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Abstract

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A Comparative Study of a New Red/Green Target for Testing Suppression and Fusion

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A Comparative Study of a New Red/Green Target for Testing Suppression and Fusion

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Sincerely,

Jay V Gallinger

Terry Siegel

Biography

Jay V. Gallinger

Graduate of Portland State University Aug, 1976 with a BS degree in Biology and Psychology. Worked in reforestation and forest management from 1976-1986. Accepted to Pacific University College of Optometry in August, 1986. Completed Doctorate in Optometry May, 1990. I plan to practice on the West Coast in a full scope optometric practice.

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Attended University of North Dakota from August !983 to May, 1986. Accepted to Pacific University College of Optometry in August, 1986. Received BS. degree with Magna Cum Laude honors from Pacific University May, 1988. Completed Doctorate in Optometry May, 1990. I have accepted commission in the United States Air Force and plan on spending the next three years in Omaha, NE. After my obligation I intend on entering private practice, with emphasis on vision training.

Abstract:

A new red/green target consisting of a ball and ring was proposed by Dr. Donald Schuman, and tested on forty-three subjects by comparing it to five other tests. Comparisons were made based on luster, diplopia, suppression and normal second degree fusion. The Ball and Ring target was found comparable to the other tests in identifying suppression, diplopia and luster. No significant differences were found in the identification of anomalies between the tests. The Ball and Ring target was found to an effective testing device. It is well suited as an economical home training device.

Key Words: Fusion, Flat Fusion, Second Degree Fusion, Suppression, Simultaneous Perception, Worth-4-Dot, Red Lens Test, Keystone Card Skills Test, Vodnoy Vectographic Slide #12 (Basic Fusion), Two Dot Flashlight Test, Ball and Ring Target.

Introduction:

There are a number of commercially available testing and training devices for fusion and suppression. Many of these are too expensive for patients with limited financial expenditures to be appropriate for home training. (Vectograms are especially expensive for home use.) Many of the devices used for home therapy incorporate red/green filters. Red/Green devices are relatively inexpensive, but they may not provide as good a stimulus for training as vectograms do because of the dioptric interval created by the refraction of light of varying wavelengths (Bogdanovich), (Cornforth). It has been found that red/green filters may increase the likelihood of suppression if the filter with the lower transmittance is placed before the suppressing eye (Cornforth). These are considerations for specific devices that practictioners must be familiar with when purchasing vision therapy equipment.

Dr. Donald Schuman proposed a new target utilizing round red/green color coded labels placed on a dark background, for the purpose of training second degree fusion at near (Figure 1). The name, Ball and Ring target, was given to this new red/green training device. It was decided to conduct a study to see how sensitive the Ball and Ring target was as a testing device for simultaneous perception, second degree fusion, and luster effects.

PROBLEM:

In order to evaluate the Ball and Ring target, several other tests of fusion and suppression were run on subjects for comparison. It was decided to compare the Ball and Ring target to a vectogram test, the red lens test, two telebinocular tests and two other red/green tests. Our goal was to test the Ball and Ring target as a device for testing fusion and suppression on patients. We wanted to rank these tests as to their sensitivity to simultaneous perception. In Griffin's textbook "Binocular Anomalies: Procedures for Vision Therapy", he listed an order of tests from most to least sensitive for simultaneous perception (Griffin). We will compare our finding to his table although the ultimate use of the Ball and Ring target is considered to be a device for training fusion and anti-suppression. We don't intend the Ball and Ring target to replace currently standardized targets/devices for suppression and flat fusion testing or diagnosis.

METHODS:

CONSTRUCTION:

The Schuman target is simple to make (Figure 1). A piece of black poster board of approximately 4" by 8" size was used for our study. A round green color coded label (3/4 inch in diameter) was placed in the center of the poster board. A small red dot (1/4 inch in diameter) was centered on the green round color coded label. The round color coded stickers and the poster board can be purchased at most office supply stores. It is important to find colors that cancel well with red/green glasses. Clear nail polish painted over the dots make them more durable but may cause increased interference from glare.

COMPARITIVE TESTS:

The additional tests performed were the Worth-4-dot, Red Lens test, Two-dot-flashlight, and Keystone DB-5K (4-ball) test and the Vodnoy basic fusion vectogram (Figure 1). Additional tests run were the Keystone lateral phoria card, and BO/BI ranges on the basic fusion vectogram. Each test was conducted using normal room illumination of about 100 ft. cd. The test distance was 40 cm. for all tests. The Keystone four-ball test was performed in the telebinocular at the simulated distance of 40 cm. Each test utilizing a red lens or red/green glasses was performed with the red being on the right eye for all subjects. All tests were conducted in primary position of gaze. When the Vodnoy basic fusion vectogram was used the eccentric rings and larger rectangle were covered, exposing only

the smaller rectangle and targets of this test. This card was exposed in the ortho position of gaze. This produced a vergence demand of 2.5 MA.

SUBJECTS:

Volunteers were from students and their families of Pacific University's College of Optometry, subjects from the clinic population at the University and at preceptor sites were utilized. Subjects were screened prior to acceptance into the study. All subjects that were strabismic or had previous strabismic surgery were excluded. Subjects were determined to be non-strabismic via case history and near objective unilateral cover test. Subjects were required to have a Snellen near point acuity of 20/30 or better. The cover test's recovery was also performed on all subjects. A delay of recovery of more than two seconds eliminated the subject from the study.

STATISTICS:

All tests were performed on each subject using a variable sequence. No single sequence of running the tests was adopted. The tests were conducted by two experimenters using a standard set of written questions for each fusion test. See Appendix A for test questionnaire.

The statistics use to analyze our data were non-parametric. The level of measurement for the data was nominal. The chi-square test was used to compare the Ball and Ring target to the other tests for significant differences in simultaneous perception, second degree fusion, and luster effects test. The Fisher-Yates exact probability test was used to compare the second degree fusional responses of our subjects on the Ball and Ring target to the subjects phoria (Keystone), and vergences

(vectographic BI/BO ranges). The significance level of $p = 0.05$ was adopted prior to testing any subjects.

Results:

Forty-three subjects were tested with each test for suppression and fusion. The subjects range in age from 5 to 42 years old. The mean was 19.3 years old with a standard deviation of 9.5.

The results of this study are represented in Appendices B, C, and D. Pages 1-3 of the Appendix B (Individual Responses) shows the individual response to each of the questions. Appendix C (Sum of Individual Responses) contains the total number of responses given for a particular question. For example: Appendix C, question 1 of Worth-4-dot, elicited forty-one responses of 4 lights and two responses of 5 lights. Appendix D contains the pass/fail per individual for each test for simultaneous perception, second degree fusion, and luster effects test.

The sum of the pass/ fail per test are shown in the Table 1 that follows. Table 1 also shows the questions used to determine pass/fail for each test.

Table 1

Total pass/fail per test

	Simultaneous Perception					
	Worth	**Ball & Ring**	**Yodnoy #12**	**Keystone DB-9B**	**Red Lens**	**Two-dot**
Question	1a	1	2a	2	2	5a
Pass	43	42	40	43	38	38
Fail	0	1	3	0	5	5

	Second Degree Fusion Subj failing Sim/Per also Fails flat fusion.				
	Worth	**Ball & Ring**	**Yodnoy #12**	**Keystone DB-5K**	**Red Lens**	**Two-dot**
Question	1a	2	1,2a	1a	1a	4
Pass	40	34	40	33	41	42
Fail	3	9	3	10	2	1

	Luster Effects			
	Worth	**Ball & Ring**	**Red Lens**	**Two-dot**
Question	1a	2	1a	3a
Pass	40	34	41	41
Fail	3	9	2	2

Table 1. Total pass/fail for each test.

The following three charts make up Table 2. They show the total pass fail for each test. It shows how the five standardized tests of simultaneous perception and second degree fusion are compared to the Ball and Ring target. Only three of the standardized tests can be compared to the Ball and Ring target, because the Vodnoy and the Keystone targets don't have luster effects. The comparisons are made in percentages of agreement and disagreement.

Table 2
Comparison of Ball and Ring
To other tests per individual

		Simultaneous Perception				
		Worth	Vodnoy #12	Keystone DB-9	Red Lens	Two-Dot
	Pass/Pass	42	39	42	38	38
Ball &	Pass/Fail	0	3	0	4	4
Ring	Fail/Pass	1	1	1	0	0
	Fail/Fail	0	0	0	1	1
	% Agree	42 - 97.7%	39 - 90.7%	42 - 97.7%	39 - 90.7%	39 - 90.7%
	% Disagree	1 - 2.3%	4 - 9.3%	1 - 2.3%	4 - 9.3%	4 - 9.3%

		Second Degree Fusion				
		Worth	Vodnoy #12	Keystone DB-9	Red Lens	Two-Dot
	Pass/Pass	34	32	32	33	34
Ball &	Pass/Fail	0	2	2	1	0
Ring	Fail/Pass	6	8	1	8	8
	Fail/Fail	3	1	8	1	1
	% Agree	37 -86.1%	33 - 76.7%	40 - 93%	34 - 79.1%	35 - 81.4%
	% Disagree	6 -13.9%	10 - 23.3%	3 - 7%	9 - 20.9%	8 - 18.6%

Table 2. Comparison of Ball and Ring target to other standardized tests.

		Phoria Compared to Ball and Ring Fusional Pass/Fail				
		Alt. Obj Cover Test		Keystone Lateral Phoria (DB-9		
		No Move.	Movement	Esophoria	0-5XO	> 5XO
Ball & Ring	Pass	16	18	7	22	5
	Fail	0	9	0	2	7

		Anaglyph Verg compared to Ball/Ring Fusional pass/fail						
Ball & Ring		Base In			Base Out			
	1 to 5D	6 to 10D	>10D	1 to 5D	6 to 10D	11 to 15D	>16D	
Pass	19	15	0	6	9	8	11	
Fail	7	2	0	3	3	2	1	

Table 2 Cont. Comparison of Ball and Ring target to standardized tests.

Table 3 contains the results of chi-square analysis. Data used to compute chi-square was obtained from Table 2. There are at least twenty other chi-square computations that are not shown in any table. Only the highest chi-square values are shown.

Table 3
Statistical Analysis
Chi-Square

	Simutaneous Perception tests with largest differences			
	Worth-4-Dot	**Two-Dot**	Sum	Expected
Agree	42	39	81	40.5
Disagree	1	4	5	2.5
Sum	43	43	N=86	df=1
Chi-Square value =1.91 Critical Chi-Square value = 3.84 for a p of .05				

	Second Degree Fusion tests with largest differences			
	Keystone 4-ball	**Vodnoy #12**	Sum	Expected
Agree	40	33	73	36.5
Disagree	3	10	13	6.5
Sum	43	43	N=86	df=1
Chi-Square value = 4.44 Critical Chi-Square value = 3.84 for a p of .05				
	tests with second largest differences			
	Keystone 4-ball	**Red Lens**	Sum	Expected
Agree	40	34	74	37
Disagree	3	9	12	6
Sum	43	43	N=86	df=1
Chi-Square value = 3.49				

	Luster Effects tests with largest differences			
	Worth-4-Dot	**Red Lens**	Sum	Expected
Agree	37	33	70	35
Disagree	6	10	16	8
Sum	43	43	N=86	df=1
Chi-Square value =1.23 Critical Chi-Square value = 3.84 for a p of .05				

Table 3. Chi-square analysis of Ball and Ring target.

Table 4 shows the comparisons made between results of the Ball and Ring target for second degree fusion and findings of vergence and phoria testing.

Table 4

Fisher-Yates exact probability test

	Base In Vergence		
	1 to 5D	**6 to 10D**	Sum
Pass	19(A)	15(B)	34(A+B)
Fail	7(C)	2(D)	9C+D)
Sum	26(A+C)	17(B+D)	N= 43
p = .159 critical value of p < .05 required			

	Base Out Vergence		
	Largest and Smallest vergence rang		
	1 to 5D	**> 16D**	Sum
Pass	6(A)	11(B)	17(A+B)
Fail	3(C)	1(D)	4(C+D)
Sum	9(A+C)	12(B+D)	N= 21
p = .168 critical value of p < .05 required			

	Keystone Lateral Phoria		
	0-5XO	**> 5XO**	Sum
Pass	22(A)	5(B)	27(A+B)
Fail	2(C)	7(D)	9(C+D)
Sum	24(A+C)	12(B+D)	N= 36
p = .002 critical value of p < .05 required			

Table 4. Comparison of phorias and vergences to Ball and Ring target.

Discussion:

SIMULTANEOUS PERCEPTION:

In our study we excluded all strabismics from participation. In doing so, we eliminated a large population of potential subjects that may have had problems with simultaneous perception. A few of our subjects that did show some momentary suppression responses, did not give a reliable sustained response so we could not determine which test was more or less sensitive.

No subjects failed the Worth-4-dot or the Keystone DB-9B test for simultaneous perception. We had three subjects fail the Vodnoy basic fusion test, one subject failed the Ball and Ring target, and five subjects failed the Red Lens test and the Two-dot-flashlight test. See Appendix D for the individual pass/fail for simultaneous perception. The sum of the pass/fail for simultaneous perception is found on Table 1 in the Results section.

In comparing the Ball and Ring target to the other tests, we can see that the Worth-4-dot test and the Keystone test are gross tests for suppression. A subject must have a deep suppression to fail either of these tests, and none of our subjects failed either test. The Ball and Ring target had only one failure and was thus also a gross test of simultaneous perception. The vectogram test had three failures. The size of the suppression test on the Vodnoy basic fusion card is fairly large which would also relate to a gross test of suppression.

The Red Lens test is not a good test for determining simultaneous perception. It is dependent on the subjects awareness of different shades of color and not on whether objects are seen or not seen. We had five sub-

jects fail the Red Lens test, but this is an uncertain figure due to the nature of the test. The Two-dot-flashlight also had five failures, but a response to simultaneous perception is easily determined with this test. This test was seen to have the most failures of the simultaneous perception tests. A possible reason for this, aside from chance, is that this test had a stimulus that was much smaller than the lights presented on the Worth or dots of the Ball and Ring target. This small target size provides a more concise central test of suppression behavior.

In a critical comparison of the Ball and Ring target to the other tests for simultaneous perception, as seen on Table 2, it is apparent that there is little difference among the test results. The Worth-4-dot and Keystone DB-9K agreed with the findings of the Ball and Ring target in all but one individual (Table 2). This is an agreement of 97.7%. The Vodnoy test, Red Lens test, and the Two-dot-flashlight were in agreement with the Ball and Ring target 90.7% of the time. This shows that the Ball and Ring target is similar to the results of each of the suppression tests.

The highest chi-square value was found to be 1.91 for the comparison of simultaneous perception tests. This is much too low to reach the critical value for the $p = 0.05$. Each of the ten possible chi-square values for the simultaneous perception tests was well below the critical value of 3.84. Table 3 contains the example of the largest chi-square value for simultaneous perception. The differences seen among the tests of suppression are not of significance, and can be attributed merely to chance. Therefore from our subject responses, we can not make an ordered sequence of the tests of simultaneous perception.

Since we could not make an ordered sequence of test sensitivity; a comparison to Griffin's table of simultaneous perception sensitivity could

not be made (Griffin). From his table he sequences tests from highest to lowest sensitivity. Our tests when placed in his table would be ordered as follows: The most sensitive test being the Vodnoy #12, followed by the Keystone test, and Red Lens test. The red/green tests were the least sensitive. So the last tests in the sequence would be the Two-dot-flashlight, Ball and Ring target and the Worth-4-Dot.

SECOND DEGREE FUSION:

The data obtained for second degree fusion showed marked contrasts between various tests (refer to Appendix D and also Table 1).

Only one subject failed the Two-dot-flashlight for second degree fusion. (The two-dot test is a gross test of flat fusion.) This subject also failed the simultaneous perception of the small center targets, and reported diplopia and not a suppression response. The subject also failed the Ball and Ring target, the Red Lens test, and Keystone 4 ball test.

Two subjects failed the Red Lens test for flat fusion. These subjects reported seeing diplopia. One subject failed the Red Lens test that also failed the Ball and Ring target. The other subject that failed the Red Lens test passed the Ball and Ring target, but failed the Keystone DB-5K. Again we were uncertain about whether simultaneous perception occurred or not; so we only included subjects reporting diplopia as failures to the Red Lens test. A cover uncover recovery test should have been performed as positive proof of the presence of second degree fusion or if suppression had taken place while testing with the Red Lens.

Three subjects failed the Worth-4-dot test. Each of these subjects also failed the Ball and Ring target. All failing subjects reported diplopia.

The Worth-4-dot test thus appears to provide an easy target for practitioners to use to determine diplopia and/or suppression tendency.

The three subjects that failed flat fusion on the Vodnoy vectogram did not report diplopia. Suppression was reported by all three and hence flat fusion could not have occurred. Only one of the subjects failing the Vodnoy target also failed the Ball and Ring target. The other two subjects that failed flat fusion on the Vodnoy did not fail any other of the flat fusion tests. This may indicate that the Vodnoy vectographic test may not be an equivalent stimulus as is other red/green tests or the Keystone.

Nine subjects failed to obtain second degree fusion on the Ball and Ring target. Ten subjects failed to obtain second degree fusion on the Keystone DB-5K. Of these two groupings eight subjects failed both of the tests. It is apparent that the Ball and Ring target and the Keystone 4 ball test have very similar results. Thus if a patient fails the Ball and Ring target it is likely that the same patient will fail the Keystone 4 ball test. We can easily determine simultaneous perception and second degree fusion when testing a patient with the Keystone 4 ball test or the Ball and Ring target.

In comparing the results of the Ball and Ring target to the other tests of fusion, it is seen that there are larger differences between tests than were seen when comparing simultaneous perception tests (see Appendix D, Tables 1 and 2). In Table 2 the fusion test in highest agreement to the Ball and Ring target was the Keystone DB-9K test at 93%. The fusion test with the lowest percentage of agreement was the Vodnoy vectogram at 76.7%. This shows a larger spread in the amount of differences between tests than the simultaneous perception test.

The highest chi-square value was found to be 4.44, and was the comparison of the Keystone 4 ball test to the Vodnoy vectogram. These two tests were the ones with the most and least agreement respectively with the Ball and Ring target. On this test the critical value of 3.84 was attained, and thus on this one test a probability of 0.05 was reached. The second highest chi-square value was found to be 3.49, and was the comparison of the Keystone 4 ball test to the Red Lens test. On this second test the critical value was not attained. The differences seen among the tests of flat fusion were not large enough to be significant. One of the ten possible chi-square values reached the critical value. The one test with a high critical value may also be attributed to chance. Therefore from subject responses we can not sequence the tests in order of sensitivity to second degree fusion.

LUSTER EFFECTS TEST:

It became apparent after testing was complete that the luster effect test was not adequately performed. The Red Lens test responses were not conclusive to indicate a specific luster response. Subjects reporting red during the luster test were not questioned as to the amount of red they perceived. This test would have been more informative if we had performed a cover uncover recovery with the Red Lens, and questioned the change (luster) in color perceived when the image became one. Therefore the diplopia response is more valid than the luster response in determining a subjects failure to the perception of luster. Question 2 of the Red Lens questionnaire was used.

The Two-dot-flashlight provided a large gross stimulus for luster. As can be seen from the Appendix D only one subject did not report a luster

effect. This same subject also failed simultaneous perception of the smaller center targets. The Two-dot-flashlight test question 3a was used to determine pass/fail to luster.

Some of the Ball and Ring target subjects also failed the question on luster. Of the total (ten) only six had failed simultaneous perception or flat fusion. Three subjects reported luster but failed flat fusion of the Ball and Ring target. Again we have encountered the problem of whether the questions for the response to luster were adequate and precise. Due to these uncertainties it was determined to fail subjects who reported luster if they had either failed flat fusion or simultaneous perception and passed. For this reason question 2 of the Ball and Ring test was used to determine pass/fail to luster.

We encountered a similar problem with the Worth-4-dot test. Eleven subjects did not respond to our luster question;" whether there appeared to be a light that changed or was not the same as any of the others?" Also our questions about the number of green or red colored lights elicited varied responses. Twenty-four subjects reported two green lights and nineteen reported three lights. Our subjects also were divided as to the number of red lights. Twelve reported one light, and thirty-one reported two. Thus we had subjects reporting our luster target to be both red and green. Some subjects did not consider the luster target as red or green. They saw a mix, or even reported odd colors such as yellow or white. Of the eleven subjects not passing our luster question (Do any of the lights appear to change?) only three failed flat fusion and had no failures of simultaneous perception. Therefore we used question 1a of the Worth-4-dot (diplopic response) to determine if a subject would pass or fail because of diplopia.

A comparison of the luster effects of the four targets capable of luster is provided on Table 3. This comparison is questionable at the very least, since the data is not directly from luster responses. Data was used from subjects that were known to not be able to obtain luster. This is combined data from simultaneous perception and second degree fusion questions. From these comparisons it can be seen that the most failures to the luster effect test was the Ball and Ring target followed by the Worth-4-dot, and then the Red Lens test and finally the Two-dot-flashlight.

In comparing the results of ball and ring target to Worth-4-dot, Red Lens and Two-dot-flashlight, it is seen that there is very little difference among the tests (Table 1). The Worth-4-dot agreed with the Ball and Ring target 86.1% of the time with the individuals tested. This was the highest percentage of agreement of the luster effect tests (Tables 2). The lowest percent of agreement with the Ball and Ring target was the Red Lens test at 76.7%. this is a difference of approximately one in ten. This chi-square value was found to be 1.23 for the Worth-4-dot and Red Lens tests which is to low to reach the critical value for a probability level of 0.05 or less (Table 3). This was the highest chi-square value of the three possible chi-square values. This draws the conclusion that the differences seen by the different tests of luster could be attributed merely to chance. Thus the difference are not significant to allow a sequencing of the most to least sensitive test to luster.

A hierarchical order of sensitivity to luster can be made not via the results, but by the size of the luster stimulus presented to the retina. The smaller the luster stimulus to the retina , the more sensitive would be the test to eliciting a failure response. The larger the luster stimulus upon the retina the more likely a valid luster response would be elicited. Thus

the Ball and Ring target, the Red Lens, and Worth-4-dot would have very similar responses; since the size of the stimulus is relatively the same size. The Two-dot-flashlight would be the least sensitive, because the stimulus is much larger. (The Two-dot-flashlight provides a gross stimulus for luster, and provides clinicians with an excellent device for the testing of the strabismus patient.)

VERGENCE AND PHORIA:

During testing procedures and entrance testing, we obtained some findings that we wanted to compare to the ball and ring's second degree fusion findings. We compared the Ball and Ring target to movement observed on the objective alternate cover test, the phoria present on the Keystone lateral phoria target (DB-9B), and we also compared it to the BI and BO findings of the Vodnoy basic fusion vectogram #12. Tables 2 contain the results of these comparisons.

Of the nine subjects failing flat fusion on the Ball and Ring target, all showed movement on the alternate near cover test. This was a 33.3% (9 of 27) failure rate. No subjects failed that did not show any movement on the alternate cover test. All subjects, showing esophoria on the Keystone test, passed the Ball and Ring target. Two subjects showing low amounts of exophoria or orthophoria failed on the Keystone. Only 8.3% (2 of 24) of all subjects in the 0-5 exophoria range failed to fuse the Ball and Ring target. Seven subjects that failed the Ball and Ring target and were in the > 5 exophoria group. This was a 58.3% (7 of 12) failure rate. From the comparisons of the cover testing and Keystone phoria testing, it can be said that as a patient shows a higher exophoric posture, there is a higher probability that he/she will not fuse the Ball and Ring target (see Table 3).

Seven of the nine subjects failing to fuse the Ball and Ring target had a BI range of 5 prism diopters or less. The actual percentage of the low BI range failures was 26.9% (7 of 26). Two of the failing subjects had a BI finding that fell in the 6-10 prism diopters range. The failure rate of this group was 11.8% (2 of 17). None of our subjects went beyond ten prism diopters BI. Three subjects failed the Ball and Ring target that fell in the 0-5 prism diopters BO range with the Vodnoy target. This was a 33% (3 of 9) failure rate. Three other subjects failed that fell into the 6-10 prism diopters range. This range had a 25% (3 of 12) failure rate. Two subjećts that had Vodnoy BO ranges of 11-15 prism diopters failed the Ball and Ring target. This group had a failure rate of 20% (2 of 10). One subject failed to fuse the Ball and Ring target even though he/she had a BO range of over 16 prism diopters. The failure rate for this group was 8.3% (1 of 12).

Comparing second degree fusion abilities of subjects tested on the Ball and Ring target to BO and BI and phoria findings may be like comparing apples to oranges, but a pattern does appear and is quite logical. As a subjects exophoria increases so is the likelihood that the subject will fail to fuse the Ball and Ring target. A determination that this also holds true for esophoria is difficult to establish because we had a low sampling of esophores. It is also seen that as a persons duction ranges increase there is a decrease in the percentage of failure to second degree fusion on the Ball and Ring target.

In critically comparing the results of the Ball and Ring target to second degree fusion tests and the results of phoria and vergence testing, we used the Fischer-Yates exact probability test. A probability level of 0.05 or less was set to establish significance to our results.

From Table 4 it can be seen that the probability for failing with a low BI vergence compared to a moderate BI vergence was equal to 0.159. From the same page the probability for failing with a low BO vergence compared to a high BO vergence was equal to 0.168. Therefore, vergence ranges are not good predictors of the subject's second degree fusional ability as tested on the Ball and Ring target. Keystone lateral phoria findings were compared to the pass/fail of the Ball and Ring target to second degree fusion. The Fischer-Yates probability was equal to 0.002. Therefore the probability that if a patient fails flat fusion to the Ball and Ring target then that patient will have a high probability of having > 5 exophoria on the Keystone lateral near point phoria test. We can't proclaim that if a patient fails Ball and Ring target, he will also show increased exophoria. This relationship is only a probability.

EXPERIMENTER'S PREFERENCES:

After running all tests on the subject. We (experimenters) determined which tests appeared easiest and best suited to administer clinically. Testing luster is difficult due to the reliance on subjective interpretation. The Two-dot-flashlight was the easiest and quickest to obtain a response to luster. The Worth-4-dot and the Ball and Ring target were more difficult. The Red Lens test would be similar to the Worth-4-dot, and Ball and Ring target if a cover uncover recovery were performed. When presenting the stimulus for the Red Lens test it would be important to allow the subject to perceive saturated red and white, before asking the subject about the extent of the luster effect. In testing simultaneous perception and flat fusion , the easiest tests to administer were the Worth-4-dot and the Ball and Ring target. The answer to one question can

precisely determine if simultaneous perception and flat fusion are present. We feel that the three other tests are essentially as good but more questioning is involved, these tests are the Two-dot-flashlight, Vodnoy target, and the Keystone test. We feel that the Red Lens test results in uncertainty as to whether simultaneous perception and flat fusion occurs together. We are again dependent on the subjects interpretation of the amount of saturated color.

The Ball and Ring target as was introduced is not intended to be used as a means of testing fusion. There are many commercially available tests that can be used clinically as a means of determining a patients ability for fusion. Our intention was to determine how well the Ball and Ring target tests fusion when it is compared to other fusion testing devices. The Ball and Ring target can be used to test fusion, but the main emphasis on introducing this target is for its use as a vision training device.

The target can be used to train fusion. The limits to variations of the Ball and Ring target are dependent on the therapist's imagination. Some variations of the target are shown in Figure 2. The card can be used to train fusion via pursuit movements. A therapist or assistant can move the card while the patient maintains fixation and fusion. Saccades can be performed by adding several ball and rings to a card (Figure 2). Many patients have good fusional abilities in primary gaze, but show poor fusion abilities or tropic responses outside of the primary position. The Ball and Ring target is well suited to demonstrate the fusional problem to a patient in different areas of gaze. Training can also be done in positions of secondary gaze.

The Ball and Ring target can be incorporated into many different vision training techniques. It can be used with other or in place of other

red/green training devices. Jump ductions and far to near rocks are an example of its usefulness. A small letter can be placed on either the small or large dot to add an accommodative lock to the target if you are concerned with the dioptric interval inherent with red/green filters.

An important consideration for using the Ball and Ring target as a training device is that it is economical to produce. Purchasing round color coded labels would cost approximately $20. This would include red, green, and white dots of varying sizes. The dots come in packages of 500 for the large dots and 1000 for the small dots. The black tag board can be purchased for approximately one dollar for a 24 inches by 36 inches in diameter sheet. One sheet can be used to make backings for over a dozen cards. It is important to remember to find dots that cancel well with red and green filters. Most office supply stores have the material needed to make our target.

Conclusions:

This experiment demonstrates that the Ball and Ring target can be used for a fusional or anti-suppression target. The target is easy to use requiring a pair of red/green glasses along with material to make the card. The Ball and Ring target functions similar to conventional targets. From chi-square testing, the tests of simultaneous perception, flat fusion, and luster effects did not reach the significant level of 0.05 except one test of fusion. The comparison of the Vodnoy target to the Keystone 4 ball was significant within 0.05, but this test was only one of twenty-three possible chi- square tests. We would expect at least one test to achieve the critical level by chance. Therefore our testing didn't identify tests or targets that were significantly different in identifying subjects with anomalies in simultaneous perception, second degree fusion, or luster effects. None of the simultaneous perception tests identified subjects with suppression tendencies. This was a result of our eliminating subjects from our study that had experienced strabismus behavior.

It was found that as subjects BI/BO vergence ranges increase, the rate of failure on the Ball and Ring target decreased. This finding was not significant to the Fisher-Yate exact probability test. It was also found that as subjects phorias increase so does the failure rate to second degree fusion on the Ball and Ring target. This is only a probability and can't be used to assume that someone with a large phoria will fail to fuse the Ball and Ring target. Also we can't assume someone failing the Ball and Ring target will also have a significant phoria.

Examiners could quickly learn to work with this new target. Subjects can learn the correct response and work to improve the length of time to keep the ball centered in the ring. The patient receives feedback

directly from the target as any red/green target. As stated the target can be used to test for a suppression or lack of a unification response. Potentially it is felt the benefit will result not only from its use as a testing device, but as a training device. There are many ways of testing suppression and fusion, and one more test would not be necessary or improve our ability to detect problems with fusion and suppression.

In summary the Ball and Ring target as proposed by Dr. Schuman appears to be a useful new tool for training anti-suppression and fusional abilities. It like other red/green targets is easy to administer and easy for patients to use. Its cost to produce and easy alteration of the target makes the Ball and Ring target useful for practitioners to incorporate into their vision therapy programs.

We suggest that this study should be followed by others to test the usefullness of the Ball and Ring target as a testing and training device. One study could be initiated to further explore our findings with a much larger sample size so that a valid statistical analysis can be made to prove or disprove any differences in sensitivity amongst the tests. If this study is initiated, we would suggest better luster controls. A study should be initiated to test the Ball and Ring target on subjects that have a need for vision therapy. Subjects to be included in a vision therapy study should have a diagnosis of General Binocular Dysfunction, Intermittent or Constant Strabismus.

References:

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Appendix A

Test Questionnaire

Worth-4-Dot

Red Lens in front of OD

1. How many lights do you see? **2 3 4 5 Other_____**
1a. Now how many do you see? _____
2. What are the color of the lights? **Normal Abnormal**
3. How many green lights? **2 3 Zero**
4. How many red lights? **1 2 Zero**
5. Do any of the lights appear to change ? **Yes No**
5a. Where is the light located? **Correct Incorrect**

Ring/Ball Target:

Red lens in front of OD

1. What do you see?(Expect a red center with a surrounding green ring or visa versa if other target is presented) Response will have a luster effect.

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2. Where is the red target(center) located? **Centered Not centered**
2a. Exo Eso Hypo Hyper
3. Is there any Luster? **Yes No**
4. Does one color dominate the other color? **Yes No**
4a. If Yes, which color? **Red Green**

Vodnoy #12(Basic Fusion) Anaglyphs

Make sure OD sees OD target through Polaroid.
Look at the small rectangle(point to it).

1. How many rectangles (blocks) do you see? **1 2**
2. What objects do you see in the block? **2 dots X square circle**
(mark only items that are <u>not</u> reported)
2a. Do you see all these objects all of the time? **Yes No**
2b. If No, which objects disappear ? **square circle**

Anaglyphic Vergences:

3. Now I am going to make changes. Tell me when the box becomes **Two** or if the **Circle** or **Square** disappear. 3a. **BO_____**
4. Again, tell me if the box becomes **Two** or if the **Circle** or **Square** disappear. 4a. **BI_____**

Keystone Card Skills:

After aligning Subject expose the DB-9B (Near-Point lateral Phoria) Card.
Passing is between 4.5 and 6.
1. To what number does the Arrow point?_____
1a. To what number does the arrow point now?_____
1b. and now?_____
2a. Do any of the **Numbers** , or the **Arrow** , ever **Fade** or **Disappear**
2. **Yes** **No** (if Yes, circle appropriate answer above)

Now remove the lateral phoria card to expose the DB-5K card(4 circles)
1. How many circles are there? **Three** **Four**
If 4 wait a moment to see if the patient can achieve "three".
1a.4 then 3 within 3 sec is considered a Pass
2.If still 4Is the red circle to the right or the left of the blue circle? **Right** **Left**

Red Lens Test

Red lens in front of OD, Penlight is the stimulus.
1. How many lights do you see ? **1** **2**
1a. If 2 can you make it one? **Yes** **No**
2. What is the color of the light? **White** **Red** **Pink**
2a. Does the color of the light ever change? **Yes** **No**
3. **Red Right** **Red Left**

Two-Dot Flashlight Test

1. How many flashlights am I holding in my hand? **1** **2**
2. How many flashlights do you see? **1** **2**
3. How many Half-moons do you see? **2** **4**
3 a. What is the color of each half-moon? **Green** **Red** **Luster**
4. Do you see one or two black stripes in the middle of my flashlight? **1** **2**
5. Do you see any colored dots(balls) in the black stripe? **Yes** **No**
5a. How many dots do you see? **1** **2**
5b. What color dot(s) do you see? **Red Only** **Green Only** **Red & Green**
If red and green dots are both reported present;
5c. Do you see both colored dots all of the time? **Yes** **No**
If only a red or only a green dot is reported;
5d. Can you find any other colored dots in the black stripe? **Yes** **No**

A - 2

Appendix B

	A	B	C	D	E	F	G	H	J	K	L	M	N	O	P	Q	R
1				Cover Test					VA		Worth 4 Ball						
2	Last Name	Age	Case #	U,s	U,o	A,s	A,o	C,un	CU		1	1a	2	3	4	5	5a
3																	
4	Miller	5	1	1	1	#NA	U	1	1	1	5	5	0	3	2	0	#NA
5	Jannus	14	2	1	1	X	0	1	1	2	4	4	1	3	1	1	1
6	Farwell	6	3	1	1	0	0	1	1	3	4	4	1	2	2	1	1
7	Villagomez	20	4	1	1	X	X	1	1	4	4	4	1	3	2	1	1
8	Hernandez	12	5	1	1	X	0	1	1	5	4	4	1	3	1	1	1
9	Costello	9	6	1	1	X	X	1	1	6	4	4	1	3	1	1	1
10	Ricks	31	7	1	1	0	0	1	1	7	4	4	1	3	1	1	1
11	Cinh	12	8	1	1	X	X	1	1	8	4	4	1	2	1	1	1
12	Babila	5	9	#NA	1	#NA	X	1	1	9	4	4	1	3	2	1	1
13	Perkins	7	10	1	1	X	X	1	1	10	4	4	1	3	2	1	1
14	McVickers	18	11	#NA	#NA	X	X	1	1	11	4	4	1	3	2	1	1
15	Hickman	22	12	1	1	S	0	1	1	12	4	4	1	3	2	1	1
16	Rosalito	10	13	1	1	X	X	1	1	13	4	4	1	2	2	1	1
17	Shaw	29	14	1	1	X	X	1	1	14	4	4	1	3	1	1	1
18	Black	5	15	1	1	X	X	1	1	15	4	4	1	3	2	1	1
19	Mahoney	25	16	1	1	X	0	1	1	16	4	4	1	2	1	1	1
20	Clark	14	17	1	1	X	X	1	1	17	4	4	1	2	2	1	1
21	Crum	20	18	1	1	S	S	1	1	18	4	4	1	2	2	1	1
22	Rose	15	19	1	1	X	0	1	1	19	4	4	1	3	1	1	1
23	Tucker	18	20	1	1	X	X	1	1	20	5	5	1	3	2	0	#NA
24	Gibson	14	21	1	1	X	0	1	1	21	4	4	1	3	1	1	1
25	Gibson	13	22	1	1	0	0	1	1	22	4	4	1	2	2	1	1
26	Malina	9	23	1	1	0	0	1	1	23	4	4	1	3	1	1	1
27	Sparkman	25	24	1	1	S	0	1	1	24	4	4	1	2	2	1	1
28	Powers	15	25	1	1	0	0	1	1	25	4	4	1	2	2	1	1
29	Thudium	29	26	1	1	S	0	1	1	26	4	4	1	3	1	1	1
30	Crespo	13	27	1	1	X	0	1	1	27	4	4	1	2	2	1	1
31	Turner	13	28	1	1	0	0	1	1	28	4	4	1	3	1	1	1
32	Monroe	25	29	1	1	X	X	1	1	29	4	4	1	2	2	0	0
33	Rouse	13	30	1	1	X	X	1	1	30	4	4	1	2	2	1	1
34	Snyder	36	31	1	1	X	0	1	1	31	4	4	1	2	2	1	1
35	Theus	33	32	1	1	X	X	1	1	32	4	4	1	2	2	1	1
36	Ferguson	24	33	1	1	X	0	1	1	33	4	4	1	2	2	1	1
37	Tryggestad	42	34	1	1	0	0	1	1	34	4	4	1	3	2	0	1
38	Perea	17	35	1	1	X	X	1	1	35	4	4	1	2	2	0	1
39	Ford	21	36	1	1	0	X	1	1	36	4	4	1	2	2	0	1
40	Samuel	23	37	1	1	X	X	1	1	37	4	4	1	2	2	0	1
41	Rodriquez	17	38	1	1	S	S	1	1	38	4	4	1	2	2	0	1
42	Konvalin	25	39	1	1	X	0	1	1	39	4	4	1	2	2	1	1
43	Aleman	24	40	1	1	X	X	1	1	40	4	4	1	2	2	0	1
44	Seward	35	41	1	1	X	X	1	1	41	4	4	1	2	2	0	1
45	Large	29	42	1	1	X	X	1	1	42	4	5	0	2	2	1	0
46	Gallinger	40	43	1	1	S	S	1	1	43	4	4	1	2	2	0	1

B - 1

Appendix B

	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	AG	AH	AI	AJ	AK	AL	AM	AN
1		Shuman		Target					Vodnoy	#12								Keystone		DB-9B		
2		1	2	2a	3	4	4a		1	2	2a	2b	3	3a	4	4a		1	1a	1b	2	2a
3																						
4	1	1	0	U	0	0	#NA	1	1	#NA	1	#NA	2	4	2	2	1	5	5	5	1	#NA
5	2	1	1	#NA	1	0	#NA	2	1	#NA	1	#NA	2	12	2	6	2	6	5.5	5	1	#NA
6	3	1	1	#NA	1	0	#NA	3	1	#NA	1	#NA	2	16	2	10	3	6	5.5	6	1	#NA
7	4	1	1	#NA	1	0	#NA	4	1	#NA	1	#NA	2	10	2	2	4	5	6	6	1	#NA
8	5	1	1	#NA	1	1	R	5	1	#NA	1	#NA	2	14	2	6	5	7	6.5	6.5	1	#NA
9	6	1	0	X	0	0	#NA	6	1	XC	0	`S	#NA	#NA	#NA	#NA	6	7	7.5	7	1	#NA
10	7	1	1	#NA	1	0	#NA	7	1	#NA	1	#NA	2	12	2	6	7	5	5.5	5.5	1	#NA
11	8	1	1	#NA	1	0	#NA	8	1	#NA	1	#NA	2	12	2	4	8	5	5.5	5.5	1	#NA
12	9	1	1	#NA	1	0	#NA	9	1	D	1	#NA	2	4	2	1	9	5	5	5	1	#NA
13	10	1	1	#NA	1	0	#NA	10	1	#NA	1	#NA	2	10	2	6	10	6	6	5.5	1	#NA
14	11	1	1	#NA	1	0	#NA	11	1	#NA	1	#NA	2	8	2	3	11	6	5.5	5.5	1	#NA
15	12	1	1	#NA	1	0	#NA	12	1	#NA	1	#NA	2	8	2	8	12	4	4.5	4	1	#NA
16	13	1	1	#NA	1	0	#NA	13	1	#NA	1	#NA	2	6	2	4	13	6	6	6	1	#NA
17	14	1	1	#NA	1	1	G	14	1	#NA	1	#NA	S	10	S	2	14	6	6.5	6	1	#NA
18	15	1	1	#NA	1	0	#NA	15	1	#NA	1	#NA	2	6	2	4	15	5.5	5	5.5	1	#NA
19	16	1	0	X,U	0	0	#NA	16	1	#NA	1	#NA	2	2	2	1	16	7	7	7	1	#NA
20	17	1	0	X	0	0	#NA	17	1	#NA	1	#NA	2	8	2	3	17	8	7.5	7.5	1	#NA
21	18	1	1	#NA	1	0	#NA	18	1	#NA	1	#NA	2	8	2	8	18	3	3	3	1	#NA
22	19	1	1	#NA	1	0	#NA	19	1	#NA	1	#NA	2	10	2	3	19	6	5.5	5.5	1	#NA
23	20	1	0	X	0	1	G	20	1	#NA	1	#NA	2	14	2	1	20	8	7.5	7.5	1	#NA
24	21	1	1	#NA	1	1	G	21	1	#NA	1	#NA	2	16	2	4	21	6	5.5	6	1	#NA
25	22	1	1	#NA	1	0	#NA	22	1	#NA	1	#NA	2	12	2	4	22	5	5	5.5	1	#NA
26	23	1	1	#NA	1	0	#NA	23	1	#NA	1	#NA	2	12	2	3	23	5	5.5	5.5	1	#NA
27	24	1	1	#NA	1	1	R	24	1	#NA	1	#NA	2	8	2	4	24	6	5	5	1	#NA
28	25	1	1	#NA	1	0	#NA	25	1	#NA	1	#NA	2	16	2	3	25	5.5	5	5.5	1	#NA
29	26	1	1	#NA	1	0	#NA	26	1	#NA	1	#NA	2	14	2	6	26	4.5	4	4	1	#NA
30	27	1	1	#NA	1	0	#NA	27	1	#NA	1	#NA	2	18	2	8	27	6	6	6	1	#NA
31	28	1	1	#NA	1	1	G	28	1	#NA	1	#NA	2	18	2	6	28	5	5.5	5	1	#NA
32	29	0	0	X	1	1	R	29	1	#NA	1	#NA	2	6	2	1	29	6	6.5	6.5	1	#NA
33	30	1	0	X	1	0	#NA	30	1	#NA	1	#NA	2	12	2	2	30	7.5	8	8.5	1	#NA
34	31	1	1	#NA	1	0	#NA	31	1	#NA	1	#NA	2	18	2	4	31	5	5.5	5	1	#NA
35	32	1	0	X	0	1	R	32	1	#NA	1	#NA	2	18	2	8	32	5.5	5.5	5.5	1	#NA
36	33	1	1	#NA	0	1	R	33	1	#NA	1	#NA	2	16	2	4	33	4.5	5	4.5	1	#NA
37	34	1	1	#NA	0	0	#NA	34	1	#NA	1	#NA	2	18	2	8	34	7	7.5	6.5	1	#NA
38	35	1	1	#NA	1	1	R	35	1	#NA	1	#NA	2	4	2	5	35	7.5	7	7.5	1	#NA
39	36	1	1	#NA	1	1	R	36	1	#NA	1	#NA	2	4	2	3	36	3	3	3	1	#NA
40	37	1	1	#NA	1	1	G	37	1	#NA	0	C	2	3	2	2	37	4	3	3	1	#NA
41	38	1	1	#NA	1	0	#NA	38	1	#NA	1	#NA	2	2	2	4	38	4	5	5	1	#NA
42	39	1	1	#NA	1	0	#NA	39	1	#NA	1	#NA	2	18	2	8	39	4.5	4.5	4	1	#NA
43	40	1	1	#NA	0	0	#NA	40	1	#NA	1	#NA	2	18	2	8	40	7.5	7	7	1	#NA
44	41	1	1	#NA	0	1	G	41	1	#NA	0	S	2	5	2	8	41	6	6	6.5	1	#NA
45	42	1	0	X,D	1	1	G	42	1	D	1	#NA	2	10	2	8	42	7.5	6.5	7.5	1	#NA
46	43	1	1	#NA	1	0	#NA	43	1	#NA	1	#NA	2	17	2	8	43	3	3.5	3.5	1	#NA

Appendix B

	AP	AQ	AR	AS	AT	AU	AV	AW	AX	AY	AZ	BA	BB	BC	BD	BE	BF	BG	BH	BI
1	DB-5k				Red Lens Test						Two-Dot Flashlight Test									
2	1	1a	2		1	1a	2	2a	3		1	2	3	3a	4	5	5a	5b	5c	5D
3																				
4	0	0	X	1	0	1	W	0	X	1	1	1	1	L	1	1	0	G	#NA	1
5	1	1	#NA	2	1	#NA	P	1	#NA	2	1	1	1	L	1	1	1	B	1	#NA
6	1	1	#NA	3	1	#NA	P	0	#NA	3	1	1	1	L	1	1	1	B	1	#NA
7	0	0	X	4	0	0	B	#NA	X	4	1	1	1	L	1	1	0	R	#NA	1
8	1	1	#NA	5	1	#NA	P	1	#NA	5	1	1	1	L	1	1	1	B	1	#NA
9	0	0	X	6	0	1	P	1	X	6	1	1	1	R	1	1	0	R	#NA	1
10	1	1	#NA	7	1	#NA	P	1	#NA	7	1	1	1	L	1	1	1	B	1	#NA
11	1	1	#NA	8	1	#NA	P	1	#NA	8	1	1	1	L	1	1	1	B	1	#NA
12	1	1	#NA	9	1	#NA	R	1	#NA	9	1	1	1	L	1	1	1	B	1	#NA
13	1	1	#NA	10	1	#NA	P	1	#NA	10	1	1	1	L	1	1	1	B	1	#NA
14	1	1	#NA	11	1	#NA	P	1	#NA	11	1	1	1	L	1	1	1	B	1	#NA
15	1	1	#NA	12	1	#NA	P	1	#NA	12	1	1	1	L	1	1	1	B	1	#NA
16	1	1	#NA	13	1	#NA	P	1	#NA	13	1	1	1	L	1	1	1	B	1	#NA
17	0	1	#NA	14	1	#NA	W	1	#NA	14	1	1	1	L	1	1	1	B	1	#NA
18	1	1	#NA	15	1	#NA	P	1	#NA	15	1	1	1	L	1	1	1	B	1	#NA
19	0	0	X	16	0	1	B	0	X	16	1	1	1	L	1	1	1	B	1	#NA
20	0	0	X	17	0	1	P	1	X	17	1	1	1	L	1	1	1	B	1	#NA
21	1	1	#NA	18	1	#NA	P	1	#NA	18	1	1	1	L	1	1	1	B	1	#NA
22	1	1	#NA	19	1	#NA	P	1	#NA	19	1	1	1	L	1	1	1	B	1	#NA
23	0	0	X	20	0	0	B	#NA	X	20	1	1	1	L	0	1	1	B	1	#NA
24	1	1	#NA	21	1	#NA	P	1	#NA	21	1	1	1	L	1	1	1	B	1	#NA
25	1	1	#NA	22	1	#NA	P	1	#NA	22	1	1	1	L	1	1	1	B	1	#NA
26	1	1	#NA	23	1	#NA	P	1	#NA	23	1	1	1	L	1	1	1	B	1	#NA
27	1	1	#NA	24	1	#NA	P	1	#NA	24	1	1	1	L	1	1	1	B	1	#NA
28	1	1	#NA	25	1	#NA	P	1	#NA	25	1	1	1	L	1	1	1	B	1	#NA
29	1	1	#NA	26	1	#NA	P	1	#NA	26	1	1	1	L	1	1	1	B	1	#NA
30	1	1	#NA	27	1	#NA	R	1	#NA	27	1	1	1	L	1	1	1	B	1	#NA
31	1	1	#NA	28	1	#NA	P	1	#NA	28	1	1	1	L	1	1	1	B	1	#NA
32	0	1	#NA	29	1	#NA	R	1	#NA	29	1	1	1	R	1	1	0	R	#NA	1
33	0	0	X	30	1	#NA	P	1	#NA	30	1	1	1	L	1	1	1	B	1	#NA
34	1	1	#NA	31	1	#NA	P	1	#NA	31	1	1	1	L	1	1	1	B	1	#NA
35	0	0	X	32	0	1	P	1	X	32	1	1	1	L	1	1	1	B	1	#NA
36	1	1	#NA	33	1	#NA	P	1	#NA	33	1	1	1	L	1	1	1	B	1	#NA
37	1	1	#NA	34	1	#NA	P	0	#NA	34	1	1	1	L	1	1	1	B	1	#NA
38	1	1	#NA	35	1	#NA	P	0	#NA	35	1	1	1	L	1	1	1	B	1	#NA
39	0	0	X	36	1	#NA	P	1	#NA	36	1	1	1	L	1	0	#NA	#NA	#NA	#NA
40	1	1	#NA	37	1	#NA	P	1	#NA	37	1	1	1	L	1	1	1	B	0	1
41	1	1	#NA	38	1	#NA	P	O	#NA	38	1	1	1	L	1	1	1	B	1	#NA
42	1	1	#NA	39	1	#NA	P	O	#NA	39	1	1	1	L	1	1	1	B	1	#NA
43	1	1	#NA	40	1	#NA	P	O	#NA	40	1	1	1	L	1	1	1	B	1	#NA
44	1	1	#NA	41	1	#NA	P	O	#NA	41	1	1	1	L	1	1	1	B	1	#NA
45	0	0	X	42	1	#NA	P	O	#NA	42	1	1	1	L	1	1	1	B	1	#NA
46	1	1	#NA	43	1	#NA	P	O	#NA	43	1	1	1	L	1	1	1	B	1	#NA

Appendix C
Sum of individual Tests

WORTH 4-DOT

	#NA	0	1	2	3	4	5
K. Worth-4-Dot test							
L.How many lights do you see?						41	2
M. How many do you see?						40	3
N. what are the color of the lights?		2	41				
O. How many green lights?				24	19		
P. How many red lights?			12	31			
Q. Do the lights appear to change?		11	32				
R. Where is the light located?	2	2	39				

BALL & RIN(

	#NA	0	1	U	X	D	R	G
S. Schuman Target								
T. What do you see?(simultaneous perception)		1	42					
U.Where is the red target (center) located?		9	34					
V. Where not centered?	35			2	7*	1		
W. Is there any luster?		10	33					
X. Does one color dominate the other color?		28	15					
Y. If yes, which color?	29						7	7

*May have both lateral and vertical displacement

VODNOY BASIC FUSION ANAGLYPH

	#NA	0	1	2	1 to5	6 to 10	10 to15	16+	X	C	D	S
AA. How many blocks do you see?			43									
AB. What objects do you see in the block?	40								1	1	2	
AC. Do you see all these objects all of the time?		3	40									
AD. If no,which objects disappear?	40									1		2
AE. Tell me when the box becomes two.	1			42								
AF. Or if the circle or square disappear.	1				8	13	9	12				
AG. Again, tell me if box becomes two.	1			41								1
AH. Or if the circle or square disappear.	1				25	16	1					

KEYSTONE CARD SKILLS

	#NA	0	1	2	< 4.5	4.5 to 6	> 6	X
AJ. To what number does the arrow point.					6	27	10	
AK. To what number does the arrow point to now?					5	26	12	
AL. and now?					7	23	13	
AM. Do any of the Numbers or the Arrow ever Fade or Disappear?			43					
AN. If AL Yes Which one fades Numbers or Arrow?	43							
AP.How many circles are there?		12	31					
AQ. 4 then 3 within 3 seconds is considered a pass.		10	33					
AR. If still 4? Is the red circle to the right or left of the blue circle?	33							10

C-1

Appendix C

RED LENS TEST

	#NA	0	1	P	W	R	B	X
AT. How many lights do you see?		7	36					
AU. If two can you make one?	36	5	2					
AV. What is the color of the light?				35	2	3	3	
AW. Does the color of the light ever change?	2	11	30					
AX. Red right (Eso) Red left (Exo)	36							7

TWO-DOT FLASHLIGHT TEST

	#NA	0	1	L	R	G	B
AZ. How many flashlights am I holding in my hand?			43				
BA. How many flashlights do you see?			43				
BB. How many half-moons do you see?			43				
BC. What is the color of each half-moon?				41	2		
BD. Do you see one or two black stripes in the middle of my flashlight ?		1	42				
BE. Do you see any colored dots (balls) in the black stripe?		1	42				
BF. How many dots do you see?	1	4	38				
BG. What color dot(s)do you see?	1				3	1	38
BH. do you see both colored dots all the time	5	1	37				
BI. Can you find any other colored dots in the black stripe?	38		5				

Appendix D

	A	B	C	D	E	F	G	H
1				Simultaneous Perception				
2								
3			Worth	Ball & Ring	Vodnoy #12	Keystone DB-9E	Red Lens	Two-dot
4	QUESTION		1a	1	2a	2	2	5a
5	NAME	Case #						
6	Miller	1	P	P	P	P	F	F
7	Jannus	2	P	P	P	P	P	P
8	Farwell	3	P	P	P	P	P	P
9	Villagomez	4	P	P	P	P	P	F
10	Hernandez	5	P	P	P	P	P	P
11	Costello	6	P	P	F	P	P	F
12	Ricks	7	P	P	P	P	P	P
13	Cinh	8	P	P	P	P	P	P
14	Babila	9	P	P	P	P	F	P
15	Perkins	10	P	P	P	P	P	P
16	McVickers	11	P	P	P	P	P	P
17	Hickman	12	P	P	P	P	P	P
18	Rosalito	13	P	P	P	P	P	P
19	Shaw	14	P	P	P	P	F	P
20	Black	15	P	P	P	P	P	P
21	Mahoney	16	P	P	P	P	P	P
22	Clark	17	P	P	P	P	P	P
23	Crum	18	P	P	P	P	P	P
24	Rose	19	P	P	P	P	P	P
25	Tucker	20	P	P	P	P	P	P
26	Gibson	21	P	P	P	P	P	P
27	Gibson	22	P	P	P	P	P	P
28	Malina	23	P	P	P	P	P	P
29	Sparkman	24	P	P	P	P	P	P
30	Powers	25	P	P	P	P	P	P
31	Thudium	26	P	P	P	P	P	P
32	Crespo	27	P	P	P	P	F	P
33	Turner	28	P	P	P	P	P	P
34	Monroe	29	P	F	P	P	F	F
35	Rouse	30	P	P	P	P	P	P
36	Snyder	31	P	P	P	P	P	P
37	Theus	32	P	P	P	P	P	P
38	Ferguson	33	P	P	P	P	P	P
39	Tryggestad	34	P	P	P	P	P	P
40	Perea	35	P	P	P	P	P	P
41	Ford	36	P	P	P	P	P	F
42	Samuel	37	P	P	F	P	P	P
43	Rodriquez	38	P	P	P	P	P	P
44	Konvalin	39	P	P	P	P	P	P
45	Aleman	40	P	P	P	P	P	P
46	Seward	41	P	P	F	P	P	P
47	Large	42	P	P	P	P	P	P
48	Gallinger	43	P	P	P	P	P	P

D-1

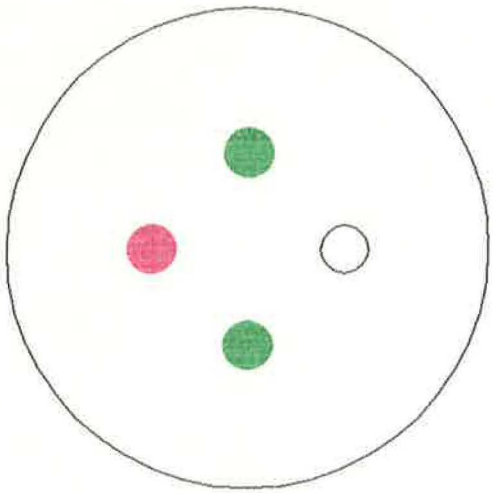
Appendix D

	I	J	K	L	M	N	O	P
1				Second Degree Fusion				
2								
3			Worth	Bell & Ring	Vodnoy #12	Keystone DB-5k	Red Lens	Two-dot
4	QUESTION		1a	2	1,2a	1a	1a	4,5a
5	NAME	Case #						
6	Miller	1	F	F	P	F	P	P
7	Jannus	2	P	P	P	P	P	P
8	Farwell	3	P	P	P	P	P	P
9	Villagomez	4	P	P	P	F	F	P
10	Hernandez	5	P	P	P	P	P	P
11	Costello	6	P	F	F	F	P	P
12	Ricks	7	P	P	P	P	P	P
13	Cinh	8	P	P	P	P	P	P
14	Babila	9	P	P	P	P	P	P
15	Perkins	10	P	P	P	P	P	P
16	McVickers	11	P	P	P	P	P	P
17	Hickman	12	P	P	P	P	P	P
18	Rosalito	13	P	P	P	P	P	P
19	Shaw	14	P	P	P	P	P	P
20	Black	15	P	P	P	P	P	P
21	Mahoney	16	P	F	P	F	P	P
22	Clark	17	P	F	P	F	P	P
23	Crum	18	P	P	P	P	P	P
24	Rose	19	P	P	P	P	P	P
25	Tucker	20	F	F	P	F	F	F
26	Gibson	21	P	P	P	P	P	P
27	Gibson	22	P	P	P	P	P	P
28	Malina	23	P	P	P	P	P	P
29	Sparkman	24	P	P	P	P	P	P
30	Powers	25	P	P	P	P	P	P
31	Thudium	26	P	P	P	P	P	P
32	Crespo	27	P	P	P	P	P	P
33	Turner	28	P	P	P	P	P	P
34	Monroe	29	P	F	P	P	P	P
35	Rouse	30	P	F	P	F	P	P
36	Snyder	31	P	P	P	P	P	P
37	Theus	32	P	F	P	F	P	P
38	Ferguson	33	P	P	P	P	P	P
39	Tryggestad	34	P	P	P	P	P	P
40	Perea	35	P	P	P	P	P	P
41	Ford	36	P	P	P	F	P	P
42	Samuel	37	P	P	F	P	P	P
43	Rodriquez	38	P	P	P	P	P	P
44	Konvalin	39	P	P	P	P	P	P
45	Aleman	40	P	P	P	P	P	P
46	Seward	41	P	P	F	P	P	P
47	Large	42	F	F	P	F	P	P
48	Gallinger	43	P	P	P	P	P	P

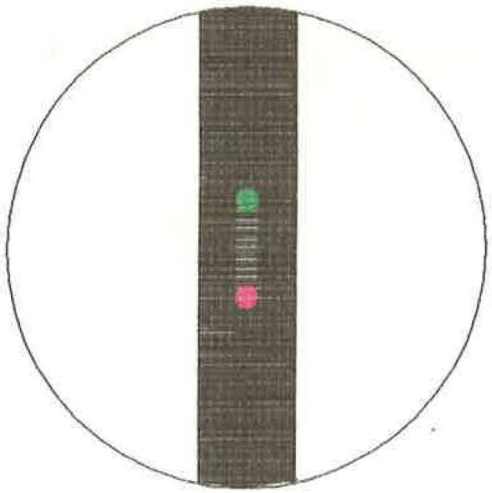
D-2

Appendix D

	Q	R	S	T	U	V
1			LUSTER EFFECTS			
2						
3			Worth	Ball & Ring	Red Lens	Two-dot
4	QUESTION		5	3	2a	3a
5	NAME	Case #				
6	Miller	1	F	F	P	P
7	Jannus	2	P	P	P	P
8	Farwell	3	P	P	P	P
9	Villagomez	4	P	P	F	P
10	Hernandez	5	P	P	P	P
11	Costello	6	P	F	P	F
12	Ricks	7	P	P	P	P
13	Cinh	8	P	P	P	P
14	Babila	9	P	P	P	P
15	Perkins	10	P	P	P	P
16	McVickers	11	P	P	P	P
17	Hickman	12	P	P	P	P
18	Rosalito	13	P	P	P	P
19	Shaw	14	P	P	P	P
20	Black	15	P	P	P	P
21	Mahoney	16	P	F	P	P
22	Clark	17	P	F	P	P
23	Crum	18	P	P	P	P
24	Rose	19	P	P	P	P
25	Tucker	20	F	F	F	P
26	Gibson	21	P	P	P	P
27	Gibson	22	P	P	P	P
28	Malina	23	P	P	P	P
29	Sparkman	24	P	P	P	P
30	Powers	25	P	P	P	P
31	Thudium	26	P	P	P	P
32	Crespo	27	P	P	P	P
33	Turner	28	P	P	P	P
34	Monroe	29	P	F	P	F
35	Rouse	30	P	F	P	P
36	Snyder	31	P	P	P	P
37	Theus	32	P	F	P	P
38	Ferguson	33	P	P	P	P
39	Tryggestad	34	P	P	P	P
40	Perea	35	P	P	P	P
41	Ford	36	P	P	P	P
42	Samuel	37	P	P	P	P
43	Rodriquez	38	P	P	P	P
44	Konvalin	39	P	P	P	P
45	Aleman	40	P	P	P	P
46	Seward	41	P	P	P	P
47	Large	42	F	F	P	P
48	Gallinger	43	P	P	P	P

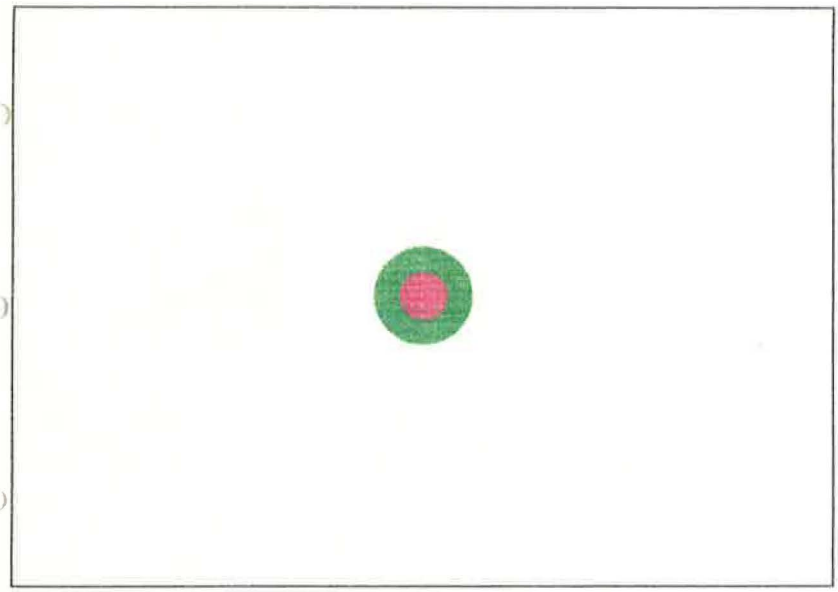


Worth 4 Dot

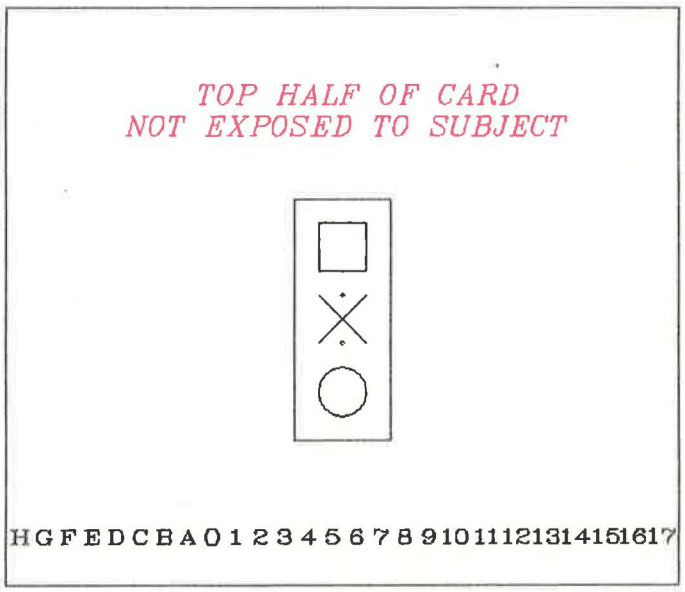


Two Dot Flashlight

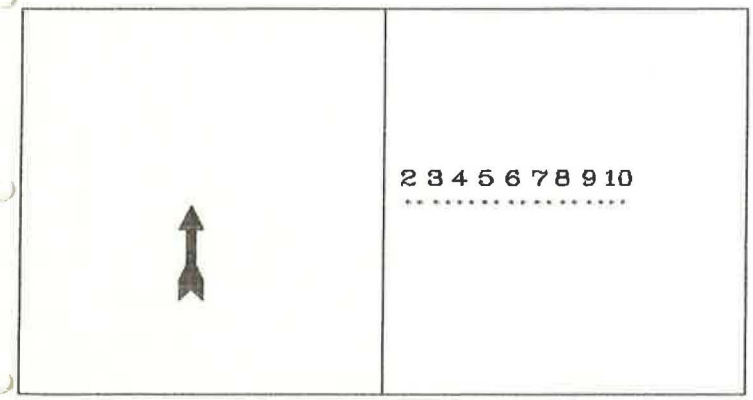
Red Lens Test not shown
Representation assumed to be universal.



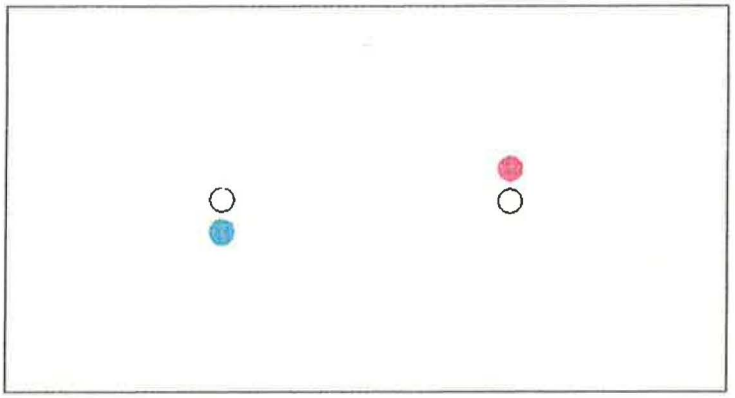
Ball and Ring



Vodnoy #12 Basic Fusion



Keystone Lateral Phoria
(DB-9B)



Keystone 4 Ball Test
(DB-5K)

FIGURE #1 Experimental Presentation Targets

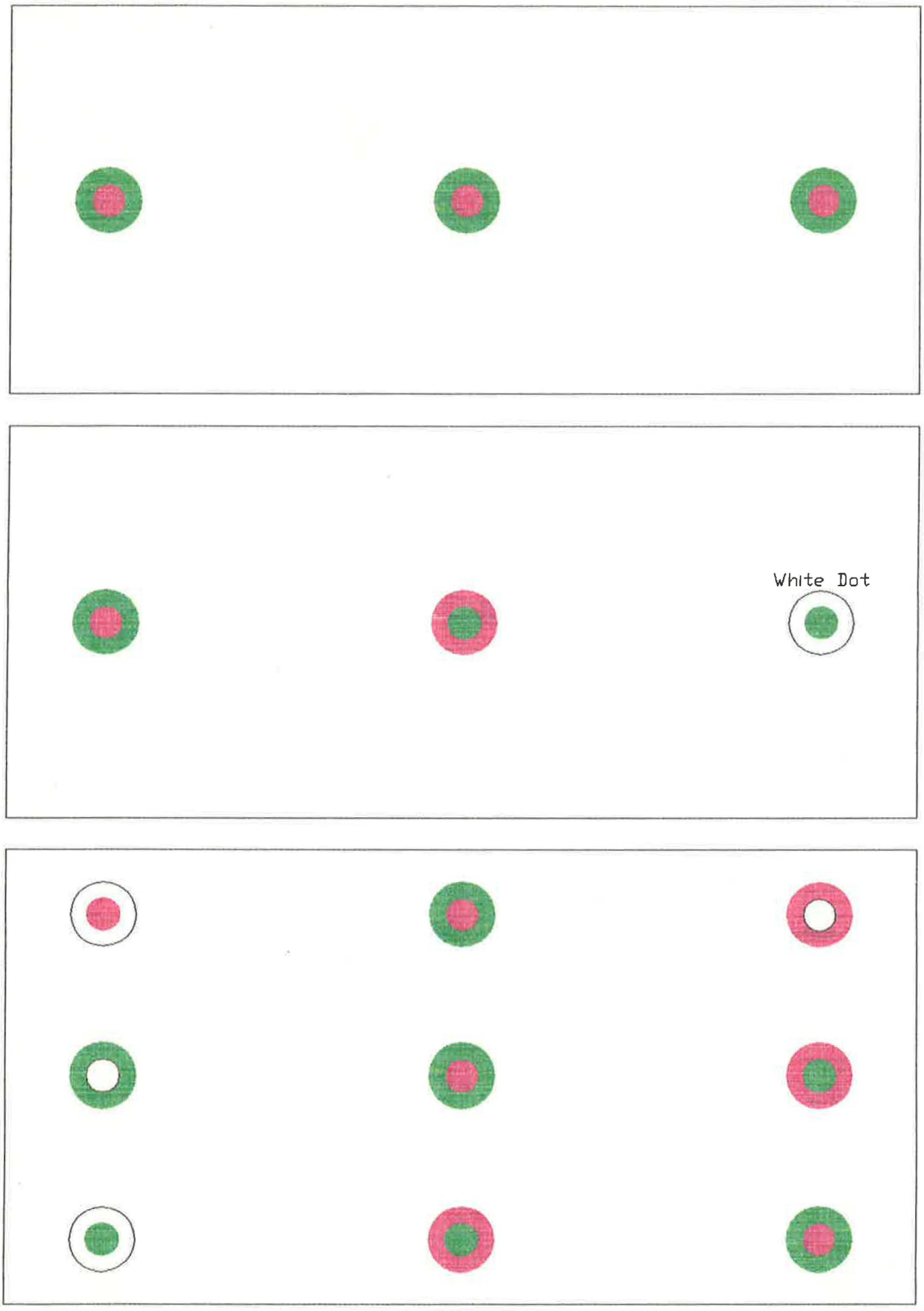


FIGURE #2 Variations of Ball and Ring