EFFECTS OF SIMULATED BLUR ON GROOVED PEGBOARD

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This paper is submitted in partial fulfillment of the requirements for the degree of

Doctorate of Optometry

Ferris State University
Michigan College of Optometry

May 2015

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ABSTRACT

Purpose: The grooved pegboard tests ability of a subject to manipulate a small “key” in a particular orientation in a corresponding hole. The pegboard contains 25 randomly oriented “keyholes”, where the objective is to put in 25 “keys” as fast as possible. The test is reliant heavily on ocular-motor coordination and dexterity. The current study investigated the association between blur from simulated uncorrected refractive error and the ability to complete the grooved pegboard test. Specifically, we were interested in determining the magnitude of the refractive error at which performance becomes drastically reduced. **Methodology**: Subjects (N = 50) were recruited from the MCO student body. Various degrees of myopia (nearsightedness) were induced through the use of convergent convex trial frame spectacle lenses allowing for standardization of refractive error. Subjects were asked to complete the grooved pegboard in four separate trials as follows- simulated emmetropia, once with simulated -0.50 D of myopia, once with simulated -1.00 D, once with simulated -1.50 D and then once with -2.00 D (this will be done by using +2.50, +3.00, +3.50, +4.00 D lenses over the subjects optimal correction respectively). The subjects performed the grooved pegboard with a set working distance of 40 cm in order to accurately simulate the correct amount of desired myopia. The lenses were inserted into a trial frame and worn by the subject in no particular order to control for potential learning effects of the subjects.

Analysis and Results: An Analysis of Variance (ANOVA) test was used to determine significance. Interpretation of the analysis revealed there was a significant increase in subject performance time with increasing blur. In other words, simulated blur impaired

the task performance as evidenced by an increase in reaction time to complete the test. In addition, task performance was significantly better with the dominant hand in all subjects.

TABLE OF CONTENTS

LIST OF TABLES

CHAPTER 1

INTRODUCTION

The grooved pegboard is a test that requires high dexterity and is highly related to accuracy of fine ocular saccades. The pegboard is a 5x5 grid with 25 different randomly oriented "keyholes" in which the objective is for the subject to insert the keys (progressing left to right, top to bottom) as fast and as accurately as they can. It has been previously reported by Schmidt et al [1] that there is a statistical difference between males and females with females performing the entire pegboard faster than males. In addition, handedness has also been investigated. It was found that subjects perform the test better with their dominant hand and times decrease with successive attempts. However, to the best of our knowledge the question of whether blur compromises performance on a high dexterity motor task has not been investigated. Therefore, the question being asked in the present study is if blur interferes with grooved pegboard test performance. Additionally, the difference between dominant and non-dominant hands as will be reinvestigated. In the current study, an attempt to counteract any learning effect was made by randomly rotating the pegboard so that the 25 "keyholes" were then in a different orientation from the previous trial.

CHAPTER 2

METHODOLOGY

The study included a sample (N=50) of subjects in the age range 21-31 years. All subjects were students or faculty members of the Michigan College of Optometry. The distribution of subjects by gender was as follows – Female N = 32; Male N = 18. Subjects were placed in a room with a table and chair with ample overhead fluorescent lighting. On the table was the grooved pegboard consisting of a 5x5 grid of differently oriented "keyholes" in no particular pattern (**fig. 1**).

Using a trial lens set and trial frame, different levels of myopia were induced using plus lenses of equal power over the patient's best correction. +2.50 D, +3.00 D, +3.50 D, and +4.00 D lenses were used, which simulated emmetropia, 0.50, 1.00, and 1.50 diopters of myopia respectively, once working distance was factored in. The standard near working distance of 40 cm was used **(fig. 2)**. The lenses were placed in the trial frames in random order, and the grooved pegboard orientation was randomly changed between trials in an attempt to reduce subject adaptation to the procedure.

Subjects were then asked to complete the pegboard proceeding from left to right, top to bottom across the pegboard as fast as they could. Subjects were not permitted to skip keyholes, nor were they permitted to use their other hand at any time. Dominant hand was determined as the hand the subject habitually writes with. Trials were completed with both dominant and non-dominant hands with each lens combination in random orders, ultimately leading to eight trials per subject. The time it took to complete the pegboard was then recorded in seconds.

CHAPTER 3

RESULTS

Reaction time data were analyzed using a two way repeated measures analysis of variance (ANOVA). The two factors in the analysis were i) the level of simulated blur (0.0D, 0.5D, 1.0D, 2.0D) and ii) hand dominance. The main effect of blur level was significant $F(2,47) = 32.59$, $\mathbf{p < 0.00}$. When looking closer at the first factor that was measured in this investigation our analysis suggests a highly significant correlation between the subjects' reaction time and the amount induced blur. As we increased the amount of simulated blur the subject's ability to perform the task decreased as evidenced by an increase in reaction time to complete the test. We also did multiple comparisons of reaction time data between different levels of blur for both the dominant and non-dominant hand. The second factor that was investigated was the effect of hand dominance and performance on the grooved pegboard.

Dominant

Groups	*Count*	*Sum*	*Average*	*Variance*
Plano	50	2902	58.04	326.8963
-0.50 D	50	3404	68.08	614.2384
-1.00 D	50	3764	75.28	1260.247
-1.50 D	50	4995	99.9	2672.133

p-value between groups: **8.16E-08**

Non_Dominant

Groups	*Count*	*Sum*	*Average*	*Variance*
Plano	50	3161	63.22	142.0935
-0.50 D	50	3564	71.28	446.0016
-1.00 D	50	4066	81.32	1403.079
-1.50 D	50	5903	118.06	3960.507

p-value between groups: **3.29E-11**

Our statistical analysis shows that the main effect of hand dominance was significant $F(1,49) = 4.90$, **$p < 0.02$**. This implies that performance on the grooved pegboard was significantly better with the dominant hand in all subjects. As seen in the above tables, the average amount of time to complete the grooved pegboard with simulated emmetropia while using the dominant hand was 58.04 seconds with a standard deviation of 18.08 seconds. With +0.50 D of induced myopia the average amount of time to complete the grooved pegboard with the subjects dominant hand was 68.08 seconds with a standard deviation of 24.79 sec. When inducing +1.00 D of myopia the average time to complete the grooved pegboard with the subjects' dominant hand was 75.28 seconds with a standard deviation of 35.50 seconds. When inducing +1.50 D of myopia the average time to complete the grooved pegboard with the subject's dominant hand was 99.9 seconds with a standard deviation of 51.69 seconds. When subjects used their non-dominant hand and with induced emmetropia, the average time to complete the grooved pegboard was 63.22 seconds with a standard deviation of 11.90 seconds. When inducing +0.50 D of myopia and performing the grooved pegboard with their non-dominant hand the average completion time was 71.28 seconds with a standard deviation of 21.11 seconds. When inducing +1.00 D of myopia the average time to complete the grooved pegboard was 81.32 seconds with a standard deviation of 37.46 seconds. When inducing +1.50 D of myopia the average time to complete the grooved pegboard was 118.06 seconds with a standard deviation of 62.93 seconds.

CHAPTER4

DISCUSSION

It has previously been reported by Schmidt et al.[1] that there is a difference in performance on the grooved pegboard between genders as well as between dominant hands. Blur was not included in that particular study. Mann et al[2] determined that optimal correction is not necessary for interceptive tasks. An interceptive task involves associating the perceptual component of a task with the physical component (e.g. hitting a baseball or catching a football). In fact, it was determined that up to three diopters of uncorrected myopia was necessary to interfere and negatively affect such tasks. This study valuable implications for athletes and whether or not it is essential to have perfect visual clarity to succeed in such tasks. For instance, if an American football player is mildly myopic (i.e. 1.00 D) and is intolerant to contact lenses, it would not be essential that they wear spectacle lenses under their helmet according to this study. One of the limitations with the aforementioned study is that some of the potentially confounding variables such as environmental lighting conditions and size and speed of interceptive target were not addressed. The study also did not consider the effects of blur when performing near tasks.

The main hypothesis as to why precise central vision is not necessary for interceptive tasks is because the peripheral retina which is represented predominantly by the magnocellular neurons has larger receptive fields and is therefore much more blur tolerant. Magnocellular cells have high levels of sensitivity for low spatial frequency and high temporal frequency visual targets. In addition to this, they have a very high conduction rate and are much better at processing motion and depth. Parvocellular cells on the other hand have smaller receptive fields and heavily represent the macular and paramacular area of the retina (Livingstone, Hubel [3]). Due to their smaller receptive field they have higher sensitivities for high spatial frequency and low temporal frequency stimuli while having a slower conduction rate than their counterparts. Additionally, parvocellular cells process chromatic visual information.

The grooved pegboard is a very small testing device with a high degree of visual detail. Therefore, it may be safe to make the assumption that the test leans more on the processing of the parvocellular system. The question asked in the current study was if simulated blur influences performance on a high detail, high dexterity task at near. While our initial goal in this research did not include direct testing of parallel processing of the visual system, our results are consistent with the theory that dioptric blur affects the parvocellular system preferentially. Our evidence also suggests that the parvocellular system is much less blur tolerant than the magno system. As stated in the results section, when blur was induced using plus lenses, there was a statistically significant decline in subject performance even at blur levels as low as 0.50 D. The decline became even more evident with increased blur and continued to prove to be highly statistically significant.

The other variable that was measured was dominant vs. non-dominant hands. Again, the grooved pegboard is regarded as a test that requires high dexterity. Our findings imply that good dexterity is required for optimal performance on the grooved pegboard as evidenced by comparisons between dominant and non-dominant hands of subjects.

An additional finding of the current study includes determination of the blur threshold that can actually interfere with high dexterity/ ocular-motor integration tasks.

This information can be beneficial to patients when deciding whether refractive correction in the form of spectacles or contact lenses would optimize performance on a high dexterity task.

Overall, the findings from our study provide further evidence that for a high detailed, motor task such as the grooved pegboard test, optimal visual correction and high dexterity are extremely necessary. This finding also relates to visual-motor integration. Visual motor integration is the ability to control movements that are guided by vision. In the presence of optical blur, these controlled movements will suffer in speed and accuracy. Such findings could be useful for young students struggling in school. A study conducted by Daly et al [4] found that visual motor integration was essential in the ability to copy letters legibly. Based on our findings we surmise that visual motor integration may be one of the factors affected negatively by blur from uncorrected refractive error at near. It could potentially be another link to misdiagnosis of learning disabilities in children struggling in school. To further investigate this, future studies should focus more on younger ages and other tasks requiring high dexterity.

APPENDIX A

FIGURES

FIG 1

FIG 2

TABLE OF RESULTS - DOMINANT HAND

Dominant Hand				
Subject	2.5D	3D	3.5D	4D
1	114	190	148	209
2	60	54	72	92
3	54	103	90	110
4	64	67	66	62
5	52	56	62	83
6	82	60	68	130
7	53	87	73	184
8	49	52	56	71
9	46	88	59	213
10	55	53	68	97
11	44	47	91	88
12	48	50	70	118
13	49	53	55	60
14	50	50	56	57
15	52	53	56	102
16	58	101	85	90
17	59	61	70	66
18	49	46	56	60
19	55	52	57	66
20	58	61	123	125
21	51	80	83	144
22	58	73	60	93
23	45	50	68	55
24	56	58	49	51
25	50	47	57	56
26	41	60	62	94
27	65	51	53	54
28	66	62	61	55
29	48	59	50	59
30	52	69	73	89
31	8	84	106	208
32	48	59	50	59
33	53	56	49	59
34	65	67	91	138
35	76	84	77	121
36	48	55	55	48
37	58	105	157	132
38	53	63	61	62
39	68	76	104	164
40	80	72	70	114
41	50	57	70	89
42	40	48	40	46
43	54	49	49	69
44	135	125	260	270
45	52	54	60	55
46	59	54	54	62
47	62	65	65	88
48	67	85	86	88
49	68	73	76	92
50	75	80	87	198
Average	**58.04**	**68.08**	**75.28**	**99.9**
Std dev	18.0802745	24.7838328	35.4999511	51.692675

TABLE OF RESULTS NON-DOMINANT HAND

Non-Dominant Hand				
Subject	2.5D	3D	3.5D	4D
1	61	157	67	160
2	68	85	78	84
3	64	74	96	106
4	67	65	60	73
5	59	63	66	75
6	64	83	89	107
7	62	83	112	122
8	61	66	78	71
9	57	58	68	77
10	66	60	94	150
11	54	60	15	89
12	58	65	66	152
13	50	56	56	58
14	52	54	57	52
15	54	62	65	113
16	56	57	58	252
17	64	70	66	91
18	52	51	54	74
19	65	53	67	69
20	59	91	104	171
21	55	56	88	113
22	61	95	167	132
23	58	61	70	61
24	58	60	55	57
25	55	61	80	87
26	61	67	68	105
27	65	70	74	54
28	66	67	69	204
29	52	64	58	76
30	63	63	134	102
31	72	57	91	202
32	52	64	58	76
33	55	50	55	68
34	72	77	95	201
35	80	114	173	177
36	53	51	50	51
37	103	130	171	196
38	59	57	58	69
39	65	85	145	266
40	84	80	105	119
41	57	50	55	182
42	43	50	45	47
43	56	60	65	64
44	109	107	186	300
45L	59	56	56	70
46	67	67	80	72
47	66	78	83	96
48	73	82	128	160
49	69	78	83	106
50	80	94	5	244
Average	**63.22**	**71.28**	**81.32**	**118.06**
Std dev	11.9202965	21.1187507	37.4576986	62.9325554

ANOVA TWO FACTOR WITH REPLICATION

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Sample	6634.102	1	6634.102	4.902713	**0.027389**	3.86529
Columns	132297.8	3	44099.26	32.59009	**7.93E-19**	2.627672
Interaction	3449.388	3	1149.796	0.849718	0.467367	2.627672
Within	530434.5	392	1353.149			
Total	672815.8	399				

APPENDIX B

IRB APPROVAL LETTER

APPENDIX C

CONSENT FORM

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