Correlation between Binocular Vision and Functional Performance

Dhivya Gnana Sekar

SAERA. School of Advanced Education Research and Accreditation

ABSTRACT

Purpose: The aims of this study were to analyze the correlation between the performance on fine motor skills tasks and sensory fusion, the level of visual acuity (VA) in the poorer seeing Eye, and the inter ocular visual acuity difference.

Methods: Subjects aged 12 to 28 years with a range of levels of binocular vision and visual acuity performed three tasks: Fishing game (time taken to pick fixed number of fishes), bead threading task (with two sizes of bead to increase the difficulty, time taken to thread a fixed number of beads), and a water pouring task (accuracy and time to pour a fixed quantity into five glass cylinders). Ophthalmic measures included Worth 4 dot, stereopsis (sensory fusion), amount of strabismus, and monocular visual acuity.

Results: Forty-five subjects with a mean age of 18.35 years (range: 12 to 27 years); 64.44 % (n=29) were female. Two subjects (4.44%) had a manifest strabismus. Of the remaining 43, 19 were orthophoric, 14 had an exophoria (up to 12), and 10 had an esophoria. There were no vertical phorias detected. Performance on fine motor skills tasks was significantly better in subjects with sensory and motor fusion compared with those without for most tasks.

Conclusions: Both sensory and motor fusion and good visual acuity in both eyes are of benefit in the performance of fine motor skills tasks, with the presence of some binocular vision being beneficial compared with no fusion on certain sensorimotor tasks. This evidence supports the need to maximize fusion and visual acuity outcomes.

Keywords: *Suppression, stereoacuity, visual acuity, binocular vision, motor skill tasks.*

INTRODUCTION

Normal binocular vision is composed of two separate perceptual responses, stereopsis and fusion (which include both a sensory and a motor component). According to O' Connor (2010), absence of binocular vision may be one of the causes for strabismus. Strabismus disrupts cortical binocularity. Alignment of the eyes and developing or restoration of the binocular vision is the main aim in the management of strabismus.

"Binocular vision is composed of simultaneous macular perception, fusion (which includes both sensory and motor component) and stereopsis. Reduced or absence of stereopsis is associated with degraded fine motor skills. In addition, reduced or nil stereoacuity is associated with degraded performance on pegboard and threading tasks (Webber& O'Connor,2008). The aim of this study was to determine whether abnormal binocular fusion negatively affects adults' performance of motor skill tasks. Prevention and/or rehabilitation of abnormal stereoacuity in the treatment of strabismus has been shown to be beneficial for both long-term stability. This study confirms that both VA and CS are better with two eyes as compared with one (Rabin, 1995). NBV subjects may have had a binocular dysfunction that we did not assess (e.g., vergence facility) or an undiagnosed learning disorder. Although it has been suggested that CI is not common in children, and the associated symptoms, such as blur and diplopia, can be the result of the child's interpretation of normal physiologicalphenomenon, (Borsting *et al*, 2003).

Binocular vision is the coordination and integration of what is received from the two eyes separately into a single binocular percept. Proper functioning of binocular vision without symptoms depends on a number of factors, which can be considered under three broad headings: (i) Theanatomy of the visual apparatus (ii) The motor system that coordinates movement of the eyes (iii) The sensory system through which the brain receives and integrates the two monocular signals (Evans, 2007). Strabismus not only disrupts binocular vision but also frequently reduces the visual acuity. While evaluating the abnormal binocular vision in case of strabismus, it is essential to consider the level of monocular visual acuity. The aim of this study was to determine whether abnormal binocular fusion negatively affects adults' performance of motor skill tasks. Reduced or nil stereoacuity is associated with degraded performance on fishing game and bead-threading tasks and ball catching (Webber *et al*, 2008). The normal maturation of eye–hand coordination skills is protracted and probably not fully complete until well into the teenage years, so that our amblyopic children were at an age equivalent to about half-way through this process. Motor skill acquisition usually proceeds by trial-and-error correction, in which cognitive demands are placed on attending to intrinsicsensory feedback derived from the movement itself and to more consciously accessible extrinsic feedback (including from explicit retrospective instruction) regarding errors and their potential cost, to enhance memorial representations for improving future action planning (Suttle *et al*, 2011). In contrast, there are no published studies that address the benefits of prevention and/or rehabilitation of abnormal sensory or motor fusion. The effects of motor and sensory fusion outcomes on the ability to perform

routine tasks of daily living are important to assess to better inform the patient's decision making regarding proposed treatment options, to more fully evaluate quality of care and clinical effectiveness, and to contribute to healthcare policy decisions.

MATERIALS AND METHODS

Subjects

Subjects from the Out-patient department of Ophthalmology and students from Optometry department who were volunteered to participate in the study were included. The inclusion criteria were age between 12 and 28 years, Visual Acuity of at least 6/12 in their better eye, no known ophthalmic defect (other than refractive error, or strabismus (within 45 prism dioptres) and no physical deficit that impacts on motor skills. All testing was performed with the subjects wearing their habitual correction.

Visual Acuity

Distance acuity was recorded uniocularly using Snellen acuity chart at a test distance of 6 m. Visual acuity should be at least 6/12. Participants who ever not familiar with alphabets or numbers they had to determine the direction of the arms of the letter "E" (i.e., up, down, left or right). Near visual acuity was assessed both binocularly and monocularly for each eye.

Fusion

Sensory fusion is assessed using Worth four dot test with target shown at 40cm and 6m. A response of 2 or 3 light indicates suppression, a response of four lights indicates fusion, a response of four lights in the presence of manifest deviation indicates anomalous retinal correspondence, and a response of five lights suggest diplopia.

Measurement of deviation

The amount of manifest deviation is measured using prism bar cover test. The amount of latent deviation is measured using Maddox rod test. The subject with no prism deviation in cover test is considered as orthophoric, the subject with base in prism values of 1 or more Δ is considered as esophoric and the subject with base out prism values of 1 or more Δ is considered as exophoric.

Motor Skills Tasks

The subjects performed three tasks to assess motor skills; the order of the tasks was randomized. The subject was seated in a normally lit room and performed the tasks under binocular conditions. The equipment was placed on a table in front of the subject, and they were able to move the chair to a comfortable working distance (approx. 25 to 40 cm). Each task was performed a total of three times before moving on to the next task to minimize practice or fatigue effects, and the median response was calculated for each task.

1.Fishing game**:** The subject is asked to catch fixed number of fishes and the time taken to catch all the fishes is noted.

2. Bead task: This task involved placing a fixed number of beads onto a needle. The beads were placed on a plate located to the subject's right or left hand side, depending on which hand they preferred to use. The subject was instructed to use only one hand and not to touch the needle with the other hand to prevent them guiding the beads in

place. The time taken to place all beads on the needle was measured using a stop watch. This task was performed twice, once with 30 large beads on a large needle and once with 30 small beads on a fine needle.

3. Water pouring task: This task involved pouring a fixed amount of water (450 ml) from a bottle into five test tube set in fixed positions. The subject was instructed to pour the water as quickly and accurately as possible up to the 90 ml line, marked with tape on each cylinder. Time taken to complete the task was recorded with a stopwatch.

RESULTS

Subjects

Forty-five subjects with a mean age of 18.35 years (range: 12 to 27 years); 64.44 % (n=29) were female and 16 were male. Subjects who had no prism deviation in cover test is considered as orthophoric, subjects who had prism values of 1or more Δ base-in considered as esophoric, subjects who had prism values of 1 or more Δbase-out considered as exophoric. Two subjects (4.44%) had a manifest strabismus. Of the remaining 43, 19 were orthophoric, 14 had an exophoria (up to 12), and 10 had an esophoria. There were no vertical phorias detected.

Table 1. *Differences in age and gender*

	Men	Women	Age	
			$\bar{x}$	SD
Ortho	6	13	19.57	6.78
Exo	6	8	14.75	4.58
Eso	3	7	18.00	7.76

Table 2. *Differences between orthophoric and exophoric*

FISHING GAME				
	$\bar{x}$	SD	Z-scores	*p-value*
Ortho	71.08	23.73	-1.40	0.16
Exo	77.75	15.72		
WATER POURING TASK				
Ortho	29.44	9.84	-2.73	0.006
Exo	47.75	16.83		
BEAD TASK (LARGE)				
Ortho	123.7	35.56	-1.45	0.15
Exo	141.75	31.87		
BEAD TASK (SMALL)				
Ortho	96.13	20.40	-1.92	0.055
Exo	122	35.14		

Table 3. *Differences between orthophoric and esophoric*

FISHING GAME				
	$\bar{x}$	SD	Z-scores	*p-value*
Ortho	71.08	23.73	-1.24	0.21
Eso	78.60	18.68		
WATER POURING TASK				
Ortho	29.44	9.84	-2.03	0.04
Eso	49.00	21.62		
BEAD TASK (LARGE)				
Ortho	123.7	35.56	-0.12	0.91
Eso	122.60	28.48		
BEAD TASK (SMALL)				
Ortho	96.13	20.40	-1.89	0.0588
Eso	119.60	26.70		

As shown in Table 2 and 3, orthophoricsubjects performed significantly better than exophoric and esophoricsubjects in the water pouring task. Besides, the differences between orthophoric and exophoric subjects and between orthophoric and esophoric subjects were marginally significant.

Connection between the Functional Performance on Motor Skills Tasks and Visual acuity.

There was a wide range of interocular VA differences (up to 1.76 logMAR), and interocular VA difference was significantly correlated with performance on the motor skill tasks. Analysis demonstrated a maximum r value of 0.4, which is classified as a large effect size.VA of the poorer seeing eye ranged from 0.2 to 1.6 logMAR and of the fellow eyes from 0.24 to 0.30 logMAR. Twenty-one subjects (17.4%) had amblyopia. Scores on both bead tasks (large beads, r0.41, p<0.001; small beads, r0.41, p<0.001) and the error on the watertask (r 0.24, p< 0.03) were statistically significantly related to the VA of the poorer seeing eye with the highest r value of 0.41 being classified as a large effect size (linear regression with age as an added factor).

DISCUSSION

Performance on some motor skills tasks was significantly better in subjects with sensory fusion compared with those without. A possible limitation of the study is that subjects wore their habitual correction, which was not necessarily their best correction, with the potential for some subjects being under corrected and, therefore, having additional accommodative demands.

Performance on the bead and fishing tasks was significantly better in subjects with motor fusion compared with those without. And for subjects with ocular deviations, there seems reduced performance in all the three tasks. When assessing the prism fusion range, we started with the base-out measure. It has been suggested that by testing base-out first will impact on the base in results; however, the only statistically significant difference reported was in the recovery points.

Because we have used the break points and not the recovery points to determine the fusional amplitude, order of testing should not have affected our results. In addition, although the difference in recovery points was statistically significant, the difference was only 1.4 D, which the authors report as being less than the estimated degree of repeatability (Rosenfield, 1995). According to Howard (2000), “binocular advantage is defined as the improvement in task performance during binocular viewing compared to monocular viewing”. The findings of this study indicate that measurements of PFR do not correlate with measurements of VF in normal subjects. The two tests may assess different aspects of the vergence system. As the VF results do not compare well with previously reported normative data, there liability of the test is questionable. Further evidence is required to establish VF as a reliable test (Melville *et al*, 2002). However, the subjects were all young (aged 12 to 30 years) and had an updated refraction within the last year (if needed), and with the tasks being performed at 30 to 40 cm, the accommodative demand was modest (2.5 to 3.3 D) for this age group.

Moreover, there are no data to support the hypothesis that small residual amounts of blur would have had an effect on these motor tasks, and as the assessments are primarily alignment tasks, we may expect minimal effects of residual blur on performance (Wertheimer, 1979). Further assessment of other aspects of binocular function would be beneficial to fully explore the relationship between binocular vision and functional performance. However, these differences between the findings seem to corroborate the results found by O'Connor and Birch (2010).

CONCLUSION

Both sensory and motor fusion as well as having good visual acuity in both eyes is of benefit in the performance of fine motor skills tasks. In addition, the presence of some binocular vision resulted beneficial compared with no fusion on certain sensorimotor tasks. This evidence supports the need to maximize fusion and visual acuity outcomes.

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