Abstract

- Visual perceptual learning (VPL) is defined as the long-term enhancement of performance in visual tasks through practice or experience. (Watanabe & Sasaki, 2015)
- VPL is an extremely valuable tool for neuroscience and psychophysics, and it has shown significant promise as a method of treatment for certain visual neuropathologies such as amblyopia.
- VPL demonstrates high degrees of restriction, often referred to as the “curse of specificity.” This means that training may not transfer to other stimulus features, retinal locations, or tasks. This poses a major obstacle to VPL’s use in clinical applications. (Levi & Li 2009)
- This registered report proposes a series of experiments to test the primary hypothesis that VPL of natural stimuli is less restricted in both task-relevant and task-irrelevant conditions than VPL of unnatural stimuli.
- Three key characteristics of natural stimuli—vertically and horizontally dominant orientations, specific spatial frequency distributions of 1/f, and categorical organization—will each be investigated as a possible source of the increased accessibility and transferability of VPL in natural stimuli.

Background

- The anatomical location of plastic changes produced by VPL training has traditionally been one of the most controversial subjects in VPL research.
- VPL can occur in both task-relevant and task-irrelevant exposure conditions; however, task-irrelevant VPL can only occur if the stimulus is subthreshold (Watanabe, et al. 2001).
- The dual plasticity model has been proposed in order to describe task-relevance and the types of plasticity that occur in VPL (Watanabe & Sasaki, 2015).
- Feature-based plasticity occurs in both task-relevant and task-irrelevant conditions and likely occurs at the early-to-mid stages. It is possibly governed by a reinforcement system modified by feedback to task-performance (Seitz & Watanabe 2005).
- Task-based plasticity only occurs under task-relevant conditions and appears to only occur in the late-stage.
- NS and US demonstrate significant differences in the degree of VPL restrictions.
- Detection of NS occurs much more readily and efficiently than detection of US (Li, et al. 2002).
- NS images demonstrate three key characteristics that will be explored in this study:
  - Dominance of vertical and horizontal orientations (V/H dominance)
  - Specific spatial frequency (SF) distributions of 1/f
  - Categorical organization.

Hypotheses

1. VPL is a function of suprathreshold NS images transfer to untrained retinal locations and orientations than VPL with US images.
2. VPL is a function of NS images transfers to untrained retinal locations and orientations than VPL with US images.
3. VPL is a function of NS images transfers to untrained retinal locations and orientations than VPL with US images.
4. VPL is a function of NS images transfers to untrained retinal locations and orientations than VPL with US images.

Methods

Participants
- 12 young, healthy subjects recruited for each condition or sub-condition.
- Subjects must have not participated in any previous VPL studies.
- Subjects will be screened for past medical history and must have normal or corrected-to-normal vision, as determined by a Snellen acuity test and an Ishihara color test.

I-VPL Conditions
- Exposure:
  - Rapid Serial Visual Presentation (RSVP)
  - Background orientation stimulus
- Pre- and Post-test:
  - Gabor stimulus
  - Orientation discrimination task
  - Two-interval forced choice (2-IFC) orientation detection task

R-VPL Conditions
- Exposure:
  - Orientation discrimination task
- Pre- and Post-test:
  - Orientation discrimination task
  - Two-interval forced choice (2-IFC) orientation detection task

Transfer Conditions
- For each of the following, subjects randomly selected for one stimulus exposure and tested on performance with both stimuli.
  - Location – Left or right of fixation point
  - Orientation – Trained or untrained orientation
  - Task (R-VPL only) – Discrimination or 2-IFC task

Discussion

- If one of either I-VPL or R-VPL demonstrates an increased ability to transfer across locations and orientations when a NS is used in orientation training, this would suggest that there is a difference in feature-based plasticity and likely early-to-mid stage mechanisms.
- If R-VPL demonstrates task transfer, this would demonstrate a difference in task-based plasticity and likely late-stage mechanisms.
- Data analysis will consist of a series of two-way analysis of variance (ANOVA) tests to determine significant main and interaction effects.
- Future research should focus on implementing brain-imaging methods such as functional magnetic resonance imaging (fMRI) and magnetic resonance spectroscopy (MRS) to determine how changes in processing might be induced and where they’re acting within the brain.
- Future research should also examine the effects of other NS characteristics on VPL.

References


Materials

- 20 natural background images will be selected from the database provided by MIT’s computational vision lab.
- NS images will be processed using a Sobel wavelet filter to detect and extract edges from within the image and to measure dominant orientation and spatial frequency distribution.
- 20 Random dot images will be generated with mean luminance spectra of the NS images. An inverse Sobel filter will be applied to give the same orientation spectra as the NS images. Lastly, a reverse Fourier transform will be used to match the mean SF distribution of the NS images.
- Trained orientations will be set at 45º or 138º from vertical.

NS Characteristic Stimuli

- VPL dominant stimuli will be oriented at 90º.
- Different images are specific SF stimuli, so a control for VH and SF stimuli will be created with random SF and orientation.
- Categorical organization stimuli will be either 1-category or 2-categories. Arrays of colored line segments will be used, with colors (green & green versus green & yellow) being used as the two categories.