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A comparison of the effect of reduced illumination and tinted lenses on stereopsis at near

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Abstract

Relative depth may be appreciated with the use of one eye using linear perspective, shadows, parallax and texture as monocular cues to depth. Stereopsis, on the other hand, is the direct appreciation of relative depth that requires the use of both eyes to construct a three-dimensional percept from disparate two-dimensional retinal images. The advantage of stereopsis is with respect to complex visual tasks especially that requiring accurate hand-eye coordination.

Tinted lenses are prescribed for a variety of reasons, including but not limited to photophobia, asthenopia, improving colour perception in colour deficient individuals, enhancing cosmesis and protection against glare or harmful radiation and enhancing visual performance as in sports. The aim of this study was to investigate the comparative effects of six specific CR39 tinted spectacle lenses (grade B), and a white CR39 lens, against a no lens condition, on stereoacuity over a range of illumination levels. Illumination was varied with the use of neutral density (ND) filters, while the Titmus Fly Stereotest (TFS) was used to measure stereoacuity. Participants (n = 60) between the ages of 17 - 29 years (mean = 23.58; sd = 3.14) were purposively sampled from a clinical practice to participate in this research study.

Using repeated measures ANOVA and appropriate post-hoc multivariate analysis, it was evident that there was a significant decline in stereopsis as the level of illumination decreased, regardless of tint condition; also there was no statistically significant difference in stereopsis between the no lens and white lens conditions at each level of illumination; and stereopsis was significantly superior with the no lens condition compared to all six other tint conditions (grade B), at each level of illumination.

These results indicate that stereoacuity, as measured by the TFS, is adversely affected by a decline in retinal illuminance and by the use of tinted lenses. This information could be utilised to advise patients on the performance implications of the six tinted lenses tested with respect to their effects on stereoacuity under different illumination levels.

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Introduction

Even though the retinal image is two-dimensional, the world one looks out on is three-dimensional[1]. The three-dimensional shape can be determined by estimating relative depths. Depth perception can be appreciated using monocular cues such as linear perspective, shadows, parallax and texture amongst others[2 - 5] as well as binocular cues such as stereopsis[6]. Stereopsis contributes to the judgment of depth and distance while facilitating the recognition of solid objects, with localisation playing a valuable role in a variety of daily tasks[2, 3]. Although we have two eyes, we usually have only one visual world[7]. This is made possible by the use of egocentric (knowing the distance and position of an object relative to our body) and oculocentric (quantification of the location of the object within the field of view) axes of localisation[1, 2]. This stereoscopic function is due to the frontal positioning of the eyes through the process of evolution in humans[1 - 3]. The horizontal separation of the two eyes results in relatively small retinal positional differences, giving rise to different principal visual directions for the same object[2, 4, 6, 8]. If this positional difference (retinal disparity) is within Panum's fusional space, it provides significant information about three-dimensional scene structures, giving rise to stereopsis[4, 6]. While similar objects stimulating non-corresponding (disparate) retinal points within Panum's fusional area may be fused to give rise to single binocular vision, very dissimilar objects cannot be fused, resulting in suppression, superimposition, binocular rivalry or diplopia[6].

Fusion is the sensory neural process whereby these two possibly disparate retinal images are associated to produce a single percept in the higher cortical centers, that is, binocular single vision[6]. However, if the horizontal disparity exceeds two degrees and if there is any vertical disparity of over a few minutes of arc, it leads to diplopia[1]. Vergence is the eye movement most commonly associated with fusion[1, 5]. Fusion together with vergence eye movements has evolved to support stereopsis[8, 9]. It has been reported that there are at least two independent stereopsis mechanisms, one sensitive to chromatic contrast and the other to luminance contrast[10]. Although the information from each mechanism may be combined into a unified percept, in comparing chromatic stereopsis to luminance stereopsis, the former mechanism is less sensitive to contrast, has a more limited disparity range, poorer stereoacuity and poorer ability to encode stereoscopically defined shape than the luminance stereopsis mechanism[11]. Empirical evidence on the effects of illumination on stereopsis indicates that stereoacuity decreases at low levels of retinal illumination[12 - 14]. A significant decrease in stereoacuity was noted when the value of the ND filter was 1.4 ND (4% transmission) with TFS[12]. Stereopsis had also been measured under scotopic conditions and was found to be possible in dark adaptation even though it decreased steeply[15].

The clinical value of stereopsis testing is that it is a good indicator of the overall functioning of both the sensory and motor aspects of the visual system[3, 5]. The unit of measure of stereopsis is seconds of arc and the stereoacuity is obtained when the least horizontal disparity evokes the perception of depth[2, 3]. Elkington and Frank[16] report that 60 seconds of arc is considered normal stereoacuity measured at 40 cm, though 15 seconds of arc or better can be measured at 80 cm using the Frisby test. Good stereopsis at near is required for accurate hand-eye coordination when using tools, threading a needle, performing surgery or even using a computer[17 - 19]. Reduced stereopsis may cause symptoms of discomfort such as eyestrain, headaches and diplopia[3, 20].
Tests of stereopsis can be broadly divided into two categories: contour stereotests and random-dot stereotests[6]. Random-dot stereotests have no monocular cues so that stereoscopic depth perception can only occur when binocular fusion has occurred. In this case, a process of global stereopsis is used as evaluation, with correlation of corresponding retinal and disparate points occurring over a large retinal area[6]. On the other hand, in the presence of monocular cues, local

stereopsis is used to evaluate horizontally disparate images in contour stereotests such as the Titmus Fly Stereotest (TFS)[6, 21]. Stereopsis may be measured at distance and at near. In a study by Wong *et al* where monocular cues were eliminated and where they used the same tests at all distances, they found no significant change in stereoacuity with viewing distance[21]. As this stereoacuity is a threshold value for the distance at which it is measured, stereopsis is not effective beyond a certain critical distance[3, 21].

An important aspect of visual information relates to the perception of colour provided by the three types of photoreceptors in the retina. Light is interpreted as colour according to the wavelengths that strike the retina[18]. When light reaches a surface, it undergoes three main changes. Some of the light is reflected, some absorbed and the remainder transmitted[18 - 20]. A tinted lens possesses a definite colour and acts as a filter that alters the intensity and the spectral distribution of light that passes through it[17 - 19]. The colour of the tint is as a result of chemicals added to the spectacle lens to alter the transmission and absorption of the different wavelengths of visible light[19, 23 - 25].

Optometrists frequently prescribe tinted lenses for their patients. Tinted lenses are prescribed, *inter alia*, in the following circumstances: for the relief of photophobia[26 - 28], to reduce asthenopic symptoms[17, 26], to decrease light scatter in conditions such as albinism, retinitis pigmentosa (RP) and cataracts[29], to provide protection for people exposed to high levels of invisible radiation such as ultra-violet and infra-radiation[19], to alleviate sensitivity to sunlight[23, 24], to improve the cosmesis in situations of disfigurements[18], to enhance visual ergonomics[17], to reduce glare from reflective surfaces such as snow, sand and water[19, 23], as a placebo[28], to improve colour perception in colour deficient individuals[30] and to decrease light sensitivity in patients taking photosensitising drugs[3].

Since different colour tints are generally used by patients under varying levels of illumination, ranging from bright sunlight to very poor light levels and in keeping with the more recent information regarding chromatic stereopsis mechanisms[11], it is important to investigate the effect of these tinted lenses on stereopsis over a range of illumination levels. Tinted lenses are commonly available in a range of colours as either gradient or solid tints from grade A (light) to grade D (much darker). Illumination levels may be consistently decreased by using Gulden neutral density filters (ND) to allow for measuring stereopsis ranging from room illumination of 300 lux to measuring stereopsis under decreased light levels (<300 lux)[24, 25].

The aim of the study was to investigate the effects of reduced illumination and tinted lenses on stereopsis at near. The specific objectives were as follows:

i. to compare stereoacuity values across five levels of illumination (No ND filter, 0.3 ND, 0.6 ND, 0.9 ND and 1.2 ND) without any lenses.
ii. to compare stereoacuity values using a white lens against a no lens condition across the five levels of illumination.
iii. to compare stereoacuity values using six tinted lenses at grade B against the no lens condition across the five levels of illumination.

Methodology

Selection of participants

A purposive sampling procedure was used to select sixty participants from the private practice of the clinician researcher (P Ramkissoon). This purposive sample comprised a non-probability cohort of participants who satisfied the inclusion criteria for this study. Adult participants ranging in age from 17 - 29 years were selected. Older adult participants were excluded in order to control for age-related changes in vision. A comprehensive eye examination (including measures of binocularity, that is, the cover test and fusional vergences) was used to screen all eligible participants to ensure that they satisfied the inclusion criteria for this study. Participants who had < 0.50 D of astigmatism and < 0.50 D sphere and monocular and binocular visual acuities of 6/6 or better at distance and near were included, thus excluding bias accruing from compromised visual status. Participants with eye diseases and those who failed the Ishihara colour test were similarly excluded. Other exclusion criteria were poor general health status and intra-ocular pressure above 21 mmHg. There was no evidence in the literature suggesting the need to control for race and gender of participants.

Lenses used

A white CR 39 lens and six tinted lenses (CR39) were used on all participants in the study, namely, pink, blue, brown, grey, yellow and green. The depth of the solid tints used in this study was grade B. All the lenses were of zero power (plano) with a 2 mm standard centre thickness and equal transmittance, as measured on a spectrophotometer. Thus, all pertinent lens characteristics, including lens material, depth of tint, power, thickness and transmittance were controlled for in order to eliminate secondary variance. Stereopsis was assessed, for each participant, using a no lens condition and seven other lens conditions.

Illumination levels

Neutral density (ND) filters have been widely used in photography, cinematography and vision research to assess visual function under controlled levels of illumination[24, 25]. Stereopsis was initially assessed under bright room illumination of 300 lux measured using a light meter, with ND filters (0.3 ND, 0.6 ND, 0.9 ND, and 1.2 ND) being subsequently used to decrease the level of illumination. Thus, stereopsis was assessed, for each participant, at five different levels of illumination.

Stereoacuity test used

Standard clinical tests for stereopsis include the TNO random-dot stereotest that does not have monocular cues based on the presence of contours, as well as the Titmus Fly Stereotest (TFS) that utilizes real contours, resulting in the presence of monocular cues. While the use of randot stimuli are generally considered the "gold standard" for measuring stereopsis, they are prone to false negative errors[31]. The TFS on the other hand has been shown to compare favourably to two randot tests under compromised levels of binocularity in young participants[32]. Provided that the page is inverted to reverse the disparity, the TFS controls adequately for the presence of monocular cues[31]. Further, the TFS is a widely used clinical test that allows for rapid testing without significant subject fatigue, thereby yielding data that could inform clinical management decisions[31]. In the TFS, horizontal disparity is presented via the vectographic technique[33]. This test comprises three subtests, with the level of disparity decreasing progressively[33]. When tested at 40 cm the first subtest (the fly) has a disparity of 3600 sec of arc, the second subtest (the rows of animals) has a disparity ranging from 400 - 100 sec of arc and the third subtest (the Wirt rings) has a disparity ranging from 800 - 40 sec of arc[6]. The ultimate measure of stereopsis is the participant's ability to discern the finest possible level of disparity. Given these considerations, the TFS was considered the measure of choice for this sample.

Procedure

Phase 1: Stereopsis measured under room illumination of 300 lux with no ND filter

Stereopsis was measured initially without any lenses (base line measure) followed by measurements through the white lens and then through each of the six tinted lenses, under normal room illumination, using the TFS. The order of presentation of tint condition was randomised to avoid treatment interaction effects. As recommended, this test was held at a test distance of 40 cm measured using a RAF rule. The participants viewed the targets binocularly using a pair of polarising spectacle lenses.

The first subtest, the fly, was shown to the participants who were asked to pinch the edge of the wings of the fly. The normal response was that the pinching fingers should be off the page by several centimetres.

In the second subtest comprising the three rows of animals, the participants were informed that all except one of the figures in each row remains flat. The participants were asked to indicate the animal that appeared raised in each row.

In the third subtest (a series of nine diamonds each of which contains four Wirt rings), one of the rings would be viewed at a different depth from the other three. The participants were asked to identify the ring that appeared to stand out from the page. The results were recorded in seconds of arc, corresponding to the last correctly identified circle/ animal.

As recommended by Garnham and Sloper[31], the page was inverted in order to reverse the disparity, thus controlling for the effects of monocular cues. Each participant was allowed a five-minute rest interval between measures in order to minimise fatigue effects. While the order of presentation of the three stereo subtests was maintained from subtest one to subtest three, the order of presentation within subtest two and three was randomised to avoid errors of habituation and expectancy, thus precluding guessing.

Phase 2: Stereopsis measured under decreasing levels of illumination

The second part of this study assessed stereopsis under decreasing levels of retinal illumination through the seven lens conditions. ND filters were placed binocularly over the no lens condition as well as with the seven tinted lenses and stereopsis was measured as per the procedure outlined in phase 1. Four ND filters (0.3, 0.6, 0.9 and 1.2) were used to decrease the luminance levels. A counterbalance design was used to control for possible confounding resulting from treatment interaction effects, where the order of presentation of luminance levels was randomised across the participants[34].

Data analysis

Data was entered onto the Statistical Package for Social Scientists (SPSS), and a file audit was conducted to eliminate entry errors. Using general linear modelling, a repeated measures ANOVA was run, incorporating within-subjects factors at two levels viz. tint and illumination. This analysis rendered statistical comparison across tint by level of illumination, in line with the objectives of the study. The Bonferroni test was used for post-hoc multivariate analysis. In this multiple comparisons procedure, the familywise error (at $\alpha = 5\%$) was divided by the number of comparisons, thus controlling for Type I error by setting alpha at a more stringent level (the Bonferroni correction).

Table 1 demonstrates the progressive increase in mean stereoacuity scores (that is decline in stereopsis), for the no lens and each of the seven tint conditions, as the level of illuminance decreased from room illumination (0 ND) towards scotopic levels (1.2 ND). This pattern of results is confirmed in the multivariate analysis (Table 2), where a statistically significant difference was evident for the main effect of illumination ($F = 119.706$; df = 4; $p = .000$). Inspection of the means in Table 1 also reveals that, at each level of illumination, the stereoacuity scores for both the no lens and white lens conditions were consistently lower, that is better, than for each of the six other tint conditions.

Table 2 demonstrates a statistically significant difference for the main effect of tint ($F = 8.996$; df = 7; $p = .000$) as well as the interaction of illumination by tint ($F = 4.760$; df = 28; $p = .000$). The graphical illustration of these results (Figure 1), as well as the post-hoc analysis (Table 3), demonstrates specifically where these differences lie.

Table 3 shows no statistically significant difference in stereoacuity scores between the no lens and the white lens condition for each of the five levels of illumination (df = 59; $p = .321$; $p = .616$; $p = .047$; $p = .048$; $p = .167$). Statistically significant differences were found between the no lens condition and each of the other six tints (pink, blue, brown, grey, yellow and green) at every level of illumination, thereby accounting for the statistically significant interaction effect reported in Table 2.

The main findings arising from the analysis of the data are that:

1. there was a significant decline in stereopsis as the level of illumination decreased, regardless of tint condition.
2. there was no statistically significant differ-

Table 1: Modified Population Marginal Means for Illumination by Tint

Illumination	Tint	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
0 ND	No lens	42.721	.906	40.890	44.553
	White Lens	42.888	.965	40.938	44.839
	Pink	46.667	1.227	44.187	49.146
	Blue	46.982	1.223	44.509	49.455
	Brown	45.881	1.381	43.090	48.672
	Grey	47.552	1.539	44.441	50.664
	Yellow	46.379	1.347	41.050	48.707
	Green	46.137	1.790	42.519	49.755
0.3 ND	No lens	67.339	2.108	63.079	71.600
	White Lens	67.274	2.252	62.723	71.824
	Pink	75.329	2.461	70.354	80.303
	Blue	77.582	2.316	72.901	82.263
	Brown	75.031	2.526	69.925	80.137
	Grey	74.862	2.047	70.725	78.999
	Yellow	72.862	3.246	66.302	79.422
	Green	74.465	2.828	68.749	80.182
0.6 ND	No lens	123.519	4.874	113.667	133.371
	White Lens	125.057	5.455	114.033	136.081
	Pink	172.845	9.266	154.119	191.572
	Blue	151.543	10.818	129.679	173.407
	Brown	154.767	9.160	136.254	173.280
	Grey	155.624	11.913	131.546	179.702
	Yellow	157.510	5.928	145.528	169.491
	Green	180.712	9.303	161.911	199.513
0.9 ND	No lens	189.205	13.519	161.883	216.527
	White Lens	205.483	17.545	170.024	240.943
	Pink	280.893	29.499	221.273	340.512
	Blue	347.019	23.916	298.683	395.356
	Brown	403.940	28.822	345.690	462.191
	Grey	284.395	27.985	227.836	340.955
	Yellow	267.898	24.464	218.454	317.341
	Green	295.514	29.266	236.365	354.664
1.2 ND	No lens	598.000	62.781	471.116	724.884
	White Lens	610.333	63.776	481.436	739.230
	Pink	860.119	98.672	660.695	1059.543
	Blue	1002.095	141.615	715.880	1288.310
	Brown	1157.262	131.507	891.477	1423.047
	Grey	1022.619	153.342	712.704	1332.534
	Yellow	887.238	114.713	655.394	1119.083
	Green	1014.095	124.517	762.437	1265.753

ence in stereopsis between the no lens and white lens conditions at each level of illumination.

3. stereopsis was significantly superior with the no lens condition compared to all six other tint conditions (grade B), at each level of illumination.

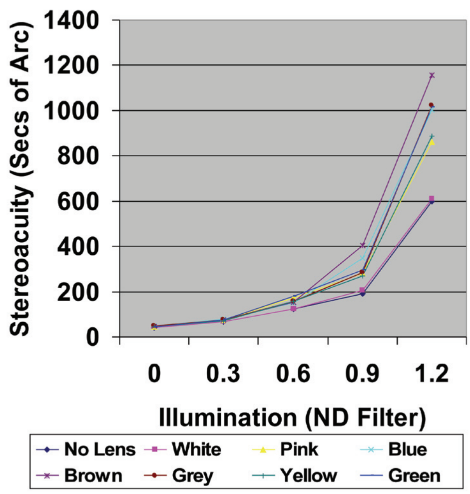
Discussion and Conclusions

Information regarding the visual world is deduced based on the changes in the quantity and quality of light from a source and its interaction with matter such that one has to consider not only variations in the level of illumination, but variations in the spectral composition of light[35]. The response of the visual system (spectral sensitivity) to different light levels and colours is an inherent property of the type and distribution of the photoreceptors and neurons across the retina. Based on the difficulty experienced in seeing depth in isoluminant random-dot stereograms it was postulated that stereopsis is "colour-blind" and that therefore the information is most probably carried by the magnocellular system[35]. However more current information suggests that there are two stereopsis mechanisms, one sensitive to luminance contrast

Table 2: Multivariate Analysis of Variance of Main Effects (Tint an Illumination) and Interaction Effects on Stereoacuity

Source (Sphericity Assumed)	Type III Sum of Squares	df	Mean Square	F	Sig.
illum	202129922.333	4	50532480.583	119.706	.000
Error (illum)	99624752.667	236	422138.782		
tint	5535304.500	7	790757.786	8.996	.000
Error(tint)	36304320.500	413	87903.924		
illum * tint	10308889.667	28	368174.631	4.760	.000
Error(illum*tint)	127772035.333	1652	77343.847		

Figure 1: Stereoacuity across varying Illumination and Tint



and the other to chromatic contrast[11]. It has been suggested that even though the disparity range of the luminance-contrast-sensitive mechanism is larger than that for the chromatic-contrast-sensitive mechanism, these two mechanisms must interact before the extraction of stereoscopic depth[11]. In fact, under certain conditions of poor stereopsis with luminance contrast alone, added isoluminant chromatic contrast does improve stereopsis significantly (probability summation) [11]. These findings formed the basis for this investigation into whether tinted lenses impacted negatively on stereopsis, as compared to no lens conditions, under decreasing levels of illumination.

The *Duplicity Theory* in vision states that, depending on the level of illumination, either the rods respond (scotopic light levels), both the rods and cones respond (mesopic light levels), or mainly the cones respond (photopic light levels)[6]. Since only the cones are responsible for chromatic sensitivity and this information is carried via the parvocellular system to the visual centers of the cortex, scotopic vision carries no information regarding the colour of objects[1, 6]. Further, maximum visual acuity is possible in bright room illumination (300 lux) for central fixation when the cones alone respond[6].

Figure 1 represents a composite illuminance response function of stereoacuity scores when various tinted lenses were used under varied retinal illuminance conditions. As shown in Figure 1, neutral density filters worsened retinal illuminance and consequently the stereoacuity (that is, the threshold values increased) for all lenses tested as well as when no (tinted) lens was used. The greater the density of the filter, the greater was the reduction in stereoacuity. This meant that as illumination was reduced, stereopsis worsened similar to other studies which compared the rapid decline in stereopsis as opposed to visual acuity under poor light conditions[15, 36]. While the decline was relatively steady up to the level of illumination decreased by the 0.9 ND, the illumination level between 0.9 ND and 1.2 ND resulted in a dramatic increase in the stereoacuity scores suggesting very poor stereopsis. It is highly likely that whilst stereopsis under scotopic conditions is possible[15], rod vision does not adequately support stereopsis in the absence of the additive effect of the chromatic mechanism of stereopsis[11]. These results therefore support the luminance contrast sensitive stereopsis mechanisms. Inspection of the marginal means reveals that at 1.2 log units, yellow and pink perform better than the other four tints. Even though it has been shown that yellow tinted lenses do not improve visual acuity, stereopsis or contrast sensitivity, they are found to enhance brightness based on rod signals car-

Table 3: Post-hoc Analysis: Familywise paired *t*-tests for Illumination by Tint(Mean Stereoacuity)*

Pairings		Mean	Std. Deviation	Std. Error	*t*	df	Sig. (2-tailed)*
Illumination	Tint						
No ND	no lens - white	-.333	2.582	.333	-1.000	59	.321
	no lens - pink	-3.667	7.584	.979	-3.745	59	.000**
	no lens - blue	-4.167	5.612	.725	-5.751	59	.000**
	no lens - brown	-3.500	6.846	.884	-3.960	59	.000**
	no lens - grey	-4.667	7.471	.965	-4.838	59	.000**
	no lens - yellow	-3.509	6.932	.902	-3.908	59	.000**
	no lens - green	-3.500	6.915	.897	-3.927	59	.000**
0.3 ND	no lens - white	-.500	7.686	.992	-.504	59	.616
	no lens - pink	-9.000	12.849	1.659	-5.426	59	.000**
	no lens - blue	-9.333	12.604	1.627	-5.736	59	.000**
	no lens - brown	-8.667	13.957	1.802	-4.810	59	.000**
	no lens - grey	-8.500	14.001	1.807	-4.703	59	.000**
	no lens - yellow	-7.333	16.351	2.111	-3.474	59	.001**
	no lens - green	-8.333	13.550	1.749	-4.764	59	.000**
0.6 ND	no lens - white	-3.667	14.018	1.810	-2.026	59	.047
	no lens - pink	-35.667	64.318	8.303	-4.295	59	.000**
	no lens - blue	-35.333	52.253	6.746	-5.238	59	.000**
	no lens - brown	-34.333	52.863	6.825	-5.031	59	.000**
	no lens - grey	-36.667	63.691	8.222	-4.459	59	.000**
	no lens - yellow	-30.667	31.346	4.047	-7.578	59	.000**
	no lens - green	-41.667	68.325	8.821	-4.724	59	.000**
0.9 ND	no lens - white	-15.333	58.729	7.582	-2.022	59	.048
	no lens - pink	-109.667	165.887	21.416	-5.121	59	.000**
	no lens - blue	-128.000	172.173	22.227	-5.759	59	.000**
	no lens - brown	-131.333	177.761	24.769	-5.693	59	.000**
	no lens - grey	-104.667	168.719	21.781	-4.805	59	.000**
	no lens - yellow	-98.667	142.988	18.460	-5.345	59	.000**
	no lens - green	-114.333	135.651	17.512	-6.529	59	.000**
1.2 ND	no lens - white	-16.667	92.364	11.924	-1.398	59	.167
	no lens - pink	-283.333	446.898	57.694	-4.911	59	.000**
	no lens - blue	-443.333	802.616	103.617	-4.279	59	.000**
	no lens - brown	-443.333	793.270	102.411	-4.329	59	.000**
	no lens - grey	-425.000	840.223	108.472	-3.918	59	.000**
	no lens - yellow	-270.000	550.901	71.121	-3.796	59	.000**
	no lens - green	-430.000	714.807	92.281	-4.660	59	.000**

* α = .001 (.05 divided by 35 paired *t*-tests)
** *t*-test values that meet the significance criterion

rying the information along the chromatic channels and amongst other optical explanations, a selective reduction of short-wavelength light has been posited[37-39]. This study indictates the need for further research to investigate between-colour comparisons using a range of tints and depths of tints as well as photochromic lenses under different levels of illumination.

Since the white lens performed as well as the no-lens condition under the different levels of illumination, but both differed statistically significantly from all the other six tinted lenses at each of the levels of illumination, it is evident that the tinted lenses adversely affected stereopsis at near under reduced levels of illumination.

As it is necessary to constantly distinguish objects in the environment at varying distances, any change in stereoacuity induced by tinted lenses will influence visually guided performance. Luria[39] also found that depth perception was diminished with tinted lenses; his proposal that the reduced transmittance produced by tinted lenses decreased the stereoacuity is corroborated by the findings of this study. Therefore, the practitioner should ensure that tinted lenses prescribed do not retard stereoacuity in circumstances where good stereoacuity is required[3]. In advising a patient concerning tinted lenses, the practitioner should question the patient not only on his sensitivity to light, but also as to the activities and levels of illumination for which the lenses are to be used[27].

Pitts and Chou[3] advised that care must be taken to ensure that the tint does not impair vision if industrial workers move quickly or frequently from brilliant sunlight into a dimly lighted environment. The optometrist must have available a range of tinted lenses that would be suitable for the environment in which the wearer works or intends to use the spectacles[25, 27]. When stereopsis is affected by tinted lenses under poor light levels, depth perception may still be appreciated using monocular cues and luminance contrast mechanisms and the individual's performance may not be significantly compromised. However, certain vocations require good depth perception and since stereopsis has been found to be the most superior cue to depth perception up to 450 metres, it is important that optometrists offer the best possible advice to these patients.

It would be valuable to compare the levels of stereopsis using a range of solid tints from A to D as well comparing the effects of gradient tints to solid tints. Clinically important information would be available if the stereopsis could be evaluated while performing dynamic critical tasks to assess the severity of the effects of the decrease in stereopsis on performance under different light levels.

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