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BLUR EFFECTS ON CLOCK-DIAL CYLINDER DETERMINATION

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INTRODUCTION

The aim of this study is to determine how the cylindrical power and axis determination using the Clock Dial test is affected by different amounts of blur. The cylinder axis and power determined by the use of the Jackson Cross Cylinder provide the reference values for our comparisons.

Standard methods for determining the pretest blur lens include: a) reducing the fogging lens until the 20/40 acuity line can barely be identified; similarly, b) reducing the fogging lens until the 20/30 acuity line can first be distinguished; or c) if a sunburst or clock dial is used, the stopping place is the point where any of the lines appears maximally distinct and/or black. Hebbard* also suggests beginning with a +.75 diopter sphere placed over the static retinoscopic correction, provided that this reduces the acuity to 20/25 or less.

HYPOTHESIS

It would be expected that a pretest blur of +.50 diopter relative to criterion c) above, would give the most accurate clock dial finding for a patient's cylindrical power and axis determination. Other amounts of blur should make the patient's discrimination more difficult, and would therefore cause the results to be less accurate. (See page 4 for further remarks.)

PROCEDURE

We designated our fogging lenses relative to a control lens which we determined by the following procedure. We started with the subject's habitual lenses in the phorometer. At this point we performed a 20/40 blur, an astigmatic clock dial, a red-green

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*Borish, I.M., Clinical Refraction, 3rd Edition, Professional Press, Inc., Chicago, Illinois, 1970, p. 729.

biochrome test, and a Jackson Cross Cylinder Test (J.C.C.) for refinement of axis and power. For the J.C.C., in particular, we extrapolated to the nearest .12 diopter of power and to the nearest 1 degree in axis. Our final control lens consisted of the J.C.C. cylinder (in minus cylinder form) reduced by .50 diopter to induce a standard astigmatic interval in a known meridian. Combined with this induced astigmatism was a sphere which we determined by using the T-chart on an AO projector slide. Here we added +.75 diopter sphere. Reducing the plus sphere in .25 diopter steps, we instructed the patient to report when the darker lines stopped becoming darker. We now increased the plus sphere until the patient first noticed the same lines become just slightly blurred, or less dark. The sphere of the control lens is .25 diopter more minus than this sphere, and is combined with the cylinder previously mentioned. It is relative to the control lens that the different amounts of blur were chosen.

Varying amounts of blur from +.25 diopter to +1.00 diopter were then added, and the effects on the clock dial findings were compared. For each amount of blur the cylinder power was tested on the T-chart with the lines of the T parallel and perpendicular to the cylinder axis of the control lens. With changing cylinder lens power, the blacker lines change by 90°, and the midpoint of this range was taken as the cylinder power. With the control cylinder restored, the cylinder axis was independently established for each standard blur by changing the orientation of the T-chart until first one set of lines was reported darker, and then the other set was reported darker. The recorded cylinder axis was 45° from the midpoint of this range.

SAMPLE

All twenty subjects for this investigation were members of the Pacific University faculty and student body, representing a total population of forty eyes. The spherical refractive errors ranged from -8.25D to +5.00D with eight eyes being hyperopic and the rest myopic, while the cylinder power ranged from -.12D to -3.50D.

RESULTS

For analysis of the data, several statistical tests were performed:

1. the mean of the differences between the J.C.C. cylinder power and the respective cylinder power recorded for each blur.
2. the mean of the differences between the J.C.C. cylinder axis and the respective cylinder axis recorded for each blur.
3. the standard deviation of these same differences for both power and axis.
4. the variance of these differences for both power and axis.
5. Pearson's product-moment correlation coefficient between each J.C.C. and each blur value for both power and axis.
6. Pearson's product-moment correlation coefficient between each J.C.C. and its respective original clock-dial measurement for both power and axis.
7. Student's t value for significance of differences

between the means of the data points correlated for both power and axis, and the means of the J.C.C.

DISCUSSION AND CONCLUSIONS

Comparing the differences of the means of the blur lenses with the mean of the J.C.C for power and axis, certain trends can be seen. The large difference between means for the +1.00 blur lens power indicates that with this much fog the power discrimination becomes very difficult for the patient to make. Because the patient is looking through so much plus, he prefers, on the average, an extra .25 diopter of minus cylinder. Likewise, the large difference between means for the +.25 blur lens axis indicates that with this little fog, the axis discrimination becomes very difficult for the patient to make. Because he is looking through so little plus, and all the lines are so much clearer, it is hard for him to determine when the change in darkness occurs*. Consequently, the +.50 or +.75 blur lenses would be preferred for use in the clock dial test because the errors are minimum for <u>both</u> cylinder power and axis determination. This is in general agreement with our hypothesis and with Hebbard's recommendation for lens control.

The correlation coefficients are all quite high, which shows that the differences between the J.C.C. and the clock dial findings are relatively constant. The t-test for significance indicates the difficulty previously mentioned for determining cylinder power through a +1.00 blur and cylinder axis through a +.25 blur. A difference of this magnitude would only occur if due to chance 2% of the time with +1.00 blur, and 14% of the time with +.25

*It is likely that accommodative fluctuations influence judgements excessively when inadequate blur is used.

blur. There is no significant difference between either the standard deviations or the variances.

There are probably many sources of error in this investigation, as there are in any experiment. However, the three major sources are (1) inaccuracies in the equipment; (2) relatively small sample population; and (3) patient and examiner bias.

Table 1. CYLINDER POWER DIFFERENCE FROM J.C.C.

	Mean of Differences	Standard Deviation	Variance
+.25 blur	.14 Diopter	.17	2.92×10^{-2}
+.50 blur	.19 Diopter	.20	.04
+.75 blur	.18 Diopter	.17	.03
+1.00 blur	.18 Diopter	.20	4.07×10^{-2}

Table 2. CYLINDER AXIS DIFFERENCE FROM J.C.C.

	Mean of Differences	Standard Deviation	Variance
+.25 blur	18.58 Degrees	19.35	374.46
+.50 blur	20.55 Degrees	20.32	412.98
+.75 blur	15.50 Degrees	21.73	472.35
+1.00 blur	16.82 Degrees	21.20	449.26

Table 3. CORRELATION WITH J.C.C. FOR CYLINDER POWER AND AXIS.

	POWER		AXIS	
	Difference of Means	Correlation Coefficient	Difference of Means	Correlation Coefficient
+.25 blur	.04 D	.97	6.47°	.90
+.50 blur	.04 D	.97	2.85°	.88
+.75 blur	.03 D	.96	4.15°	.76
+1.00 blur	.26 D	.69	1.52°	.89
Original C.D.	.01 D	.96	2.00°	.94

Table 4. t-TEST FOR SIGNIFICANCE OF DIFFERENCES BETWEEN THE MEANS OF THE DATA POINTS CORRELATED FOR BOTH POWER AND AXIS, AND THE MEANS OF THE J.C.C.

	POWER		AXIS	
	t-value	probability	t-value	probability
+.25 blur	1.28	.20	1.52	.14
+.50 blur	1.28	.20	.59	.55
+.75 blur	.90	.38	-.68	.50
+1.00 blur	-2.25	.02	.34	.73
Original C.D.	.34	.75	.66	.51

	O.D.		O.S.	
M.J.				
C.D.	pl -2.25 x 165		pl -2.25 x 180	
R.G.	-.75 -2.25 x 165		-.25 -2.25 x 180	
J.C.C.	-.75 -2.75 x 175		-.25 -2.50 x 180	
CONTROL	pl -2.25 x 175		pl -2.00 x 180	
	power	axis	power	axis
+.25 blur	-2.62	177	-2.62	2
+.50 blur	-2.62	180	-2.50	15
+.75 blur	-2.87	180	-2.25	7
+1.00 blur	-2.50	170	-2.37	5

	O.D.		O.S.	
G.W.				
C.D.	-7.25 -1.25 x 180		-7.00 -2.50 x 15	
R.G.	-8.25 -1.25 x 180		-7.75 -2.50 x 15	
J.C.C.	-8.25 -1.25 x 175		-7.75 -3.00 x 5	
CONTROL	-7.75 -1.25 x 175		-8.25 -2.50 x 5	
	power	axis	power	axis
+.25 blur	-1.25	151	-3.00	175
+.50 blur	-.75	150	-3.00	170
+.75 blur	-1.25	150	-2.87	169
+1.00 blur	-1.25	150	-2.87	180

	O.D.		O.S.	
G.G.				
C.D.	-2.50 -1.25 x 168		-1.25 -.75 x 30	
R.G.	-3.50 -1.25 x 168		-2.50 -.75 x 30	
J.C.C.	-3.50 -1.25 x 165		-2.50 -.75 x 175	
CONTROL	-3.25 -.75 x 165		-2.50 -.25 x 175	
	power	axis	power	axis
+.25 blur	-1.25	180	-1.12	162
+.50 blur	-1.87	5	-1.62	165
+.75 blur	-1.87	173	-1.25	169
+1.00 blur	-1.87	177	-1.75	165

R.H.				
C.D.	-1.75 -1.75 x 105		-2.00 -1.25 x 90	
R.G.	-2.00 -1.75 x 105		-2.50 -1.25 x 90	
J.C.C.	-2.00 -2.00 x 100		-2.50 -1.00 x 87	
CONTROL	-1.50 -1.50 x 100		-2.25 -.50 x 87	
	power	axis	power	axis
+.25	-2.12	82	-1.12	75
+.50	-2.00	73	-1.00	35
+.75	-1.87	74	-1.25	86
+1.00	-2.25	72	-1.12	93

W.C.

	O.D.		O.S.	
C.D.	-4.50 -1.00 x 180		-5.00 -1.50 x 180	
R.G.	-5.00 -1.00 x 180		-5.00 -1.50 x 180	
J.C.C.	-5.00 -1.00 x 175		-5.00 -1.75 x 172	
CONTROL	-4.50 -1.00 x 175		-4.75 -1.75 x 172	
	power	axis	power	axis
+.25 blur	-.87	5	-1.37	165
+.50 blur	-1.00	175	-1.50	157
+.75 blur	-.87	175	-1.62	163
+1.00 blur	-.75	150	-1.75	173

S.M.

	O.D.		O.S.	
C.D.	-4.00 -1.00 x 60		-3.75 -.87 x 150	
R.G.	-4.87 -1.00 x 60		-5.12 -.87 x 150	
J.C.C.	-5.00 -.75 x 57		-5.25 -1.00 x 150	
CONTROL	-4.00 -.75 x 57		-4.25 -1.00 x 150	
	power	axis	power	axis
+.25 blur	-.75	37	-.87	137
+.50 blur	-.75	35	-.87	130
+.75 blur	-.87	37	-.87	130
+1.00 blur	-.75	35	-.62	132

	O.D.		O.S.	
D.K.				
C.D.	-.75 -2.75 x 180		-1.50 -3.75 x 180	
R.G.	-1.62 -2.75 x 180		-1.87 -3.75 x 180	
J.C.C.	-1.50 -3.25 x 180		-1.75 -3.50 x 180	
CONTROL	-1.75 -2.75 x 180		-1.50 -3.00 x 180	
	power	axis	power	axis
+.25 blur	-2.87	45	-3.37	60
+.50 blur	-3.00	61	-3.75	69
+.75 blur	-2.87	70	-3.50	70
+1.00 blur	-2.87	72	-3.62	70

	O.D.		O.S.	
D.S.				
C.D.	-.75 -.50 x 120		-.25 -.62 x 135	
R.G.	-1.50 -.50 x 120		-1.25 -.75 x 135	
J.C.C.	-1.25 -.75 x 160		-1.50 -.50 x 157	
CONTROL	-1.00 -.25 x 160		-1.25	
	power	axis	power	axis
+.25 blur	-.12	172	-.25	60
+.50 blur	-.25	170	-.37	56
+.75 blur	-.25	170	-.25	55
+1.00 blur	-.50	172	-.37	60

	O.D.		O.S.	
J.R.				
C.D.	-.25 -.50 x 60		pl -.62 x 110	
R.G.	-.75 -.50 x 60		-.25 -.62 x 110	
J.C.C.	-.75 -.75 x 60		-.25 -.25 x 110	
CONTROL	-.25 -.25 x 110		-.25 -.25 x 20	
	power	axis	power	axis
+.25 blur	-.62	70	-.25	30
+.50 blur	-.62	117	-.50	45
+.75 blur	-.62	124	-.50	47
+1.00 blur	-.50	80	-.25	35

	O.D.		O.S.	
D.V.				
C.D.	+5.25 -1.25 x 90		+5.25 -1.75 x90	
R.G.	+4.75 -1.25 x 90		+5.25 -1.75 x 90	
J.C.C.	+4.75 -.75 x 97		+5.25 -1.75 x 82	
CONTROL	+5.00 -.25 x 97		+5.00 -1.25 x 82	
	power	axis	power	axis
+.25 blur	-1.00	110	-1.75	80
+.50 blur	-1.00	110	-1.50	81
+.75 blur	-.75	110	-1.50	80
+1.00 blur	-.87	?	-1.25	70

Patient J.A.

	OD			OS		
C.D.	-2.00 -.50 X 15			-1.75 -.25 X 105		
R.G.	-3.00 -.50 X 15			-2.75 -.25 X 105		
J.C.C.	-3.00 -.37 X 15			-2.75 -.62 X 135		
Control	-2.75 sph			-2.25 -.25 X 135		
		power	axis		power	axis
+.25 blur	-2.50	-.12	X 180	-2.00	-.62	X 160
+.50 blur	-2.25	-.12	X 5	-1.75	-.37	X 150
+.75 blur	-2.00	-.25	X 15	-1.50	-.12	X 140
+1.00 blur	-1.75	-.37	X 8	-1.25	-.25	X 145

Patient L. C.	OD			OS		
C.D.	-3.00 sph			-4.00 sph		
R.G.	-3.75 sph			-4.75 sph		
J.C.C.	-3.75 -.37 X 100			-4.75 -.12 X 15		
Control	-3.50 -.25 X 10			-4.25 -.50 X 105		
		power	axis		power	axis
+.25 blur	-3.25	-.25	X 120	-4.25	sph	X 35
+.50 blur	-3.00	-.37	X 132	-4.00	-.12	X 37
+.75 blur	-2.75	-.37	X 128	-3.75	-.12	X 30
+1.00 blur	-2.50	-.50	X 118	-3.50	-.25	X 23

Patient C. H.

	OD	OS
C.D.	-2.25 -.50 X 90	-1.75 -.75 X 60
R.G.	-3.25 -.50 X 90	-2.25 -.75 X 60
J.C.C.	-3.25 -.75 X 145	-2.25 -.62 X 60
Control	-3.25 -.25 X 140	-2.00 sph

		power	axis		power	axis
+.25 blur	-3.00	-.75	X 142	-1.75	-.25	X 60
+.50 blur	-2.75	-1.00	X 147	-1.50	-.25	X 65
+.75 blur	-2.50	-.75	X 134	-1.25	-.25	X 62
+1.00 blur	-2.25	-.75	X 142	-1.00	-.50	X 63

Patient C. M.

	OD	OS
C.D.	+1.00 -.25 X 90	+1.00 sph
R.G.	-.25 -.25 X 90	plano sph
J.C.C.	-.25 -.12 X 90	plano -.12 X 90
Control	+.25 -.50 X 180	+1.00 -.50 X 180

	OD			OS		
		power	axis		power	axis
+.25 blur	+.50	-.50	X 85	+1.25	-.12	X 85
+.50 blur	+.75	-.25	X 85	+1.50	sph	X 80
+.75 blur	+1.00	-.50	X 90	+1.75	-.37	X 90
+1.00 blur	+1.25	-.37	X 80	+2.00	-.37	X 80

Patient D. M.

	OD			OS		
C.D.	+.50 -.25 X 75			+.50 -.75 X 75		
R.G.	-.75 -.25 X 75			-.50 -.75 X 75		
J.C.C.	-.75 -.12 X 83			-.50-.62 X 92		
Control	plano -.50 X 173			-.25 sph		
		power	axis		power	axis
+.25 blur	+.25	-.37	X 67	plano	-.62	X 88
+.50 blur	+.50	-.37	X 66	+.25	-.87	X 101
+.75 blur	+.75	-.12	X 79	+.50	-.37	X 99
+1.00 blur	+1.00	-.12	X 86	+.75	-.62	X 104

Patient L. M.

	OD			OS		
C.D.	+1.00 -.50 X 45			+1.00 -1.00 X 105		
R.G.	+.25 -.50 X 45			+1.00 -1.00 X 105		
J.C.C.	+.25 -.12 X 180			+1.00 -.87 X 105		
Control	-.25 -.50 X 90			plano -.75 X 105		
		power	axis		power	axis
+.25 blur	plano	-.12	X 145	+.25	-.87	X 87
+.50 blur	+.25	-.12	X 170	+.50	-.87	X 92
+.75 blur	+.50	-.12	X 178	+.75	-.87	X 102
+1.00 blur	+.75	-.37	X 5	+1.00	-.87	X 97

Patient S. R.

	OD			OS		
C.D.	+1.50 -.50 X 30			+1.50 -1.00 X 90		
R.G.	+ .75 -.50 X 30			+1.50 -1.00 X 90		
J.C.C.	+ .75 -.12 X 175			+1.50 -.87 X 100		
Control	+.25 -.50 X 85			+.50 -.25 X 100		
		power	axis		power	axis
+.25 blur	+.50	-.12	X 140	+.75	-.87	X 82
+.50 blur	+.75	-.12	X 165	+1.00	-.87	X 77
+.75 blur	+1.00	-.12	X 173	+1.25	-.87	X 97
+1.00 blur	+1.25	-.37	X 180	+1.50	-.87	X 92

Patient N. R.

	OD			OS		
C.D.	+1.00 -.25 X 90			+1.00 -.75 X 90		
R.G.	-.25 -.25 X 90			plano -.75 X 90		
J.C.C.	-.25 -.12 X 78			plano -.62 X 87		
Control	+.50 -.50 X 168			+.25 sph		
		power	axis		power	axis
+.25 blur	+.75	-.37	X 62	+.50	-.62	X 83
+.50 blur	+1.00	-.37	X 61	+.75	-.87	X 96
+.75 blur	+1.25	-.12	X 74	+1.00	-.37	X 94
+1.00 blur	+1.50	-.12	X 81	+1.25	-.62	X 99

Patient D. T.

	OD	OS
C.D.	-3.50 -1.00 X 30	-4.25 -1.25 X 152
R.G.	-4.75 -1.00 X 30	-4.75 -1.25 X 152
J.C.C,	-4.75 -1.12 X 15	-4.75 -1.12 X 155
Control	-4.25 -1.00 X 15	-4.25 -1.00 X 155
	power ↘ axis ↘	power ↘ axis ↘
+.25 blur	-4.00 -1.12 X 170	-4.00 -1.12 X 160
+.50 blur	-3.75 -1.12 X 180	-3.75 -1.12 X 155
+.75 blur	-3.50 -1.37 X 11	-3.50 -1.25 X 162
+1.00 blur	-3.25 -1.37 X 15	-3.25 -1.37 X 172

Patient F. Z.

	OD			OS		
C.D.	-2.00 -.25 X 90			-1.50 -.50 X 60		
R.G.	-3.00 -.25 X 90			-2.00 -.50 X 60		
J.C.C.	-3.00 -.50 X 140			-2.00 -.37 X 55		
Control	-3.00 sph			-1.75 -.25 X 145		
		power	axis		power	axis
+.25 blur	-2.75	-.50	X 137	-1.50	sph	X 55
+.50 blur	-2.50	-.75	X 142	-1.25	sph	X 60
+.75 blur	-2.25	-.50	X 129	-1.00	sph	X 57
+1.00 blur	-2.00	-.50	X 137	- .75	-.25	X 58