].

5Equipment

Geodesic EEG System 400

6EEG Recording

Continues EEG activity will be amplified using an SynAmps system from 64 electrodes, digitized at 512Hz. Eye movements were recorded using two vertical electro-oculogram (EOG) electrodes placed above and below the left eye and two horizontal EOG electrodes placed at the outer canthus of each eye. Data was analyzed in MNE. Noisy EEG channels were interpolated using spherical spline interpolation implemented in MNE and EEG data were re-referenced offline to the average reference.

Target epochs were extracted from 750 ms before target onset to 400 ms after peak sensory evidence. Trials were rejected if the bipolar vertical EOG signal exceeded ±200 μV at any time in the epoch or if any scalp channel exceeded 100 μV.

SSVEP(21.25HZ), LHB(22-30Hz) were measured using the standard short-time Fourier transform with a boxcar window size fitting exactly eight cycles of the SSVEP frequency and 50-ms step size. SSVEP was averaged over seven electrodes centered on standard 10–20 site Oz. LHB was averaged over three electrodes around standard left-hemisphere motor site C3. The CPP analysis consisted simply of averaging the single-trial waveforms, which were baseline-corrected relative to the 500-ms interval before target onset. CPP amplitude and latency measures were taken from the average of three electrodes centered on standard site CPz.

Target epochs were extracted from 750 ms before target onset to 400 ms after peak sensory evidence. Trials were rejected if the bipolar vertical EOG signal exceeded ±200 μV at any time in the epoch or if any scalp channel exceeded 100 μV.

7Analysis Plan