Novel Methods to Clinically Quantify Suppression and Stereopsis Thresholds in Studies of Amblyopia

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Background

- Two uses of stereopsis tests in routine eye exams:
  - establish whether binocular vision is present and evaluate its quality
  - assess the patient's ability to undertake a visual task that requires certain level of depth perception
- However, currently available clinical tests for stereopsis do not relate to everyday visual tasks, in fact they do not relate to each other.
- Current need for effective clinical tools to evaluate suppression and stereopsis.
- Particularly when fine (thresholds) and accurate measures (no monocular cues) are required (e.g., clinical research for new amblyopia therapy).
- Currently available research methods to evaluate suppression and stereopsis are not practical for clinical use.
- The importance of stereopsis and binocular vision is increasing with the widespread use of 3D technology.

Purpose

- The goal of this cross-sectional study was to explore the clinical feasibility of methods developed by Kwon, Wiecek, Dakin, & Bex (2015) in evaluating stereo acuity and suppression thresholds.

Subjects

- Subjects with various levels of stereopsis and suppression were evaluated:
- n = 18 adults (18 - 32 years)
  (n = 7 with diagnosed amblyopia / strabismus)
- n = 6 children (10 - 17 years)
  (n = 2 with diagnosed amblyopia / strabismus)

- Vision screening:
  - Ocular history
  - Autorefraction and subjective refraction to determine best refractive correction
  - BCVA with LogMAR computer chart
  - Cover Test with best correction
- Subjects wore best refractive correction for all experimental procedures

Methods

Stereopsis and suppression thresholds were compared between the clinical and experimental tests.

1.Stereopsis clinical tests:

a) Random Dot 3 @ 40cm

* Random-dot stereogram
* 900-12.5arcsec, 17 steps

b) Randot® Preschool @ 40cm

* Random-dot stereogram
* 800-40arcsec, 6 steps

c) Frisby real space

* Real depth disparities. Avoiding monocular cues.
* 600 - 5 sec of arc (varying viewing distance)

2.Experimental stereopsis test:

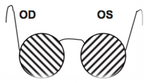
d) Spatial frequency-dependent stereoscopic Sloan letters chart (Kwon et al, 2015)

* Band-pass filtered Sloan letters (SF 0.5, 1.5, 2.5, 5.0 cpd) presented binocularly in 3D computer display (120Hz) and Nvidia 3D Vision 2 glasses (60Hz per eye)
* Subjects asked which letter pops in or out "*One letter will either be closer to you or further away than the other four letters*"

3.Suppression clinical tests:

a)Worth-4 Dot light test @ 40cm & @ 6m

b) Bagolini Striated lenses @ 40cm



* With ND filters (0.3 to 1.8 log units)

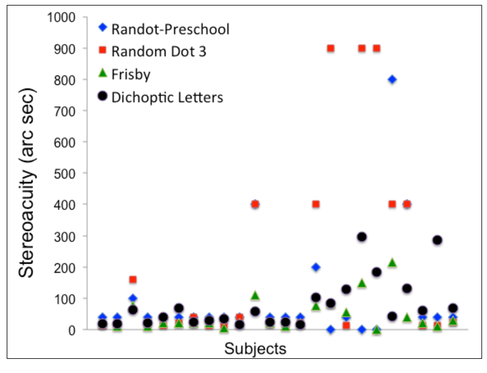
4.Experimental suppression tests

c) Spatial frequency-dependent suppression dichoptic letter chart (Kwon et al, 2015)

* Band-pass filtered Sloan letters presented binocularly in 3D computer display (120Hz) and Nvidia 3D Vision 2 glasses (60Hz per eye)
* Subjects asked "*You should see five letters in each row, please read the letters you see. You may see two letters alternating in one position, choose the letter you see most of the time.*"
* Eye dominance was evaluated using the Miles and Porta test.

Results

Stereopsis



- Bland Altman analyses revealed differences between all tests (p<0.001 for all) due to the different ranges.
- The three clinical stereopsis test were highly correlated (Spearman Rho>0.75, p<0.003).
- The experimental stereopsis threshold test was significantly correlated (average of all spatial frequencies) with the Frisby (Spearman Rho=0.51, p=0.01) and Random Dot 3 (Spearman Rho=0.44, p=0.04) tests, but not with the Randot Preschool test (Spearman Rho=0.41, p=0.06).
- The mid (1.5 and 2.5cpd) spatial frequencies used in the experimental stereopsis test were more closely related to the clinical stereopsis tests (which use broadband stimuli).

Suppression

Subject #	W-4 Dot (D)	W-4 Dot (N)	Bagolini	Balance Point	Dominant Eye
101	0	0	0	0.48	OD
102	0	0	0	0.55	OS
103	0	0	0	0.54	OD
104	0	0	0	0.57	OD
105	0	0	0	0.66	OS
106	0	0	0	0.56	OD
107	0	0	0	0.54	OS
108	0	0	0	0.47	OD
109	0	0	0	0.56	OD
110	0	0	0	0.56	OD
111	**1.5**	**0**	**0.9**	**0.64**	**OS**
112	0	0	0	0.49	OS
113	0	0	0	0.54	OD
114	0	0	0	0.56	OD
115	**0.6**	**1.2**	**0**	**0.72**	**OS**
116	0	0	0	0.46	OS
117	0	0	0	0.51	OD
118	**0.9**	**0**	**0**	**0.82**	**OD**
119	**0.6**	**0**	**0**	**0.57**	**OD**
120	**0.3**	**0.6**	**0**	**0.63**	**OD**
121	**0**	**0**	**0**	**0.79**	**OD**
122	0	0	0	0.54	OS
123	0	0	0	0.55	OD
124	0	0	0	0.39	OS

- Ocular dominance is quantified by the balance point – the interocular contrast ratio at which the letter in each eye is reported with equal probability.
- A balance point significantly different from 0.50 indicates one of the eyes is dominant.
- All subjects who showed suppression in one or more of the clinical tests also showed suppression (balance point > 0.5) with the experimental test.
- For some of these subjects not all clinical tests succeeded at finding suppression.
- One subject with amblyopia (#121) did not show suppression with clinical tests but did with the experimental test.
- Subject #124 (alternating XT) showed dominance with a different eye than predicted by the Porta dominance test.

Discussion

- The experimental stereo-threshold test was correlated with clinical test at mid-spatial frequencies, suggesting that these frequencies determine perception in broad-band stimuli and that stereo-function at coarser spatial scales may not be assessed by clinic tests.
- The experimental suppression tests identified small suppression levels that could not be detected with clinical tests, suggesting that this may be a more sensitive metric of suppression.
- These tests are quick and easy to administer and deliver accurate and precise estimates of binocular vision that may be used as clinical endpoints in studies of amblyopia.

References

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Acknowledgements

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The methodology was previously presented at: Kwon, M., Wiecek, E., Dakin, S.C., & Bex, PJ. (2015). Spatial-frequency dependent binocular imbalance in amblyopia. Scientific Reports, accepted subject to minor revision.

Conflict of Interest

Kwon and Bex are co-inventors on a provisional patent related to these experimental methods: Kwon M, Wiecek E, Dakin S, Bex P. (2015) Assessment Methods for Inter-ocular Suppression. United States TBD.