

Submission ID #: 70954

Scriptwriter Name: Poornima G

Project Page Link: <https://review.jove.com/account/file-uploader?src=21641018>

Title: A Battery of Quantitative Binocular Vision Tests for Adults: Testing Protocols

Authors and Affiliations:

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Author Questionnaire

- 1. Microscopy:** Does your protocol require the use of a dissecting or stereomicroscope for performing a complex dissection, microinjection technique, or something similar? **No**
- 2. Software:** Does the part of your protocol being filmed include step-by-step descriptions of software usage? **Yes, all done**
- 3. Filming location:** Will the filming need to take place in multiple locations? **No**
- 4. Testimonials (optional):** Would you be open to filming two short testimonial statements **live during your JoVE shoot**? These will **not appear in your JoVE video** but may be used in JoVE's promotional materials. **No**

Current Protocol Length

Number of Steps: 27

Number of Shots: 55 (41 SC)

Introduction

Videographer: Obtain headshots for all authors available at the filming location.

Authors: Please note that **the questions will not appear on screen.** Please answer in **stand-alone full sentence with sufficient context**

INTRODUCTION:

~~REQUIRED: Summarize your research focus and the main questions it aims to answer.~~

- 1.1. **Xiaoxin Chen:** This protocol presents a battery of eight tests that aims to provide a comprehensive assessment of binocular vision.
 - 1.1.1. Please hold off on assigning this to VO until we receive confirmation from the authors.

~~Describe the research contexts or systems in which this protocol can be applied.~~

- 1.2. **Xiaoxin Chen:** These tests are designed to reveal hidden binocularity in patients who show no stereo vision in current clinical tests.
 - 1.2.1. Please hold off on assigning this to VO until we receive confirmation from the authors.

CONCLUSION:

~~What does this protocol allow researchers to study or measure?~~

- 1.3. **Fermin Retnavarathan:** The eight tests in our battery provide valuable insights into sensory fusion, peripheral stereopsis and motion-in-depth perception.
 - 1.3.1. Please hold off on assigning this to VO until we receive confirmation from the authors.

~~Describe the most important consideration or challenge when performing this protocol.~~

- 1.4. **Fermin Retnavarathan:** The most important consideration is to provide clear instruction to ensure participants understand each task correctly.
 - 1.4.1. Please hold off on assigning this to VO until we receive confirmation from the authors.

~~How can future studies build on this work? Describe the questions or research directions that can be investigated next.~~

1.5. **Fermin Retnavarathan**: We aim to better understand how binocular vision develops to guide future rehabilitation in amblyopia.

1.5.1. Please hold off on assigning this to VO until we receive confirmation from the authors.

Videographer: Obtain headshots for all authors available at the filming location.

Ethics Title Card

This research has been approved by the University of Waterloo Office of Research Ethics
and the McMaster Research Ethics Board

Protocol

***Videographer:** Please always record an audio slate while filming each shot mentioned in the shotlist.*

2. Mirror Stereoscope Alignment and Main Menu Steup

Demonstrator: Xiaoxin Chen

- 2.1. To begin, set up and calibrate the mirror stereoscope and the monitor [1] and open the BinocularBattery.py (*binocular battery pie*) script in PsychoPy (*psycho-pie*) Coder [2].
 - 2.1.1. WIDE: Talent standing beside the mirror stereoscope and monitor and turning the system on.
 - 2.1.2. SCREEN: JoVE70954_Screen 1.mp4. 00:07-00:09 and 00:18 to 00:26
- 2.2. Modify the monitor information in PsychoPy Monitor Center and in the script, including the monitor's name, viewing distance, screen size, refresh rate, resolution and gamma calibration according to the monitor in use [1]. Click the **Run experiment** button at the top [2].
 - 2.2.1. SCREEN: JoVE70954_Screen 1.mp4.. 00:26-00:40
 - 2.2.2. SCREEN: JoVE70954_Screen 1.mp4.. 00:46-00:51
- 2.3. Next, instruct a participant to look through the mirror stereoscope [1].
 - 2.3.1. Talent guiding the participant to position their eyes at the mirror stereoscope.
- 2.4. Ask the participant if a cross is visible in the middle, comprised of a vertical line and a horizontal line [1]. If not, ask whether the vertical line should move to the left or right [2].
 - 2.4.1. Talent speaking to the participant while the participant looks through the stereoscope.
 - 2.4.2. Talent asking for directional feedback from the participant while moving their hands left or right to describe the action.

- 2.5. Use the left and right arrow keys to move the vertical line in the indicated direction until it aligns at the center of the horizontal line [1].

2.5.1. SCREEN: JoVE70954_Screen 2.mp4. 00:13-00:16

- 2.6. Assign and input a participant identification [1]. At the Main Menu screen, use the numeric pad to select among the eight available tasks [2].

2.6.1. SCREEN: JoVE70954_Screen 2.mp4. 00:16-00:19

2.6.2. SCREEN: JoVE70954_Screen 2.mp4. 00:20-00:25

3. Fine Peripheral Stereopsis Testing

- 3.1. Select the **Fine Peripheral Stereopsis** task from the Main Menu [1].

3.1.1. SCREEN: JoVE70954_Screen 2.mp4. 00:52-00:53 *Video editor: Highlight Fine Peripheral Stereopsis .*

- 3.2. Start by running a practice test [1] and choose the **Stationary** task to familiarize the participant and provide the required instructions [2].

3.2.1. SCREEN: JoVE70954_Screen 2.mp4. 00:53-00:55 *Video editor: Highlight Practice*

3.2.2. SCREEN: JoVE70954_Screen 2.mp4. 00:56-00:58 *Video editor: Highlight Stationary*

- 3.3. Instruct the participant to fixate on the cross, wherever it is presented on the screen [1]. Ask the participant whether the black square appears behind or in front of the white frame or on the same plane [2] and press 1 if the depth is perceived or 2 if no depth is perceived [3]. Complete the practice test and evaluate the results [4].

3.3.1. Talent instructing the participant while the fixation cross appears on screen.

3.3.2. Talent questioning the participant as the stimulus is displayed on the screen beside.

3.3.3. SCREEN: JoVE70954_Screen 2.mp4. 01:00-01:10

3.3.4. SCREEN: JoVE70954_Screen 2.mp4. 01:56-02:04

- 3.4. If the practice results are below 80 percent correct, press Enter and restart the practice test [1].

3.4.1. SCREEN: JoVE70954_Screen 2.mp4. 01:35-01:39

- 3.5. Next, proceed to run the **Regular** practice when the results are above 80 percent correct for the Stationary practice [1]. Inform the participant that the stimulus will flash twice and the depth will appear in one of the two flashes. Instruct the participant to report in which of the two flashes the depth is observed [2].

3.5.1. SCREEN: JoVE 70954_Screen 3.mp4. 00:26-00:29

3.5.2. SCREEN: JoVE70954_Screen 3.mp4. 00:30-00:0 and 01:20-01:28

- 3.6. Then, run a formal test when practice results are above 80 percent correct [1]. Once the task is completed, press Enter to return to the Main Menu [2].

3.6.1. SCREEN: JoVE70954_Screen 3.mp4. 01:29-01:33

3.6.2. SCREEN: JoVE70954_Screen 3.mp4. 01:35-01:40

4. Dynamic Local Stereopsis Testing

- 4.1. Select the **Dynamic Local Stereopsis** task from the Main Menu [1].

4.1.1. SCREEN: JoVE70954_Screen 4.mp4. 00:38-00:41 *Video editor: Highlight Fine Dynamic Local Stereopsis*

- 4.2. Start by running a practice test [1]. Among the four practice types that allow step-by-step familiarization, run the practice **Task 1** for a single location and a single interval [2].

4.2.1. SCREEN: JoVE70954_Screen 4.mp4. 00:41-00:43 *Video editor: Highlight Practice*

4.2.2. SCREEN: JoVE70954_Screen 4.mp4. 00:43-00:44 *Video editor: Highlight 1 = Left left signal only*

- 4.3. Instruct the participant to look at the center while paying attention to the specified target location [1]. Ask the participant whether the square moved closer or farther away. Instruct them to use peripheral vision if it is helpful [2]. Press 1 if motion in depth is observed, or 2 if not [3].

- 4.3.1. ~~Talent instructing the participant while the stimulus is displayed.~~
SCREEN: JoVE70954_Screen 4.mp4) 00:45-00:50. **TXT: This is a binocular task**
- 4.3.2. Talent questioning the participant during stimulus presentation.
- 4.3.3. SCREEN: JoVE70954_Screen 4.mp4. 00:47-00:55

- 4.4. Proceed to the next practice task if the participant reports motion in depth. Run the practice Task 2 for a single location with a two-interval forced-choice task [1].
 - 4.4.1. SCREEN: JoVE70954_Screen 4.mp4. 00:56-01:01 *Video editor: Highlight 2 = Left 2IFC*

- 4.5. Inform the participant that the stimulus will flash twice [1]. Ask the participant which of the two flashes contains motion in depth at the specified target location [2]. Press 1 or 2 based on the participant's choice [3]. If the participant cannot reliably perceive motion in depth, reinstruct the participant and allow direct viewing of the target location [4].
 - 4.5.1. SCREEN: JoVE70954_Screen 4.mp4. 01:02-01:06
 - 4.5.2. Talent questioning the participant during the task.
 - 4.5.3. SCREEN: JoVE70954_Screen 4.mp4. 01:05-01:21
 - 4.5.4. Talent reinstructing the participant.

- 4.6. If the participant correctly identifies motion in depth, run the practice Task 3 for two locations with a two-interval forced-choice task [1]. Provide the same instructions as in the previous task, except that the target may appear at either of two locations [2].
 - 4.6.1. SCREEN: JoVE70954_Screen 4.mp4 01:22-01:25 *Video editor: Highlight 3 = Left or Right 2IFC*
 - 4.6.2. SCREEN: JoVE70954_Screen 4.mp4. 01:23-01:44

- 4.7. Next, run the practice Task 4. In this case, the target may appear at any of the four peripheral locations [1].
 - 4.7.1. SCREEN: JoVE70954_Screen 4.mp4. 01:45-03:01 *Video editor: Highlight 4 = Full practice*

- 4.8. Review the test results carefully. If the practice results are below 80 percent correct, ask the participant to restart the practice [1].

4.8.1. SCREEN: JoVE70954_Screen 4.mp4. 03:02-03:09

4.9. When ready, run the **Dynamic Periphery** and **Dynamic Center** for the formal test. Once the task is completed, press **Enter** to return to the Main Menu [1].

4.9.1. SCREEN: JoVE70954_Screen 4.mp4. 03:13-03:20 *Video editor: Highlight Dynamic Periphery and Dynamic Center*

5. Pulfrich Task and Response Box Depth Matching

5.1. Select the **Pulfrich** task from the Main Menu [1].

5.1.1. SCREEN: JoVE70954_Screen 4.mp4. 03:25-03:27 *Video editor: Highlight Pulfrich task*

5.2. Start by running a practice test. Ask the participant whether the depth is visible and whether the moving moons appear in front of or behind the stars [1].

5.2.1. SCREEN: JoVE70954_Screen 4.mp4. 03:30-03:40

5.2.2. ~~Talent asking the participant about perceived depth and relative motion of moons and stars.~~

5.3. Ask the participant to use the slash or asterisk key to move the stationary moon at the bottom of the screen forward or backward until it appears at the same depth as the moving moons [1]. Optionally, ask the participant to indicate the perceived depth using the response box [2].

5.3.1. SCREEN: JoVE70954_Screen 4.mp4. 03:59-04:03

5.3.2. Talent introducing the response box to the participant.

5.4. Present the response box facing the participant with the center positioned approximately 40 centimeters from the participant's eyes [1]. Ask the participant to move the sliders on both sides of the box until the moons inside the box appear at the same depth as the moving moons on the screen [2].

5.4.1. Talent positioning the response box in front of the participant.

5.4.2. Participant adjusting sliders on the response box while observing alignment.

5.5. Type the reading from the slider onto the computer screen [1]. Press the plus button then Enter to continue and complete the rest of the trials [2].

5.5.1. SCREEN: JoVE70954_Screen 4.mp4. 04:13-04:17

5.5.2. SCREEN: JoVE70954_Screen 4.mp4. 04:18-04:25

5.6. For a participant with normal vision, the practice results should show a linear response pattern [1]. Proceed to a formal test if the practice results appear normal, or consistent for the last two practice tests [2].

5.6.1. SCREEN: JoVE70954_Screen 4.mp4. 06:37-06:42

5.6.2. SCREEN: JoVE70954_Screen 4.mp4. 06:44-06:49 *Video editor: Highlight Match actual task*

Results

6. Results

6.1. Results showed fine stereopsis thresholds at the central and at four peripheral locations at 10 degrees eccentricity [1], with lower thresholds at the center compared to the periphery [2].

6.1.1. LAB MEDIA: Figure 4C. *Video editor: Show the five small plots labeled Left, Central, Right, Upper, and Lower.*

6.1.2. LAB MEDIA: Figure 4C. *Video editor: Highlight the Central plot.*

6.2. In the dynamic local stereopsis test, thresholds for crossed and uncrossed disparities at the central and at four peripheral locations were identified [1]. Crossed disparities correspond to stimuli perceived in front of the fixation plane [2], whereas uncrossed disparities correspond to stimuli perceived behind it [3], with slightly lower thresholds observed at the center compared to the periphery [4].

6.2.1. LAB MEDIA: Figure 6C. *Video editor: Show all five plots labeled Upper, Left, Central, Right, and Lower.*

6.2.2. LAB MEDIA: Figure 6C. *Video editor: Highlight the pink curves and bars*

6.2.3. LAB MEDIA: Figure 6C. *Video editor: Highlight the blue curves and bars*

6.2.4. LAB MEDIA: Figure 6C. *Video editor: Highlight the Central plot.*

6.3. The Pulfrich task results showed a linear relationship between filter strength and perceived depth in both the disparity-matching and the physical depth-matching tasks [1], with intercepts close to zero, indicating no spontaneous Pulfrich effect [2].

6.3.1. LAB MEDIA: Figure 7C,D. *Video editor: Highlight the four dots falling on or very close to the fitted blue straight lines running diagonally across both plots.*

6.3.2. LAB MEDIA: Figure 7C,D. *Video editor: Highlight the “intercept” values shown in the blue boxes and circle the central part of the blue line that intercepts with the vertical x-axis=0 grid*

1. Stereoscope

Pronunciation link: <https://www.merriam-webster.com/dictionary/stereoscope>

IPA: /'steriə,skoʊp/

Phonetic Spelling: ster·ee·uh·skohp

2. Calibrate

Pronunciation link: <https://www.merriam-webster.com/dictionary/calibrate>

IPA: /'kælə,brɛɪt/

Phonetic Spelling: kal·uh·brayt

3. BinocularBattery.py

Pronunciation link: No confirmed link found

IPA: /bə'nɑ:kjələr 'bætəri paɪ/

Phonetic Spelling: buh·naa·kyuh·ler bat·uh·ree pie

4. PsychoPy

Pronunciation link:

<https://www.howtopronounce.com/psychopy>

IPA: /'saɪkoʊ paɪ/

Phonetic Spelling: sy·koh pie

5. Gamma

Pronunciation link: <https://www.merriam-webster.com/dictionary/gamma>

IPA: /'gæmə/

Phonetic Spelling: gam·uh

6. Resolution

Pronunciation link: <https://www.merriam-webster.com/dictionary/resolution>

IPA: /,rezə'lu:ʃən/

Phonetic Spelling: rez·uh·loo·shuhn

7. Participant

Pronunciation link: <https://www.merriam-webster.com/dictionary/participant>

IPA: /pɑ:r'tɪsəpənt/

Phonetic Spelling: par·tiss·uh·puhnt

8. Peripheral

Pronunciation link: <https://www.merriam-webster.com/dictionary/peripheral>

IPA: /pəˈrɪf(ə)rəl/

Phonetic Spelling: puh·rif·er·uhl

9. Stereopsis

Pronunciation link:

<https://www.howtopronounce.com/stereopsis>

IPA: /ˌsteriˈɑːpsɪs/

Phonetic Spelling: ster·ee·aap·suhs

10. Stationary

Pronunciation link: <https://www.merriam-webster.com/dictionary/stationary>

IPA: /ˈsteɪʃəˌneri/

Phonetic Spelling: stay·shuh·nair·ee

11. Fixate

Pronunciation link: <https://www.merriam-webster.com/dictionary/fixate>

IPA: /fɪkˈseɪt/

Phonetic Spelling: fik·sayt

12. Stimulus

Pronunciation link: <https://www.merriam-webster.com/dictionary/stimulus>

IPA: /ˈstɪmjələs/

Phonetic Spelling: stim·yuh·luhs

13. Perceived

Pronunciation link: <https://www.merriam-webster.com/dictionary/perceive>

IPA: /pərˈsiːvd/

Phonetic Spelling: per·seevd

14. Dynamic

Pronunciation link: <https://www.merriam-webster.com/dictionary/dynamic>

IPA: /daɪˈnæmɪk/

Phonetic Spelling: dye·nam·ik

15. Interval

Pronunciation link: <https://www.merriam-webster.com/dictionary/interval>

IPA: /'ɪntərvəl/

Phonetic Spelling: in·ter·vuhl

16. Peripheral vision

Pronunciation link: <https://www.merriam-webster.com/medical/peripheral%20vision>

IPA: /pə'rɪf(ə)rəl 'vɪʒən/

Phonetic Spelling: puh·rif·er·uhl vizh·uhn

17. Reinstruct

Pronunciation link:

<https://www.howtopronounce.com/reinstruct>

IPA: /,riːɪn'strʌkt/

Phonetic Spelling: ree·in·strukt

18. Pulfrich

Pronunciation link:

<https://www.howtopronounce.com/pulfrich>

IPA: /'pʊlfrɪk/

Phonetic Spelling: puul·frik

19. Response box

Pronunciation link: No confirmed link found

IPA: /rɪ'spɑːns bɑːks/

Phonetic Spelling: ruh·spons boks

20. Stationary moon

Pronunciation link: No confirmed link found

IPA: /'steɪʃəˌneri muːn/

Phonetic Spelling: stay·shuh·nair·ee moon

21. Slider

Pronunciation link: <https://www.merriam-webster.com/dictionary/slider>

IPA: /'slaɪdər/

Phonetic Spelling: sly·der

22. Alignment

Pronunciation link: <https://www.merriam-webster.com/dictionary/alignment>
IPA: /əˈlaɪnmənt/
Phonetic Spelling: uh·line·muhnt

23. Eccentricity

Pronunciation link: <https://www.merriam-webster.com/dictionary/eccentricity>
IPA: /ˌɛksənˈtrɪsəti/
Phonetic Spelling: ek·sen·triss·uh·tee

24. Thresholds

Pronunciation link: <https://www.merriam-webster.com/dictionary/threshold>
IPA: /ˈθreʃˌhoʊldz/
Phonetic Spelling: thresh·hohldz

25. Disparities

Pronunciation link: <https://www.merriam-webster.com/dictionary/disparity>
IPA: /dɪˈspərətiz/
Phonetic Spelling: dih·spair·uh·teez

26. Crossed disparities

Pronunciation link: No confirmed link found
IPA: /krɔːst dɪˈspərətiz/
Phonetic Spelling: krawst dih·spair·uh·teez

27. Uncrossed disparities

Pronunciation link: No confirmed link found
IPA: /ʌnˈkrɔːst dɪˈspərətiz/
Phonetic Spelling: un·krawst dih·spair·uh·teez

28. Fixation plane

Pronunciation link: No confirmed link found
IPA: /fɪkˈseɪʃən pleɪn/
Phonetic Spelling: fik·say·shuhn playn

29. Disparity-matching

Pronunciation link: No confirmed link found

IPA: /dɪ'sperəti 'mætʃɪŋ/

Phonetic Spelling: dih·spair·uh·tee mach·ing

30. Physical depth-matching

Pronunciation link: No confirmed link found

IPA: /'fɪzɪkəl depθ 'mætʃɪŋ/

Phonetic Spelling: fiz·uh·kuhl depth mach·ing

31. Intercepts

Pronunciation link: <https://www.merriam-webster.com/dictionary/intercept>

IPA: /'ɪntərˌsepts/

Phonetic Spelling: in·ter·septs

32. Pulfrich effect

Pronunciation link:

<https://www.howtopronounce.com/pulfrich>

IPA: /'pʊlfrɪk ɪ'fekt/

Phonetic Spelling: puul·frik ih·fekt