THE EFFECT OF TINTED LENSES ON VISUAL ACUITY

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INTRODUCTION

Visual acuity can be defined as "clearness of vision (especially form vision) which depends on the sharpness of the retinal focus, the sensitivity of the nervous elements and the interpretative faculty of the brain."[1] Assuming that the neurological elements of the visual system are normal and no pathology exists, many things can still influence the visual acuity by changing the sharpness of the retinal image as it is focused on the back of the eye. The most obvious condition influencing the clarity of the retinal image would be an uncorrected refractive error. However other less obvious conditions can also influence the image. These include room illumination, retinal adaption to light, background illumination and color vision. Just as there are many ways of testing for acuity. Because the effect certain variables have on visual acuity can be subtle, different testing procedeers may have to be used instead of the Snellen visual acuity.

One variable that may influence acuity is now very popular fad of placing tints or lens coatings on ophthalmic lenses for full time and multi-purpose uses. Most times, a tinted lens is given for its cosmetic appeal without regard as to how that tint may change the visual environment of the person wearing it. By reducing the illumination entering the eye with a tinted lens, could acuity problems arise as a person performs daily tasks? Does a cosmetic tint or a sunglass type tint, even affect visual performance at all? Obviously any affect a tint may have will not be dramatic enough to show up on tests such as Snellen acuity. What if instead of Snellen, a test was used where idenification of a target depended only on the subtense of the visual angle and is not affected by surrounding objects or clues. Such a test would depend

angular acuity only. Since this test would be able to pick up small changes in acuity levels, will tints affect this acuity test?

Equipment and Subjects

To measure minimum angle of resolution, a checkerboard pattern was choosen as the target. The acual target was a slide of the checkerboard pattern imaged on a wall by a projection. The projector was capable of changing magnification of a target so that a single size target would produce various Snellen letter acuities as the size image changed. The checkerboard pattern was designed so that each square had a projected image size that corresponded to a 20/20 Snellen letter when the projectors magnification was set on 1.0x at a distance of 10 ft. The overall size of the pattern image was 4.1 cm.

Four different tints were using in this experiement. They were a Brown tint with a transmittion of 70%, a photogrey extra lens, transmittion 80% unbleached, 65% U.V. bleached, a Green tint, 35% transmittion and a Grey lens 20% transmittion. These tints were combined with 3 Kodac Wrattan neutral density filters of 0.6, 1.0, and 2.0 N.D.

Thirteen subjects were used in the experiment. They ranged in age from 18 to 39. All had acuity of 20/20 or better unaided or corrected with lenses to that point. There were 5 females and 8 males. None of the subjects had any pathological conditions or field defects at the time of testing.

Procedure

Two different procedures were used to obtain the minimum angle of resolution. The four different tints were used and also a trial done without any tints. Each person was asked to look through each tint (or no tint) while the other eye was covered with a black occluder. The

subject was asked to use the eye he thought had ~~the~~ best vision or the eye he used most in a monocular situation. The sequence of each person tested was first no tint, then Photogrey, Brown, Green and lastly Grey. Each person was allowed approx. 1 min. to adapt to the lens. This lens sequence was performed with each neutral density filter as a combination in the following order o.o N.D., 0.6 N.D., 1.0 N.D. and 2.0 N.D. The complete sequence was performed once in full room illumination and again with all room lights turned off. (The photogrey lens was exposed 10 mins. to U.V. lights beforeit was used in the "daylight"test and the lens was allowed to lighten 1 hour before its use in the "darkness" test.)

Test #1 - was performed by all 13 people. They were asked to view the checkerboard pattern using the full lens and neutral density sequence in both "daylight" and "darkness" conditions. With the projector distance and target size remaining constant (10 ft. and 4.1 cm respectively) the subject was asked to slowly walk towards the target starting from a distance where no pattern could be distinquished and to stop when he could first recognize a checkerboard pattern. This distance was measured and the visual angle it represented computed.

Test #2 - was done by 6 subjects again using the full tint and filter sequence and lighting conditions. They were asked to sit at the same distance from the target as the projector (10 ft.) Keeping the distance constant the subject was asked to vary the magnification of the image pattern until it could be just recognised as a checkerboard. As before, the person started from a point where the pattern was unrecognizable. A scale was placed along the movable magnification control knob. Each value corresponded to a certain size target. The visual angle was also computed.

In addittion one subject was asked to perform each trial of each test 10 times to establish the reliability of individual responses. These responces were not included in the overall data.

RESULTS

As expected there were a lot of differences between individual responces. The standard deviation for Test #1 ranged from .160 S.D. with no tint and no filter in "daylight" to 1.474 S.D. with a green tint, 1.0 N.D. in daylight. For Test #2 responces ranged between .004 S.D. with a Green tint, 0.6 N.D. in "darkness" to .646 with a Grey tint 1.0 N.D. in "daylight." Test #3 (the combination of both tests) results ranged from .131 S.D. with no tints and no filters in "daylight" to 1.531 S.D. with a Grey tint, 1.0 N.D. in "daylight". The average of all the standard deviations are for #1 - .460 S.D., for #2 - .126 S.D. and #3 - .416 S.D. It would appear that the conditions in test #2 promoted more uniform data between the subjects tested. (See charts for standard deviations scores)

Eventhough there was a wide range in data between the subjects tested, when 1 person was asked to show repeatability of individual findings, the standard deviation were low with an average of .043 S.D. in test #1 and .019 S.D. in test #2. Again test #2 seems to give more consistant data.

So it would seem the wide differences between the data gathered from each subject shouldn't interfere with the end results, because individual results are repeatable. The variation simply shows that the tints, filters and lighting conditions affected each subject differently.

Comparing the means of the various tints, in all cases the means

for test #2 were lower than test #1 means. The means of the combination (test #3) normally were similar to test #1 but always lower. This may relate to the more consistant scores obtained in test #2. Also, the mean scores for the trials were lower in "darkness" conditions. It may have been because the contrast between the checkerboard light and dark squares was 10% in "daylight" conditions while it was 27.7% in "darkness" conditions.

To finally answer the question, "Did the tints tested significantly reduce the subject's ability to resolve the checkerboard pattern?" the data must be looked at in a different manner. If the tints had no effect on the subjects, the difference between the scores found using no tints vs. any tint in the trials should be equal to zero, allowing for differences due to normal variations. To compare the differences between no tint and using a tint, a Z score was found for all trials (see chart) After arriving at the Z score for situations, the question is then how much of the score is due to normal variation. Two percentage error scores were choosen 95% and 99%. These scores have a value which means that for any Z score the difference must be greater than their set value or the cause of the difference is only due to normal variation. The 95% and 99% scores mean that this situation would apply to 95 cases out of 100 and 99 cases out of 100. If the Z scores found for any trial was greater than the percentage error value , the difference could not be blamed only on normal variation. The difference in Z scores would mean the difference in the affect of tint vs. no tint would <u>not</u> be zero. Therefore the tint had affected the measured acuity and it interfered with the subjects ability to resolve the target.

If the 95% error value is used only the trial test Z score comparing no tint to the brown tint with no filter in "daylight" can be explained away by normal variations. All other comparisions showed that the tints

did reduce the subjects ability to resolve the target. If the 99% error value is used 6 out of 28 comparisions could be the result of normal variations. The 6 cases were mostly those tints with large transmittion percentages. By far the majority of the cases suggest that a tint will increase the minimum angle needed to first recognize a target, thereby suggesting an interference with visual performance.

Conclusion

As first stated in the introduction, there are many things that can interfere with vision and visual performance. Some like a tint may not cause a great deficiency when compared to other visual problems such as an uncorrected refractive error but the reduction still exists. As noted by the differences in Z scores different tints will affect visual performance to a lesser or greater degree. For the most part the sunglass tints (Green and Grey) will reduced visual performance the greatest. The Photogrey and Drown tints also will reduce the performance more often than not even using the 99% error value.

As noted in this study, there is a wide variation between individuals in how the tints and lighting conditions affected their performance level. If it would be impossible to know which people may be hurt in their visual performance by a tint and the type and amount of transmittion loss would be necessary for this reduction to show up. Because every person is exposed to hundreds of different lighting conditions and acuity tasks, this further complicates determining when a tint may be harmful. A practitioner must then use common sense in giving his O.K. to a patient wanting a tint especially if that tint is to be worn on a full time basis.

Minimum Angles of Resolution

Means and Standard Deviations

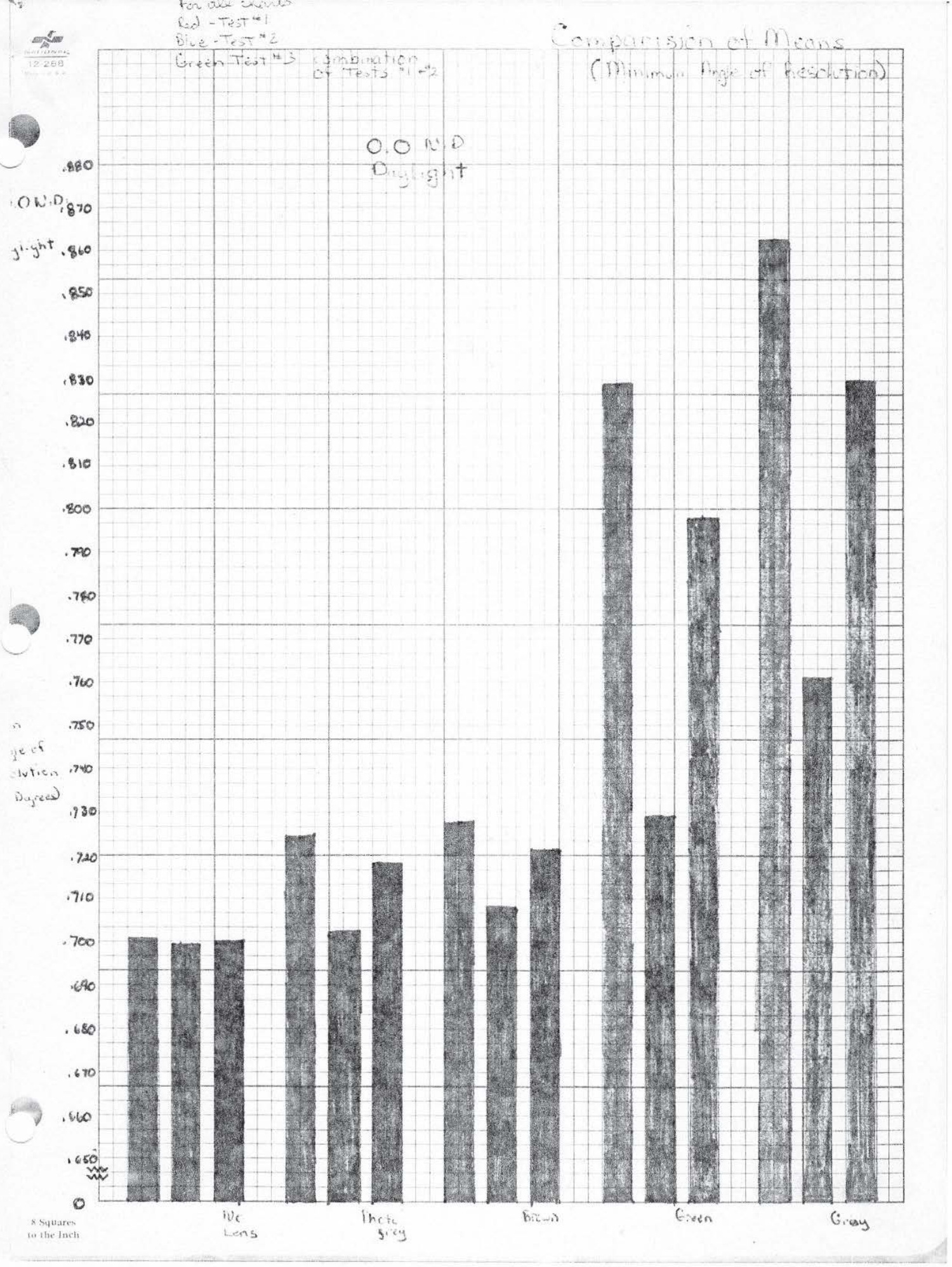
O.O N.D.	CLEAR		PHOTO		BROWN		GREEN		GREY	
Subject#	(L)	(D)	(L)	(D)	(L)	(D)	(L)	(D)	(L)	(D)
1	.453	.453	.484	.479	.528	.505	.680	.525	.766	.541
2	.826	.833	.898	.963	.818	.841	.916	.889	.925	.898
3	.994	.963	1.051	1.005	1.075	1.051	1.340	1.284	1.541	1.468
4	.872	.872	.881	.898	.881	.872	1.028	.984	1.028	1.005
5	.541	.550	.574	.560	.560	.560	.612	.593	.638	.597
6	.711	.811	.717	.833	.717	.811	.872	.973	.925	.994
7	.528	.541	.505	.532	.525	.550	.665	.574	.665	.589
8	.711	.818	.723	.841	.740	.818	.856	.984	.881	1.005
9	.604	.479	.621	.528	.651	.525	.690	.550	.701	.578
10	.617	.589	.593	.625	.593	.621	.656	.670	.711	.685
11	.651	.661	.665	.638	.680	.670	.701	.723	.711	.766
12	.898	.560	.994	.701	.973	.777	.984	.833	.984	1.114
13	.706	.675	.706	.661	.711	.675	.777	.706	.734	.797
TOTAL (1)										
Mean	.701	.680	.724	.713	.727	.714	.829	.791	.862	.849
SD	.160	.162	.181	1.770	.170	.164	.204	.224	.241	.268
1	.718	.680	.695	.688	.711	.695	.726	.695	.763	.695
2	.650	.628	.658	.643	.643	.665	.650	.665	.665	.680
3	.718	.680	.695	.688	.711	.695	.726	.695	.763	.695
4	.688	.733	.695	.688	.688	.688	.728	.733	.756	.733
5	.726	.695	.741	.658	.763	.665	.782	.711	.804	.763
6	.680	.628	.726	.635	.726	.680	.771	.695	.816	.726
TOTAL (2)										
Mean	.697	.674	.702	.667	.707	.681	.729	.699	.761	.711
SD	.029	.041	.029	.025	.040	.014	.047	.022	.053	.036
TOTAL (3)										
Mean	.700	.678	.717	.698	.721	.703	.797	.762	.830	.807
SD	.131	.134	.150	.146	.141	.135	.175	.189	.205	.228

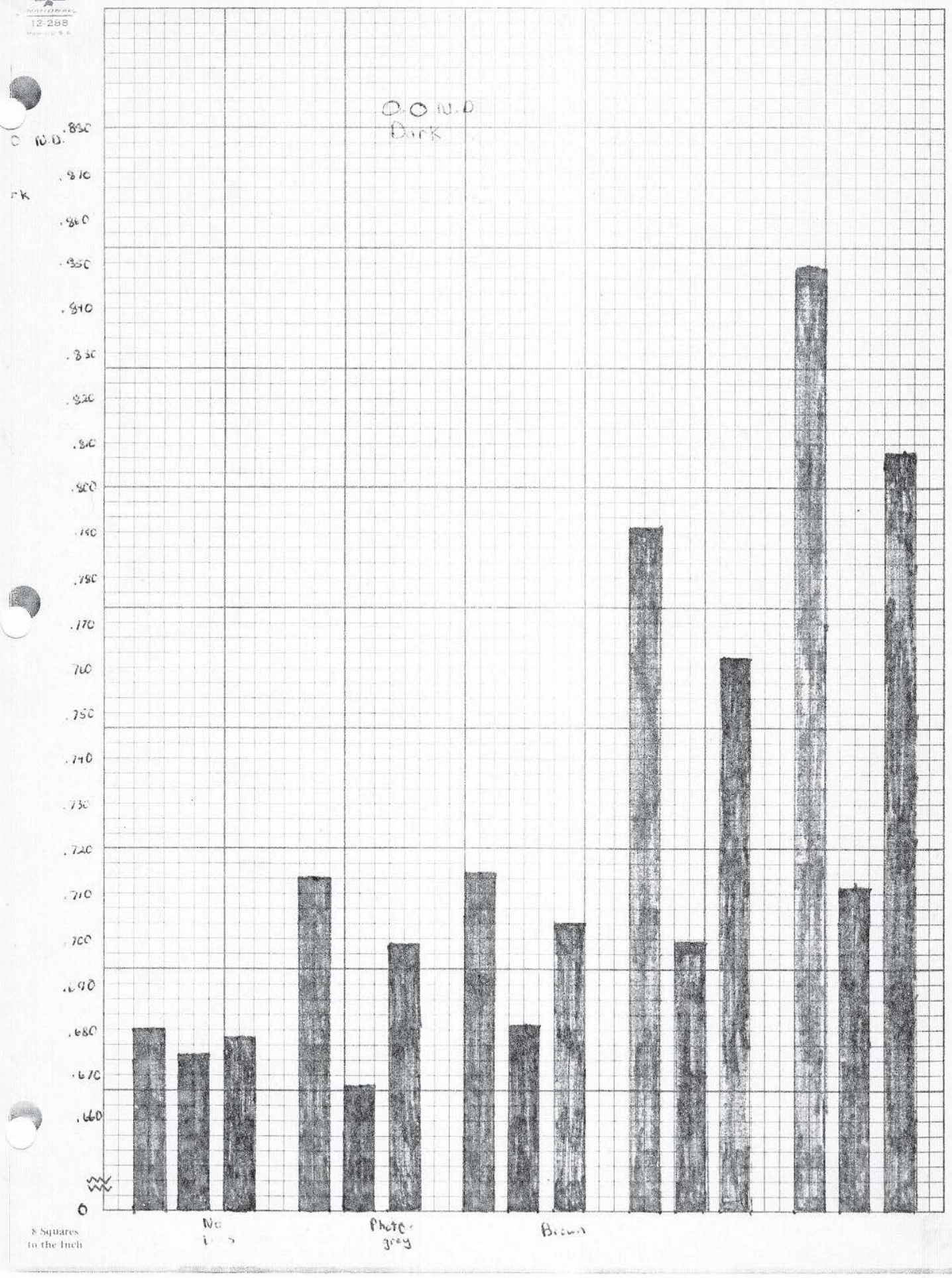
0.6	CLEAR (L)	CLEAR (D)	PHOTO (L)	PHOTO (D)	BROWN (L)	BROWN (D)	GREEN (L)	GREEN (D)	GREY (L)	GREY (D)
1	.984	.973	1.114	1.088	1.101	.934	1.267	.984	1.380	1.250
2	.984	1.005	1.039	1.016	1.063	1.028	1.250	1.101	1.401	1.250
3	1.491	1.491	1.651	1.541	1.516	1.541	2.054	1.926	2.201	2.010
4	.944	.925	1.005	.984	.953	.934	1.156	.984	1.171	1.016
5	.934	.889	.934	.889	.925	.907	1.744	1.321	2.101	1.541
6	1.128	1.028	1.142	1.016	1.142	1.028	1.340	1.250	1.516	1.302
7	.764	.740	.784	.766	.841	.766	.984	.864	1.028	.872
8	1.028	1.039	1.142	1.142	1.156	1.075	1.302	1.233	1.321	1.321
9	.766	.511	.811	.532	.826	.532	.907	.617	1.051	.585
10	.706	.717	.706	.685	.734	.711	.752	.766	.804	.790
11	.717	.680	.758	.690	.841	.701	.856	.701	.881	.717
12	.804	.746	.833	.797	.811	.790	.856	.872	.872	.907
13	.856	.680	.717	.889	.752	.771	1.016	.833	1.156	.953
TOTAL (1)										
Mean	.931	.896	.972	.918	.974	.890	1.191	1.035	1.299	1.116
SD	.212	.239	.260	.250	.218	.257	.373	.345	.437	.385
1	.703	.726	.714	.718	.842	.733	1.109	.741	1.170	.763
2	.695	.658	.703	.688	.695	.711	.718	.748	.741	.782
5	.726	.620	.741	.635	.771	.688	.793	.711	.827	.763
6	.874	.733	.940	.763	.996	.771	1.139	.842	1.297	.874
3	.703	.726	.741	.718	.842	.733	1.109	.741	1.170	.763
4	.695	.733	.718	.726	.771	.726	.921	.763	1.064	.756
TOTAL (2)										
Mean	.733	.699	.764	.708	.820	.727	.965	.758	1.045	.784
SD	.070	.048	.089	.043	.102	.027	.181	.004	.217	.045
TOTAL (3)										
Mean	.869	.834	.906	.852	.925	.839	1.120	.947	1.157	1.011
SD	.201	.218	.239	.229	.200	.224	.337	.312	.466	.353

1.0	CLEAR		PHOTO		BROWN		GREEN		GREY	
	(L)	(D)	(L)	(D)	(L)	(D)	(L)	(D)	(L)	(D)
1	1.926	1.926	2.255	1.516	1.516	1.778	2.498	2.255	2.498	2.311
2	1.712	1.622	1.813	1.778	1.813	1.778	2.150	1.926	2.255	2.010
3	2.888	2.718	2.718	2.567	2.888	2.800	6.577	4.196	7.078	4.614
4	1.681	1.567	1.681	1.567	1.622	1.541	2.101	1.849	2.201	1.426
5	1.926	1.774	1.926	1.813	1.926	1.712	3.299	2.981	3.848	3.299
6	1.594	1.128	1.744	1.142	1.744	1.156	2.800	1.302	2.888	1.401
7	1.088	1.016	1.171	1.101	1.267	1.142	1.541	1.250	1.712	1.284
8	1.926	1.114	2.010	1.128	2.054	1.233	2.432	1.302	2.498	1.423
9	1.142	.706	1.171	.717	1.302	.740	1.468	.732	1.849	.758
10	.833	.717	.925	.717	1.016	.746	1.075	.784	1.088	.826
11	1.005	.723	1.039	.734	1.005	.746	1.088	.833	1.340	.848
12	1.186	.728	1.114	.766	1.063	.833	1.186	.848	1.186	.934
13	1.217	.907	1.028	1.075	1.114	1.142	1.321	1.267	1.423	1.267
TOTAL (1)										
Mean	1.548	1.311	1.584	1.324	1.565	1.334	2.272	1.656	2.451	1.722
SD	.555	.625	.557	.594	.537	.587	1.474	1.008	1.589	1.121
1	1.447	.733	1.710	.748	1.863	.763	1.920	.782	-	.793
2	.842	.695	.865	.711	.827	.718	.902	.741	.902	.783
3	1.447	.733	1.710	.748	-	.756	-	.782	-	.782
4	1.170	.726	1.658	.726	1.297	.726	-	.756	-	.887
5	1.260	.763	1.410	.756	1.500	.793	1.710	.816	1.815	.874
6	1.019	.741	1.170	.793	1.410	.827	1.710	.865	-	.959
TOTAL (2)										
Mean	1.198	.732	1.421	.747	1.379	.764	1.561	.790	1.359	.846
SD	.240	.022	.345	.028	.375	.041	.450	.045	.646	.072
TOTAL (3)										
Mean	1.437	1.107	1.533	1.141	1.513	1.154	2.105	1.382	2.305	1.446
SD	.499	.562	.496	.558	.493	.552	1.329	.921	1.531	1.007

(D) Only

2.0	CLEAR	PHOTO	BROWN	GREEN	GREY
1	2.010	2.201	1.967	2.498	2.718
2	2.010	2.010	2.101	2.567	2.800
3	-	-	-	-	-
4	1.926	2.054	2.010	2.201	2.432
5	1.491	1.567	1.594	1.967	2.054
6	1.744	1.813	1.778	2.101	2.255
7	1.186	1.217	1.217	1.340	1.380
8	1.778	1.849	1.849	2.054	2.370
9	.764	.784	.831	.963	1.016
10	1.128	1.250	1.285	1.380	1.468
11	.984	1.005	.973	1.171	1.516
12	1.267	1.284	1.284	1.541	1.926
13	1.401	1.401	1.778	2.718	2.981
TOTAL (1)					
Mean	1.474	1.511	1.556	1.875	2.076
SD	.420	.456	.425	.584	.626
1	1.086	1.109	1.170	1.372	1.868
2	1.260	1.372	1.500	1.710	1.920
3	1.297	1.372	1.447	1.710	-
4	1.410	1.372	1.447	1.763	-
5	.959	1.450	1.139	1.260	1.552
6	1.447	1.500	1.710	-	-
TOTAL (2)					
Mean	1.243	1.363	1.402	1.563	1.780
SD	.189	.135	.215	.230	.199
TOTAL (3)					
Mean	1.397	1.462	1.504	1.783	2.017
SD	.370	.381	.369	.518	.574

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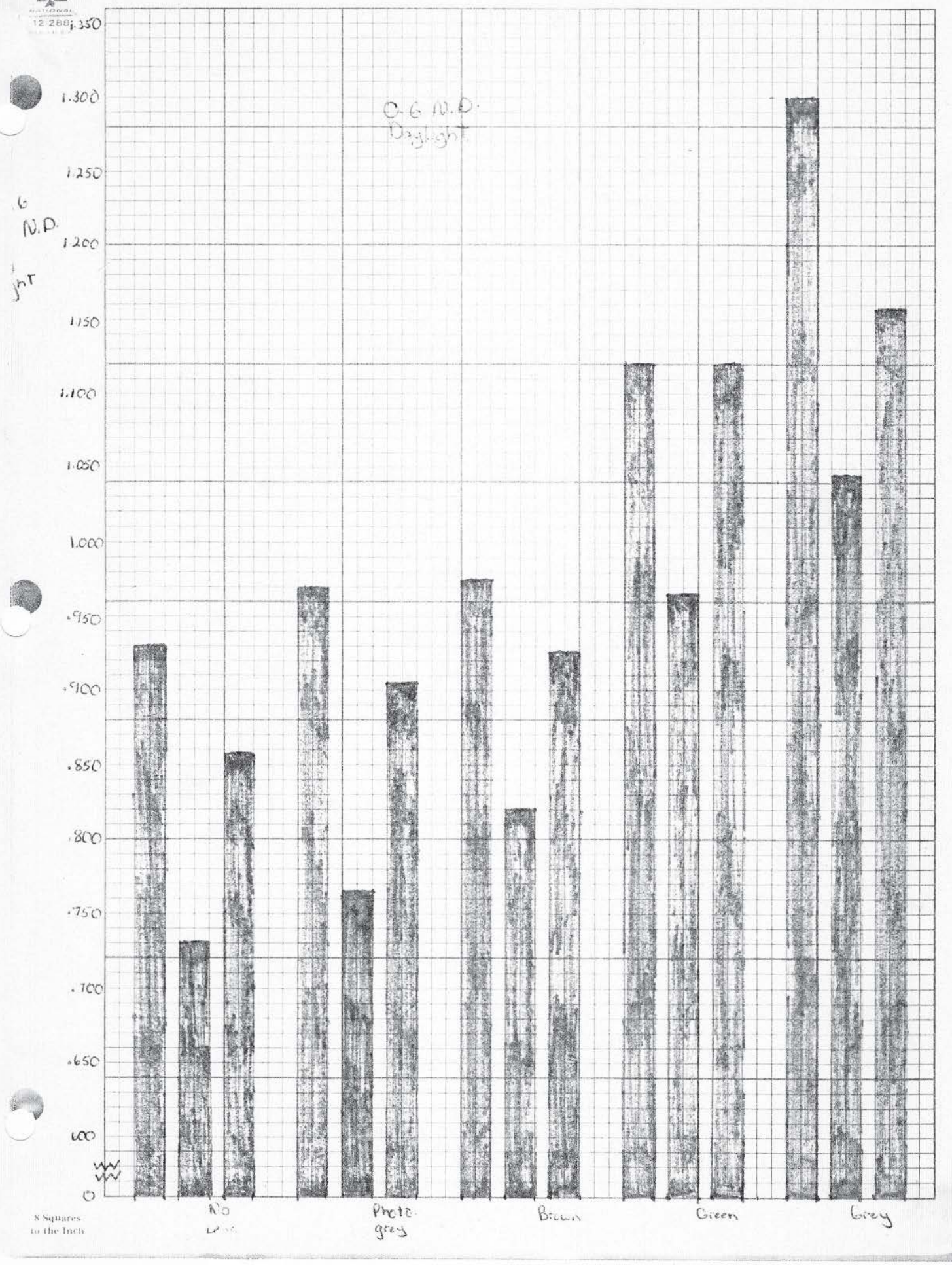

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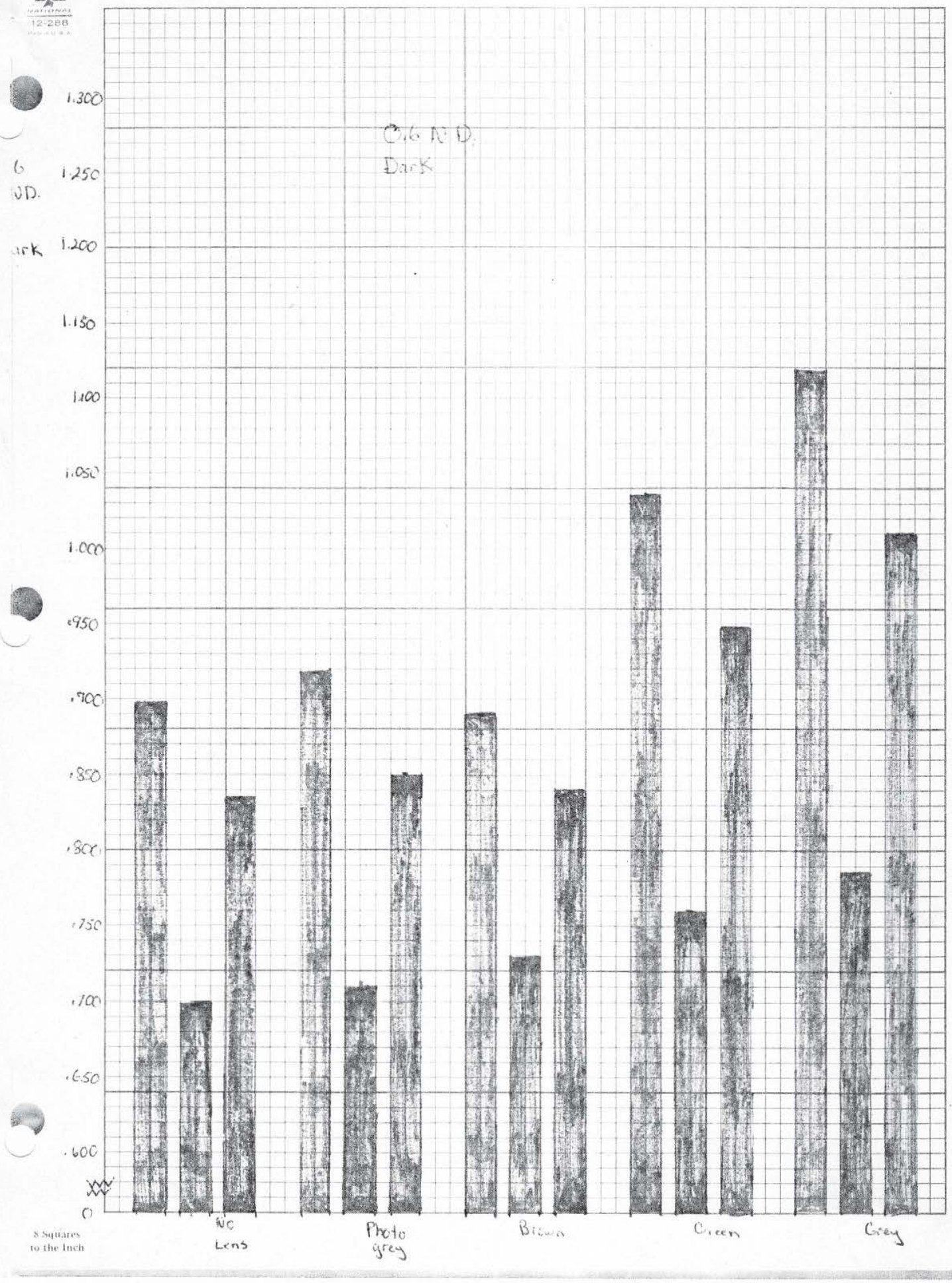

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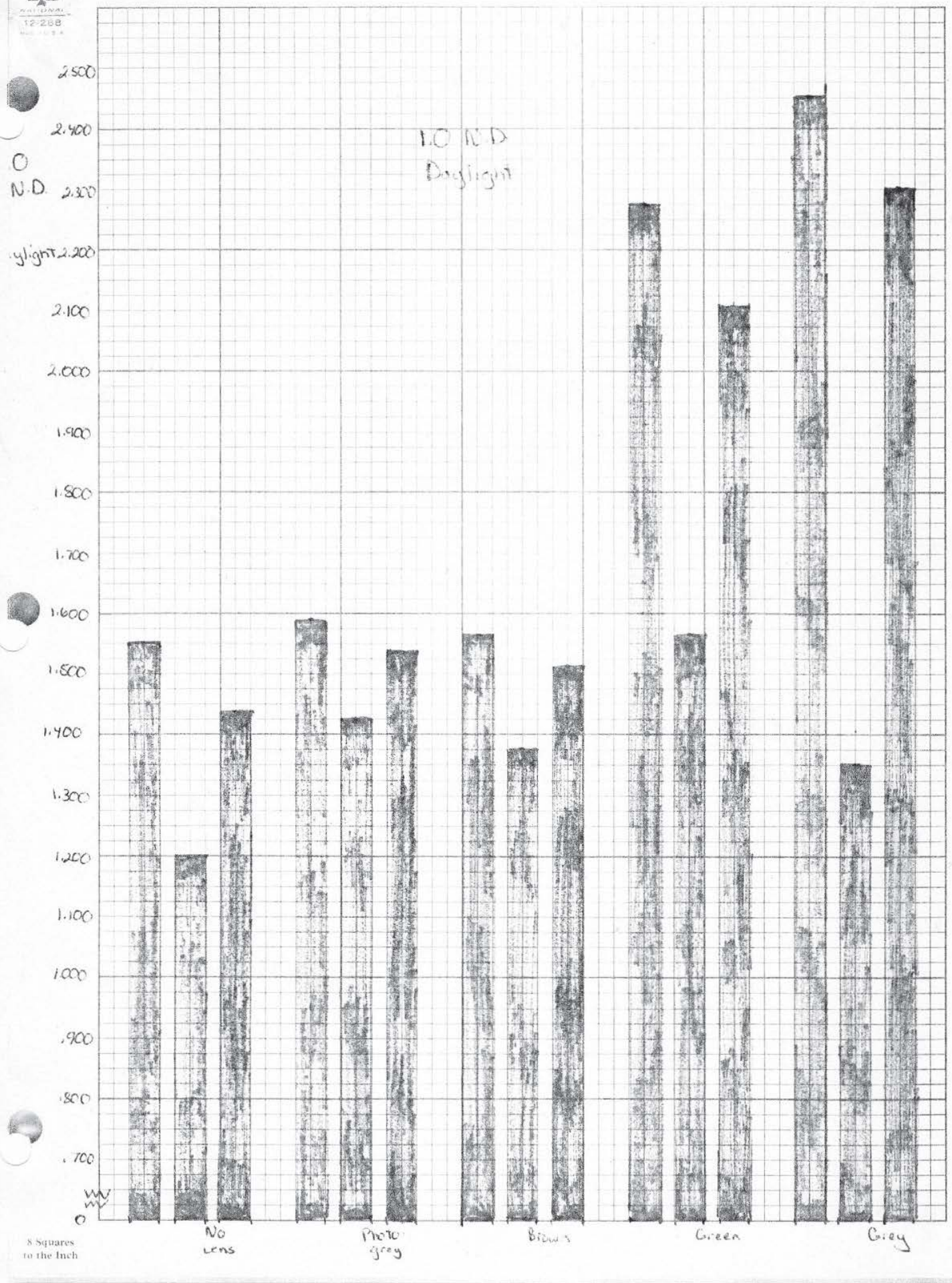

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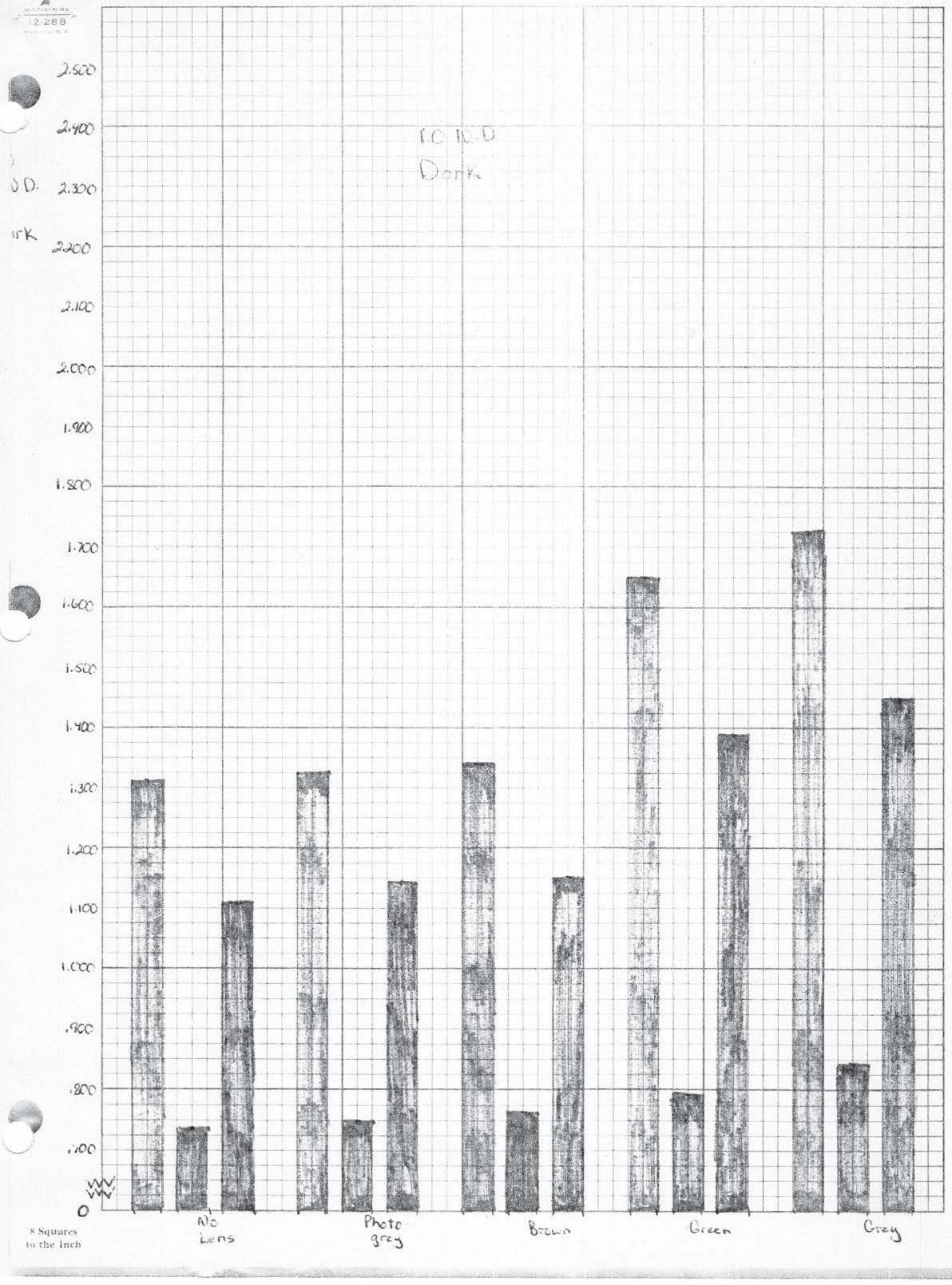
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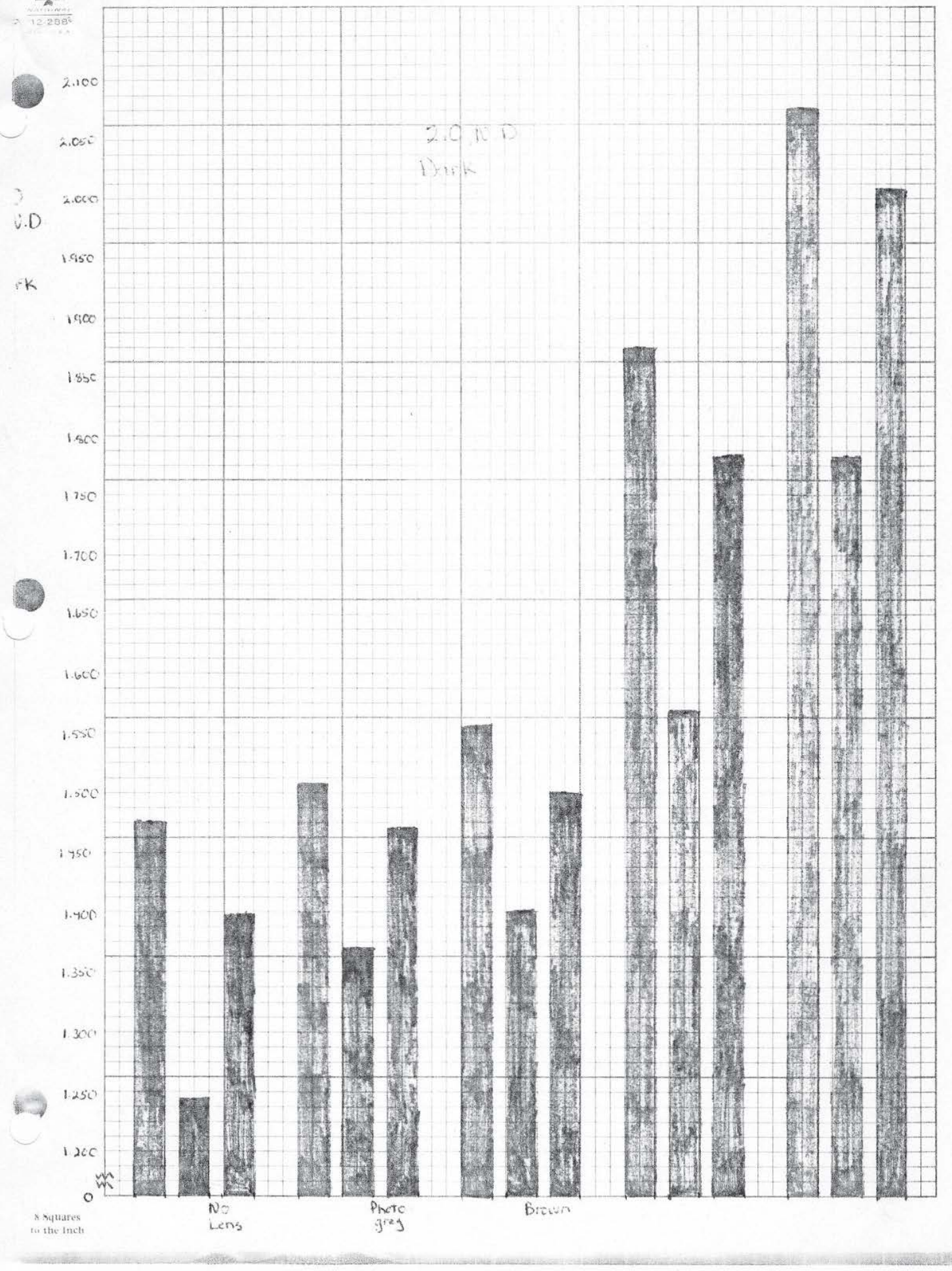

8 Squares to the Inch

Z VALUE SCORES

CLEAR VS	PHOTO	BROWN	CRAYON	GREY
0.0	2.025 (2)	1.478 (1)	5.026	4.690
	2.029 (2)	2.139	3.605	3.019
0.6	2.702	1.925 (2)	5.267	5.511
	2.538	3.906	4.397	4.929
1.0	2.523 (1)	1.670 (2)	2.961	2.365
	2.012 (1)	2.458	3.046	2.923
2.0	2.953	7.829	4.070	7.503

1) 95% - 1.65 score or below shows normal variation
2) 99% - 2.06 score or below shows normal variation