THE EFFECT OF LENS TINT ON SHOOTING ACCURACY

by

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THE EFFECT OF LENS TINT ON SHOOTING ACCURACY

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ABSTRACT

Background: This research study explores the effect of the tint of the shooting glasses worn by an individual on the accuracy of their shots. Accuracy in shooting situations is of fundamental importance, and the results of this study will have implications and practical applications in many societal arenas. Hunters, law enforcement, and military personal would all benefit from conclusive research indicating whether a certain tint was more efficacious in increasing shooter accuracy over another. *Methods:* The following study examined three different lens tints to evaluate whether they had an effect on the shooting accuracy of the wearers. *Results:* Through the use of the method of mean radius and other statistical analysis, there was found to be no statistically significant difference between the three tested tints when it came to accuracy of the shots fired. *Conclusions*: The tint of the lenses in shooting glasses worn does not have a statistically significant effect on the shooting accuracy of an individual.

AKNOWLEDGEMENTS

There are numerous people who had a hand in making this project a success, and to whom I would like to express my gratitude. To Dr. Robert Buckingham, whose intellectual and material resources laid the foundation upon which this research was carried out. To Dr. Chad Rosen, whose invaluable counselling and brainstorming steered me in the right direction. And finally, to the participating students and faculty of the Ferris State University Criminal Justice Program, led by Dr. Gregory Vanderkooi. Thank you for giving up an October Saturday morning to come out to the range and participate in this research! Your enthusiasm and professionalism were much appreciated.

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CHAPTER 1

INTRODUCTION TO MAXIMIZING SHOOTING ACCURACY

The ability of a marksman to accurately hit his target is as fundamental an aspect to the process of successfully using a firearm as any other. It allows the individual to most effectively accomplish the goal which brought them to the point of discharging their weapon. The exact situation the shooter is in is quite irrelevant. Whether attempting to deliver food for their family, providing for the safety of our society, participating in firearms competitions, perpetrating a military goal, or any other situation in which a firearm is being employed, maximizing the accuracy of the firing process is of paramount importance.

In our American culture, shooting accuracy is romanticized in many ways. The heroes of the silver screen only save the world and win the heart of the girl because they can place the bullets that come out of their firearms with a high degree of precision. Villains often meet their end due to the precisely opposite outcome; a shooting process that results in an inaccurate placement of the projectile. Besides being the crux of many a motion picture, an accurate firing process has many real world repercussions as well. Competitive shooting offers one example. Dr. Norman H. Wong, OD states in his 2005 publication titled, “Bullseye Shooting for the Eyecare Professional”, that, “At the upper levels of competition, a millimeter or two of accuracy can make the difference between winning and simply placing in the top twenty. …shooting is a sport in which incremental improvements in equipment, technique and consistency can result in vastly improved scores."[1]

With Dr. Wong's sentiments about improvements in equipment in mind, the goal of evaluating the effect of shooting glass tint being worn on shooter accuracy was established. Despite his advanced knowledge of the optical requirements for individuals who participate in shooting activities, Dr. Wong's process for determining an appropriate tint for placement in shooting glasses is a highly subjective one. Indeed, he mentions in his report that he has "found that it is best for the patients to view tint samples and have them report what they find most comfortable."[1] Our goal, then, was to research whether a fundamental improvement in shooting accuracy could be objectively contributed to a specific tint of lens by analyzing the spread of shots taken by individuals during a shooting activity.

Research similar to the proceeding format has been conducted in the past. In 1950, Sherman Ross, of Bucknell University in Pennsylvania, conducted a research project titled "A Study of Shooting Glasses by Means of Firing Accuracy". As stated in the study, Ross's purpose was to determine the effectiveness of several types of plastic filters when they were used at shooting glasses by a group of skilled Marine Corps riflemen during range firing.[2] Through statistical analysis, Ross's research led him to conclude that there was no statistically significant difference in firing accuracy between the various tints, nor between wearing shooting glasses and not wearing any at all.[2] The research contained within this report aimed to re-evaluate the relationship between shooting accuracy and lens tint of the shooting glasses, using both the statistical analysis used in Ross's study, and additional measures decided on by these researchers.

CHAPTER 2

METHODS

The data collection portion of this research experiment was conducted on Saturday, October 3rd, 2015 at the Ferris State University Firing Range. The individuals who participated in the firing of the rounds were six well-trained upperclassmen from the Ferris State University Criminal Justice Program under the supervision of Dr. Greg Vanderkooi. Each individual participant in the study was asked to read and sign an information and consent letter before the firing commenced. Each subject was asked, "Are you interested in being in this study?", and if the response was positive, the testing continued. If it had been negative, the subject would have been discharged prior to testing. All participants in this study had previously received extensive firearm training as part of the Criminal Justice Program.

Upon arriving at the testing facility, the weather conditions present at the facility were noted and recorded. Though the research was conducted in early October, the weather on the designated shooting day was significantly cooler than the average temperature for the area and season, with temperatures remaining in the low to mid 40's under partially overcast skies throughout the data collection process. Wind conditions were variable during the shooting process, with swirling winds maintaining at 8-12 miles per hour. Each participant had their visual acuities, both in the right and left eye, measured, and a brief color vision screening was administered as well. Distance visual acuities are reported here as Snellen fractions, along with the results of the color vision testing, carried out as an administration of the Ishihara Test for Color Deficiency under a standardized light source, in Table 1.

Table 1 Distance Visual Acuities and Color Vision Testing Results

Visual Acuity	OD	OS		Color Vision Results
Shooter 1	20/25+	20/25+2		All plates seen, no defects
Shooter 2	20/20+2	20/20+2		All plates seen, no defects
Shooter 3	20/16-2	20/16		All plates seen, no defects
Shooter 4	20/16+2	20/16+2		All plates seen, no defects
Shooter 5	20/16-	20/16+		All plates seen, no defects
Shooter 6	20/20-	20/20		All plates seen, no defects

Once entrance testing had been completed, the firing portion of the data collection began. The order of tinted shooting glasses worn were clear (colorless), yellow, orange, and finally clear again. During each round of shooting, each shooter took 10 shots at a previously shot-free target located 25 yards downrange, for a total of 240 shots taken (6 shooters x 4 pairs of glasses x 10 shots per pair of glasses) in the study, and 40 shots were taken per subject. The subjects were rotated so that only 10 shots were taken at a time by any given subject. This was done in an attempt to minimize the effects of shooter fatigue on the collected data. The shooting process was centered around the noon hour to maximize the amount of ambient light, providing optimal shooter visibility.

CHAPTER 3

RESULTS

A one-way repeated measures analysis of variance (ANOVA) was conducted to determine if there were differences in shooting accuracy between shooting glasses with clear lenses, yellow lenses, amber lenses and then again with clear lenses. There were no outliers in the data, as assessed by inspection of a boxplot. Table 2 reveals that shooting accuracy scores for each type of lens were normally distributed, as assessed by Shapiro-Wilks test ($p > .05$).

Table 2 Shapiro-Wilks Test for Normality

	Shapiro-Wilk		
Shooting Accuracy Measurements	Statistic	df	Sig.
Clear 1 Mean Radius	.948	6	.728
Clear 1 Horizontal Spread	.972	6	.905
Clear 1 Vertical Spread	.935	6	.622
Clear 1 Cluster Center Deviation	.986	6	.976
Yellow 1 Mean Radius	.976	6	.932
Yellow 1 Horizontal Spread	.949	6	.732
Yellow 1 Vertical Spread	.941	6	.667
Yellow 1 Cluster Center Deviation	.963	6	.844
Amber 1 Mean Radius	.897	6	.356
Amber 1 Horizontal Spread	.875	6	.248
Amber 1 Vertical Spread	.813	6	.077
Amber 1 Cluster Center Deviation	.920	6	.505
Clear 2 Mean Radius	.879	6	.265
Clear 2 Horizontal Spread	.939	6	.651
Clear 2 Vertical Spread	.954	6	.773
Clear 2 Cluster Center Deviation	.913	6	.460

Mean Radius

Table 3 reveals the mean, standard deviation, and number of subjects for the Mean Radius. Maulchy’s test evaluates whether the sphericity assumption has been violated.

As shown in table 4, with a significance of 0.107, sphericity can be assumed. Using the sphericity assumed, Table 5 reveals that there is not a statistical significant difference between the mean radius of the different colored lenses, F(3) = 0.259, p = 0.854. A pairwise comparison (Table 6) also reveals no statistical significant difference between the mean radius of the different colored lenses. Table 7 reveals the confidence intervals and Figure 1 has the chart of the average scores of the mean radius of the different colored lenses.

Table 3 Mean Radius Descriptive Statistics

Colored Lenses	Mean (mm)	Std. Deviation	N
Clear 1 Mean Radius	16.3587	4.94163	6
Yellow 1 Mean Radius	16.2787	3.35016	6
Amber 1 Mean Radius	17.9053	7.09361	6
Clear 2 Mean Radius	16.6898	3.34650	6

Table 4 Mean Radius Mauchly's Test of Sphericity

Measure: Mean Radius

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Mean Radius	.082	9.320	5	.107	.564	.821	.333

Table 5 Mean Radius Tests of Within-Subjects Effects

Measure: Lens Color

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Lens Color	Sphericity Assumed	10.201	3	3.400	.259	.854
	Greenhouse-Geisser	10.201	1.691	6.031	.259	.742
	Huynh-Feldt	10.201	2.463	4.142	.259	.817
	Lower-bound	10.201	1.000	10.201	.259	.632
Error(factor1)	Sphericity Assumed	196.649	15	13.110		
	Greenhouse-Geisser	196.649	8.457	23.253		
	Huynh-Feldt	196.649	12.314	15.969		
	Lower-bound	196.649	5.000	39.330		

Table 6 Mean Radius Pairwise Comparison

Measure: Lens Color

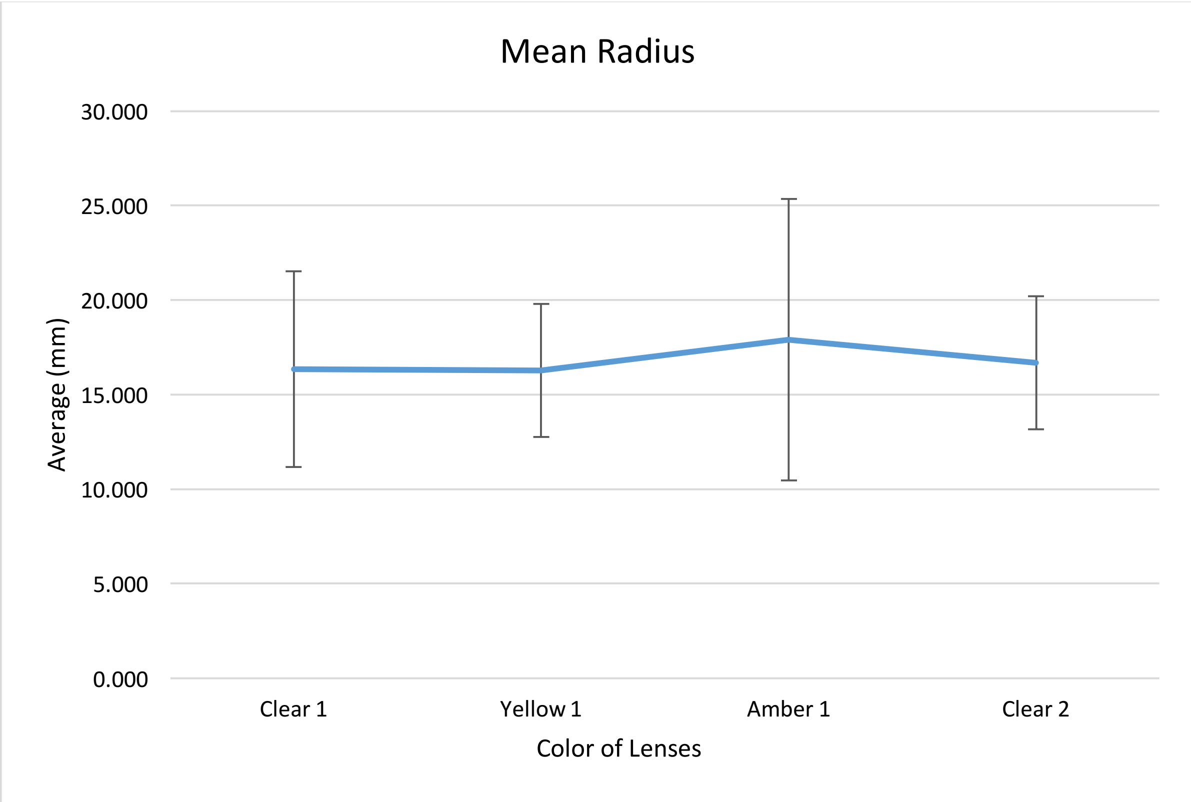
Lenses		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference[a]	
					Lower Bound	Upper Bound
Clear 1 Mean Radius	Yellow 1 Mean Radius	.080	1.287	.953	-3.229	3.389
	Amber 1 Mean Radius	-1.547	2.367	.542	-7.631	4.538
	Clear 2 Mean Radius	-.331	1.849	.865	-5.084	4.422
Yellow 1 Mean Radius	Clear 1 Mean Radius	-.080	1.287	.953	-3.389	3.229
	Amber 1 Mean Radius	-1.627	2.929	.603	-9.156	5.903
	Clear 2 Mean Radius	-.411	1.255	.756	-3.637	2.815
Amber 1 Mean Radius	Clear 1 Mean Radius	1.547	2.367	.542	-4.538	7.631
	Yellow 1 Mean Radius	1.627	2.929	.603	-5.903	9.156
	Clear 2 Mean Radius	1.216	2.321	.623	-4.751	7.182
Clear 2 Mean Radius	Clear 1 Mean Radius	.331	1.849	.865	-4.422	5.084
	Yellow 1 Mean Radius	.411	1.255	.756	-2.815	3.637
	Amber 1 Mean Radius	-1.216	2.321	.623	-7.182	4.751

Table 7 Mean Radius Confidence Interval

Measure: Lens Color

Mean Radius	Mean (mm)	Std. Error	95% Confidence Interval Lower Bound	95% Confidence Interval Upper Bound
Clear 1 Mean Radius	16.359	2.017	11.173	21.545
Yellow 1 Mean Radius	16.279	1.368	12.763	19.794
Amber 1 Mean Radius	17.905	2.896	10.461	25.350
Clear 2 Mean Radius	16.690	1.366	13.178	20.202

Figure 1 Chart of Average Mean Radius



Horizontal Distance

Table 8 reveals the mean, standard deviation, and number of subjects for the Horizontal Spread. Maulchy's test evaluates whether the sphericity assumption has been violated. As shown in table 9, with a significance of 0.121, sphericity can be assumed. Using the sphericity assumed, Table 10 reveals that there is not a statistical significant difference between the mean radius of the different colored lenses, F(3) = 0.619, p = 0.613. A pairwise comparison (Table 11) also reveals no statistical significant difference between the horizontal spread of the different colored lenses. Table 12 reveals the confidence intervals and Figure 2 has the chart of the average scores of the horizontal spread of the different colored lenses.

Table 8 Horizontal Spread Descriptive Statistics

Colored Lenses	Mean	Std. Deviation	N
Clear 1 Horizontal Spread	37.00	11.866	6
Yellow 1 Horizontal Spread	34.58	13.059	6
Amber 1 Horizontal Spread	31.83	13.152	6
Clear 2 Horizontal Spread	38.67	12.323	6

Table 9 Horizontal Spread Mauchly's Test of Sphericity

Measure: Horizontal Distance

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Colored Lenses	.090	8.982	5	.121	.484	.631	.333

Table 10 Horizontal Spread Tests of Within-Subjects Effects

Measure: Horizontal Spread

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Colored Lenses	Sphericity Assumed	159.365	3	53.122	.619	.613
	Greenhouse-Geisser	159.365	1.453	109.679	.619	.515
	Huynh-Feldt	159.365	1.894	84.142	.619	.551
	Lower-bound	159.365	1.000	159.365	.619	.467
Error(factor1)	Sphericity Assumed	1287.448	15	85.830		
	Greenhouse-Geisser	1287.448	7.265	177.212		
	Huynh-Feldt	1287.448	9.470	135.950		
	Lower-bound	1287.448	5.000	257.490		

Table 11 Horizontal Spread Pairwise Comparison

Measure: Horizontal Spread

Lens Color		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Clear 1	Yellow 1	2.417	2.329	.347	-3.570	8.403
	Amber 1	5.167	7.378	.515	-13.798	24.131
	Clear 2	-1.667	4.991	.752	-14.497	11.163
Yellow 1	Clear 1	-2.417	2.329	.347	-8.403	3.570
	Amber 1	2.750	7.103	.715	-15.508	21.008
	Clear 2	-4.083	3.798	.331	-13.846	5.679
Amber 1	Clear 1	-5.167	7.378	.515	-24.131	13.798
	Yellow 1	-2.750	7.103	.715	-21.008	15.508
	Clear 2	-6.833	4.693	.205	-18.898	5.231

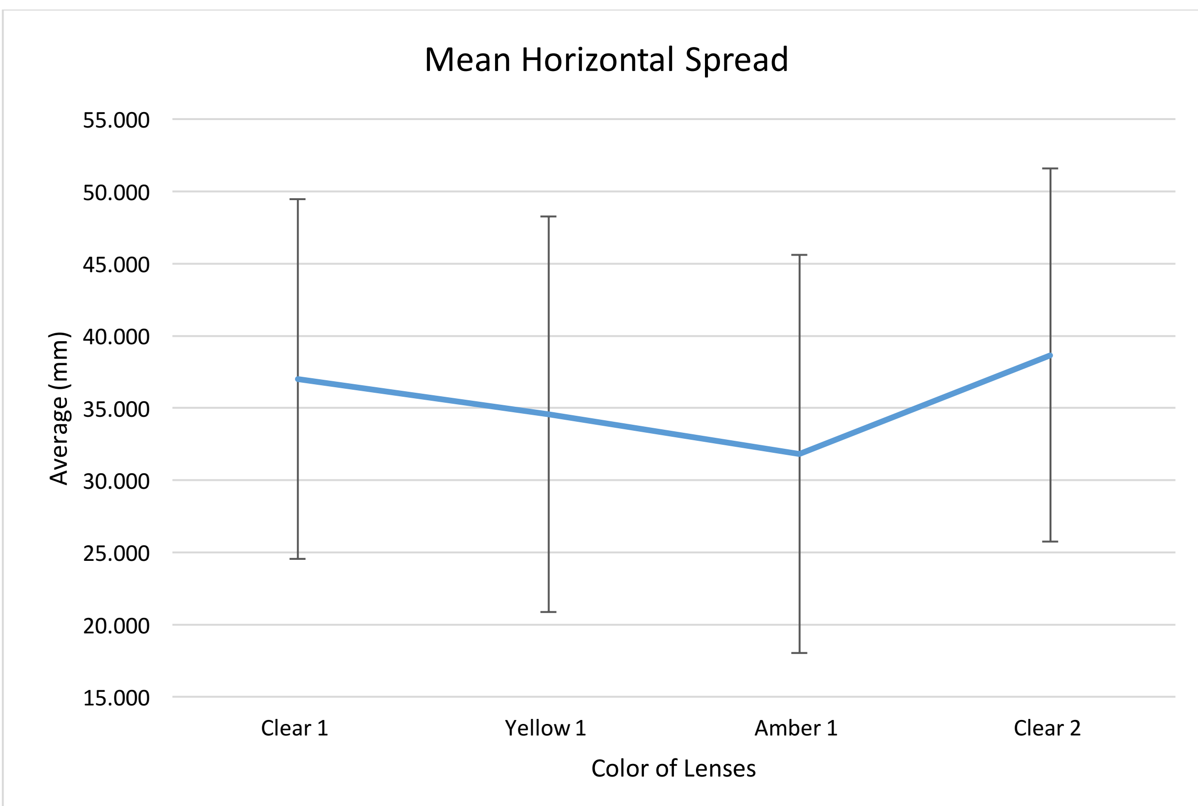
Clear 2	Clear 1	1.667	4.991	.752	-11.163	14.497
	Yellow 1	4.083	3.798	.331	-5.679	13.846
	Amber 1	6.833	4.693	.205	-5.231	18.898

Table 12 Horizontal Spread Confidence Interval

Measure: Horizontal Spread

Lens Color	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Clear 1	37.000	4.844	24.547	49.453
Yellow 1	34.583	5.331	20.879	48.288
Amber 1	31.833	5.369	18.031	45.635
Clear 2	38.667	5.031	25.734	51.599

Figure 2 Chart of Average Horizontal Spread



Vertical Spread

Table 13 reveals the mean, standard deviation, and number of subjects for the Vertical Spread. Maulchy's test evaluates whether the sphericity assumption has been violated. As shown in table 14, with a significance of 0.329, sphericity can be assumed. Using the sphericity assumed, Table 15 reveals that there is not a statistical significant difference between the mean radius of the different colored lenses, F(3) = 0.505, p = 0.685. A pairwise comparison (Table 16) also reveals no statistical significant difference between the horizontal distance of the different colored lenses. Table 17 reveals the confidence intervals and Figure 3 has the chart of the average scores of the vertical spread of the different colored lenses.

Table 13 Vertical Spread Descriptive Statistics

Color of Lenses	Mean	Std. Deviation	N
Clear 1 Vertical Spread	49.08	19.65	6
Yellow 1 Vertical Spread	45.25	12.83	6
Amber 1 Vertical Spread	51.04	24.33	6
Clear 2 Vertical Spread	40.00	4.26	6

Table 14 Vertical Spread Mauchly's Test of Sphericity

Measure: Vertical Spread

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Colored Lenses	.204	5.914	5	.329	.604	.928	.333

Table 15 Vertical Spread Tests of Within-Subjects Effects

Measure: Vertical Spread

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Colored Lenses	Sphericity Assumed	426.091	3	142.030	.505	.685
	Greenhouse-Geisser	426.091	1.813	235.032	.505	.602
	Huynh-Feldt	426.091	2.785	152.971	.505	.672
	Lower-bound	426.091	1.000	426.091	.505	.509
Error(factor1)	Sphericity Assumed	4218.049	15	281.203		
	Greenhouse-Geisser	4218.049	9.065	465.336		
	Huynh-Feldt	4218.049	13.927	302.865		
	Lower-bound	4218.049	5.000	843.610		

Table 16 Vertical Spread Pairwise Comparison

Measure: Vertical Spread

Lens Color		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Clear 1	Yellow 1	3.833	9.415	.701	-20.368	28.035
	Amber 1	-1.958	8.750	.832	-24.452	20.535
	Clear 2	9.083	9.505	.383	-15.351	33.518
Yellow 1	Clear 1	-3.833	9.415	.701	-28.035	20.368
	Amber 1	-5.792	13.063	.676	-39.371	27.788
	Clear 2	5.250	5.180	.357	-8.066	18.566
Amber 1	Clear 1	1.958	8.750	.832	-20.535	24.452
	Yellow 1	5.792	13.063	.676	-27.788	39.371
	Clear 2	11.042	10.458	.339	-15.841	37.925

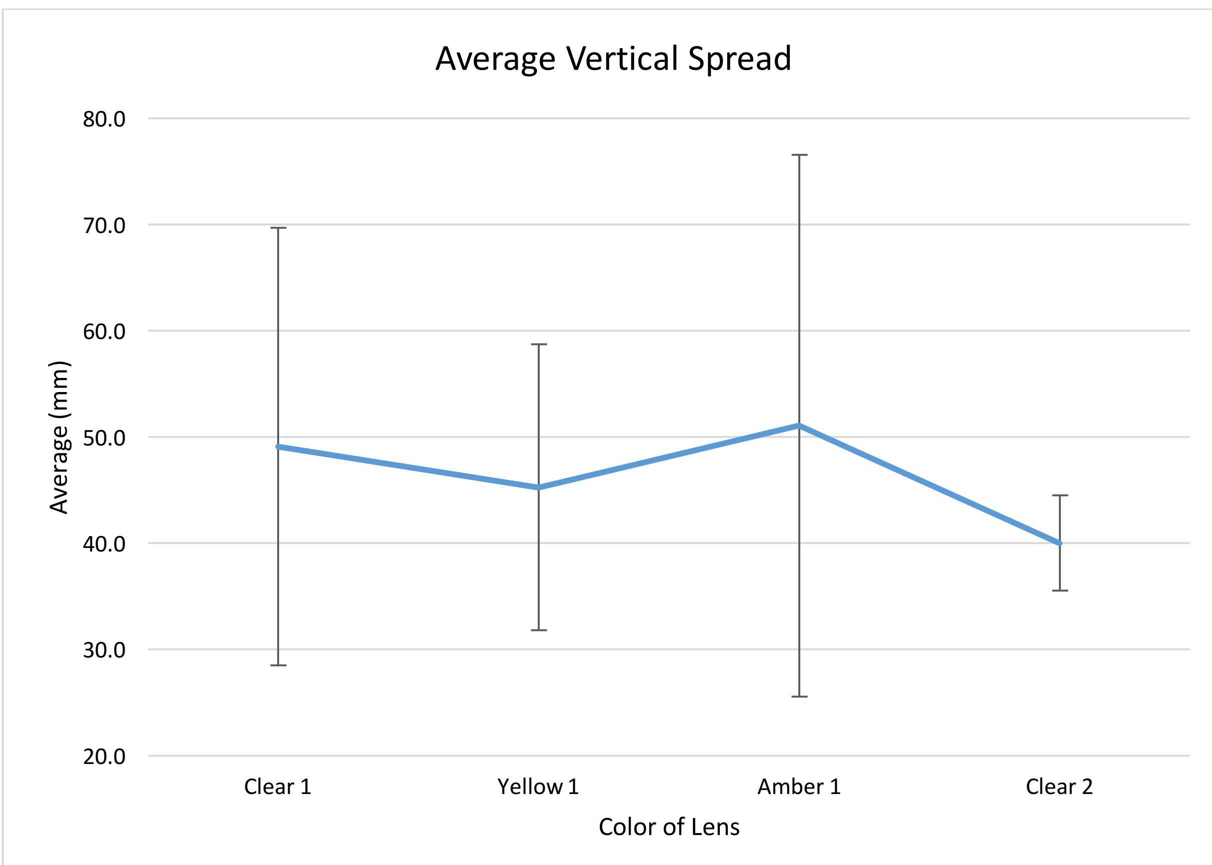
Clear 2	Clear 1	-9.083	9.505	.383	-33.518	15.351
	Yellow 1	-5.250	5.180	.357	-18.566	8.066
	Amber 1	-11.042	10.458	.339	-37.925	15.841

Table 17 Vertical Spread Confidence Interval

Measure: Vertical Spread

Colored Lenses	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Clear 1	49.083	8.023	28.459	69.708
Yellow 1	45.250	5.236	31.790	58.710
Amber 1	51.042	9.931	25.513	76.570
Clear 2	40.000	1.740	35.526	44.474

Figure 3 Chart of Average Vertical Spread



Cluster Center Deviation

Table 18 reveals the mean, standard deviation, and number of subjects for the Cluster Center Deviation. Maulchy's test evaluates whether the sphericity assumption has been violated. As shown in table 19, with a significance of 0.134, sphericity can be assumed. Considering that sphericity may be assumed, Table 20 reveals that there is not a statistical significant difference between the mean radius of the different colored lenses, F(3) = 1.069, p = 0.392. A pairwise comparison (Table 21) also reveals there was a statistical significant difference between the Cluster Center Deviation of the different colored lenses.

Six paired samples t-tests were used to make post hoc comparisons between colored lenses. The first paired samples t-test indicated that there was not a significant difference in the scores for Clear 1 Lens (M=31.63, SD=10.55) and Yellow 1 Lens (M=20.71, SD=10.05); t(5)=2.160, p = . 083. The second paired samples t-test indicated that there was a significant difference in the scores for Clear 1 Lens (M=31.63, SD=10.55) and Amber 1 Lens (M=21.96, SD=4.11); t(5)=2.732, p = .041. The third paired samples t-test indicated that there was no significant difference in the scores for Clear 1 Lens (M=31.63, SD=10.55) and Clear 2 Lens (M=26.71, SD=15.45); t(5)=0.586, p = .584. The fourth paired samples t-test indicated that there was no significant difference in the scores for Yellow 1 Lens (M=20.71, SD=10.05) and Amber 1 Lens (M=21.96, SD=4.11); t(5)=-

0.335, p = .751. The fifth paired samples t-test indicated that there was no significant difference in the scores for Yellow 1 Lens (M=20.71, SD=10.05) and Clear 2 Lens

(M=26.71, SD=15.45); t(5)=-0.591, p = .580. The sixth paired samples t-test indicated that there was no significant difference in the scores for Amber 1 Lens (M=21.96, SD=4.11) and Clear 2 Lens (M=26.71, SD=15.45); t(5)=-0.657, p = .541.

Table 22 reveals the confidence intervals and Figure 4 has the chart of the average scores of the Cluster Center Deviation of the different colored lenses.

Table 18 Cluster Center Deviation Descriptive Statistics

Color of Lenses	Mean	Std. Deviation	N
Clear 1 Cluster Center Deviation	31.63	10.55	6
Yellow 1 Cluster Center Deviation	20.71	10.05	6
Amber 1 Cluster Center Deviation	21.96	4.11	6
Clear 2 Cluster Center Deviation	26.71	15.45	6

Table 19 Cluster Center Deviation Mauchly's Test of Sphericity

Measure: Cluster Center Deviation

Within Subjects Effect	Mauchly's W	Approx. Chi-Square	df	Sig.	Epsilon		
					Greenhouse-Geisser	Huynh-Feldt	Lower-bound
Lens Color	.097	8.681	5	.134	.484	.630	.333

Table 20 Cluster Center Deviation Tests of Within-Subjects Effects

Measure: Cluster Center Deviation

Source		Type III Sum of Squares	df	Mean Square	F	Sig.
Lens Color	Sphericity Assumed	445.375	3	148.458	1.069	.392
	Greenhouse-Geisser	445.375	1.452	306.831	1.069	.367
	Huynh-Feldt	445.375	1.891	235.557	1.069	.378
	Lower-bound	445.375	1.000	445.375	1.069	.349
Error(factor1)	Sphericity Assumed	2083.313	15	138.888		
	Greenhouse-Geisser	2083.313	7.258	287.050		
	Huynh-Feldt	2083.313	9.454	220.371		
	Lower-bound	2083.313	5.000	416.663		

Table 21 Cluster Center Deviation Pairwise Comparison

Measure: Cluster Center Deviation

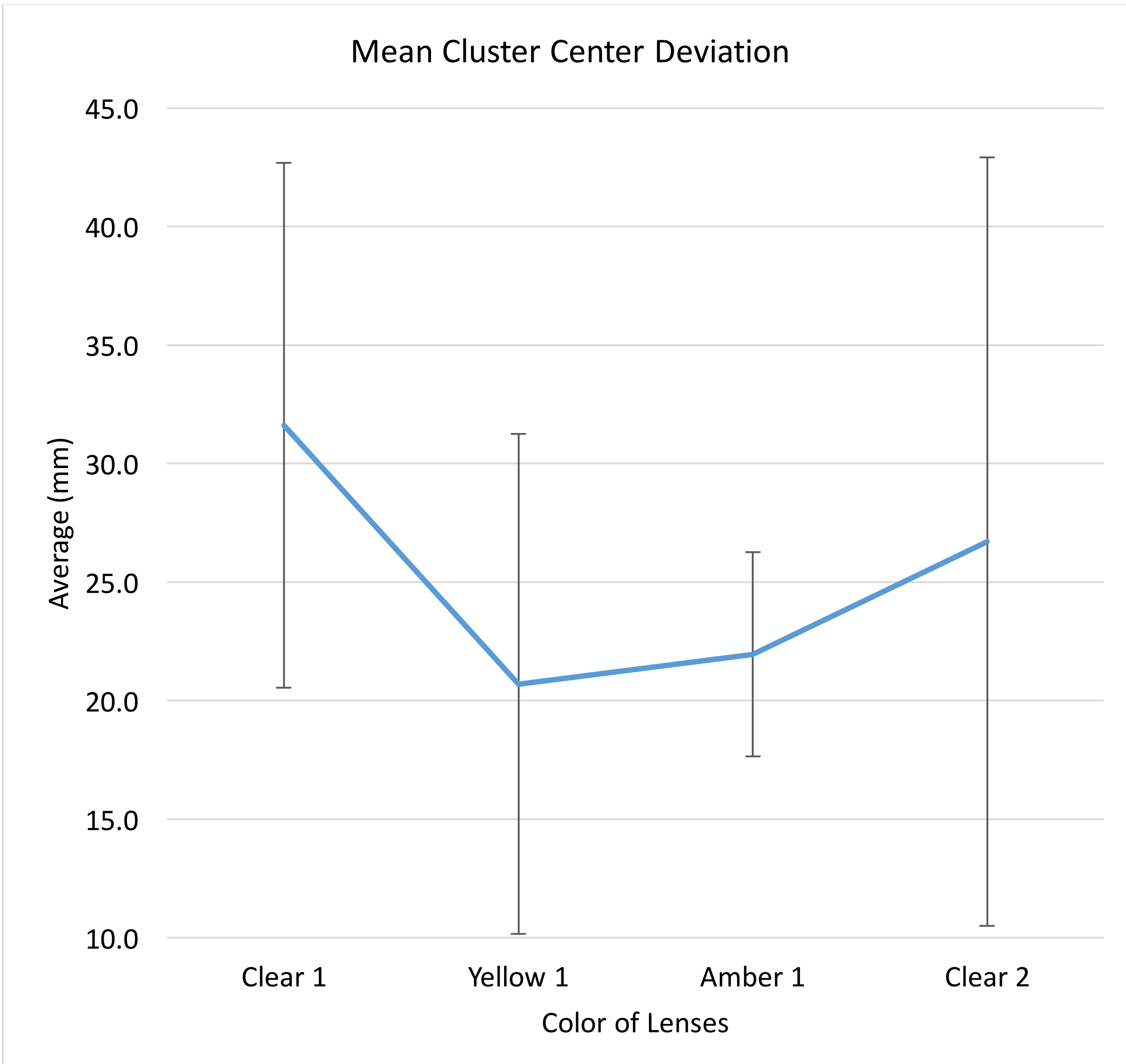
Lens Color		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval for Difference	
					Lower Bound	Upper Bound
Clear 1	Yellow 1	10.917	5.053	.083	-2.073	23.907
	Amber 1	9.667*	3.539	.041	.570	18.764
	Clear 2	4.917	8.396	.584	-16.666	26.500
Yellow 1	Clear 1	-10.917	5.053	.083	-23.907	2.073
	Amber 1	-1.250	3.728	.751	-10.834	8.334
	Clear 2	-6.000	10.147	.580	-32.085	20.085
Amber 1	Clear 1	-9.667*	3.539	.041	-18.764	-.570
	Yellow 1	1.250	3.728	.751	-8.334	10.834
	Clear 2	-4.750	7.235	.541	-23.349	13.849
Clear 2	Clear 1	-4.917	8.396	.584	-26.500	16.666
	Yellow 1	6.000	10.147	.580	-20.085	32.085
	Amber 1	4.750	7.235	.541	-13.849	23.349

Table 22 Cluster Center Deviation Confidence Interval

Measure: Cluster Center Deviation

Lens Color	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Clear 1	31.625	4.306	20.556	42.694
Yellow 1	20.708	4.104	10.158	31.258
Amber 1	21.958	1.676	17.649	26.267
Clear 2	26.708	6.308	10.494	42.922

Figure 4 Chart of Average Cluster Center Deviation



CHAPTER 4

DISCUSSION

On October 3rd, 2015, three tints of shooting glasses were tested at the firing range of Ferris State University in Big Rapids, Michigan. Clear, yellow, and amber were the experimental tints. The shooters were six well-trained upperclassmen from the Ferris State University Criminal Justice Program. These six individuals fired the Tavor SAR rifle from a seated and supported position at a Birchwood Casey "Shoot-N-C" target from a distance of 25 meters. Once each round of ten shots was taken, the targets were replaced with fresh ones and the Mean Radius of each ten-shot target was measured. Additional statistical analysis including a one way repeated measures analysis of variance was conducted.

Through this statistical analysis of the data collected, this study found comparable results to what has been reported in past research, such as Ross's 1950 study, which had similar research questions. Though many aspects of the collected data were compared within our analytical parameters, no benefit of selecting one lens tint over another could be determined for individuals who participate in shooting activities such as hunting, competitive shooting, or other firearm use.

It should be noted that the data collection portion of this study was performed under weather conditions specific to this study and that those weather conditions limited the reliability of the collected data. Future studies should aim to mitigate external variables which may have negatively affected the reliability of the experimental measurements collected here including wind, cold temperatures, sunlight variability, and uneven shooting surfaces. These environmental factors should be of particular concern to future studies as they all negatively affect the performance of the human operators of the firearms being used. An additional limitation to this study was the small number of shooting participants. A larger number of participants, and a subsequent increase in data points, would lend more accuracy to the data analysis and should be considered for future studies which aim to further explore this research area. The major conclusion reached was that the tint of shooting glasses had no effect on the shooters firing accuracy.

REFERENCES

1 - Wong, NH. Bullseye Shooting for the Eyecare Professional. The Encyclopedia of Bullseye Pistol. October, 2005. Available at: http://www.bullseyepistol.com/wong1.htm. Accessed January 23, 2017.

2 - Ross, S. A Study of Shooting Glasses by Means of Firing Accuracy. J Appl Psychol. 1950 Apr;34(2): 118-122.

APPENDIX A

IRB APPROVAL FORM

FERRIS STATE UNIVERSITY

Institutional Review Board for Human Subjects in Research

Office of Academic Research, 220 Ferris Drive, PHR 308 · Big Rapids, MI 49307

Date: July 24, 2015

To: Dr. Chad Rosen, Dr. Robert Buckingham and Joseph Mork

From: Dr. Joshua Lotoczky, Interim IRB Chair

Re: IRB Application #150515 *(The Effect of Lens Tint on Shooting Accuracy)*

The Ferris State University Institutional Review Board (IRB) has reviewed your application for using human subjects in the study, *"The Effect of Lens Tint on Shooting Accuracy"* (#150515) and determined that it meets Federal Regulations *Expedited-category 2D*. This approval has an expiration of one year from the date of this letter. **As such, you may collect data according to the procedures outlined in your application until July 24, 2016**. Should additional time be needed to conduct your approved study, a request for extension must be submitted to the IRB a month prior to its expiration.

Your protocol has been assigned project number (#150515), which you should refer to in future correspondence involving this same research procedure. Approval mandates that you follow all University policy and procedures, in addition to applicable governmental regulations. Approval applies only to the activities described in the protocol submission; should revisions need to be made, all materials must be approved by the IRB prior to initiation. In addition, the IRB must be made aware of any serious and unexpected and/or unanticipated adverse events as well as complaints and non-compliance issues.

Understand that informed consent is a process beginning with a description of the study and participant rights with assurance of participant understanding, followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document and investigators maintain consent records for a minimum of three years.

As mandated by Title 45 Code of Federal Regulations, Part 46 (45 CFR 46) the IRB requires submission of annual reviews during the life of the research project and a Final Report Form upon study completion. Thank you for your compliance with these guidelines and best wishes for a successful research endeavor. Please let us know if the IRB can be of any future assistance.

Regards,

Ferris State University Institutional Review Board

Office of Academic Research, Academic Affairs