5-1998

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Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Karl Citek

Subject Categories

Optometry

ARTIFICIALLY INDUCED ANISEIKONIC EFFECTS ON STEREOMOBILIZATION

By

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A thesis submitted to the faculty of the
College of Optometry
Pacific University
Forest Grove, Oregon
for the degree of
Doctor of Optometry
May, 1998

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BIOGRAPHIES

Carl J. Roth graduated from the University of Wyoming in 1994, majoring in exercise physiology. Following, he entered Pacific University College of Optometry and is a candidate for graduation in May of 1998. Future plans include private practice in Wyoming or Montana.

Charles W. Peterson graduated from Minnesota's Moorhead State University in 1994. He received a B.A. degree in biology with a minor in chemistry and business administration. Upon completion of his undergraduate degree, he entered Pacific University College of Optometry the fall of 1994 and his expected graduation date is spring of 1998. His future plans consist of entering a group practice in Minnesota with an emphasis on vision training.

ACKNOWLEDGMENTS:

First, we would like to thank Dr. Kohl for helping us develop the hypothesis. Dr. Kohl is a tremendous role model. Likewise, we would like to thank Dr. Citek for his dedication to us and his insight into the technical aspects of the thesis. Dr. Citek made extraordinary efforts to be available to us and to guide us through the learning process.

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Abstract:

Aniseikonia affects binocular visual function. The effects of aniseikonia on stereomobilization, however, have not been studied. A Latin Square design was used to test the effect's aniseikonia has on stereomobilization. Results indicate that increased aniseikonia decreased stereomobilization. Also, reduced presentation time decreased stereomobilization.

Introduction:

The highest level of binocular vision is stereopsis. Stereopsis is the ability to perceive three dimensional targets as a result of the stimulation of non-corresponding retinal points (Grosvenor, 1989). Stereopsis demand is measured in arc seconds of disparity. Stereopsis is often evaluated during visual screenings or complete vision examinations to determine how a patient's binocularity is functioning (Lovasik and Szymkiw, 1985). The speed at which one can perceive stereopsis is known as stereomobilization. Based on conclusions of Larsen and Fabert (1992) that stereomobilization is a superior predictor of binocular depth perception than stereoacuity, Thompson and Yudcovitch (1996) sought to establish stereomobilization norms. Chretien and Lindberg (1997) expanded Thompson's and Yudcovitch's (1996) study and established that increasing the amount of anisometropia significantly increases stereomobilization times.

Aniseikonia can interfere with stereoacuity (Simons and Grisham, 1987; Lovasik and Szymkiw, 1985). However, the effects of aniseikonia on stereomobilization have not been studied. Approximately 2 to 8% of the normal population have clinically significant aniseikonia (Thill, 1986). Aniseikonia may lead to reading difficulties and asthenopic complaints (Simons and Grisham, 1987). It can cause perceptual distortions such as the tilting or curving of vertical objects (Grosvenor, 1989). Aniseikonia is usually caused by magnification differences from corrective lenses used for anisometropic refractive conditions. Two to four percent aniseikonia is often induced by cataract surgeons implanting a unilateral intraocular lens (Katsumi et al., 1992). A realistic value for anisometropic induced aniseikonia is one percent per diopter of anisometropia (Polasky, 1974; Ryan, 1975; Griffin and Grisham, 1995).

Thompson and Yudcovitch (1996) first developed norms for stereomobilization on an adult population. Chretien and Lindberg (1997) later studied the effects of artificially induced anisometropia on stereomobilization. We studied the effects of varying amounts of aniseikonia and presentation time on stereomobilization.

SUBJECTS:

The study subjects were forty students from Pacific University College of Optometry. Participants ranged in age from 22 to 43. Nineteen (44%) were female, and 21 (56%) were male. The screening criteria for entry into the study included the following: Snellen acuity of at least 20/20 at 40 cm both monocularly and binocularly, stereoacuity of at least sixty arc seconds, as measured by the Titmus stereo test, and no strabismus at near as measured by cover test. Baseline amounts of aniseikonia were measured with an American Optical Space Eikonometer. If subjects were not emmetropic, they were required to use a current contact lens prescription to reduce spectacle induced aniseikonia. Passing these criteria and signing an informed consent form in agreement with the Institutional Review Board allowed entry into the study. The characteristics of the subjects are summarized in Table A in the appendix.

METHODS:

Numerous factors can affect stereomobilization ability including angular subtense of the targets, contrast of the targets, observer distance and luminance conditions. To keep testing procedures consistent, the methods we used were modeled from the stereomobilization norm-establishing studies performed by Thompson and Yudcovitch (1996) and Chretien and Lindberg (1997).

Subjects were seated one meter from a Macintosh Centris computer with a 16" monitor emitting 20 cd/m^2 luminance. Each subject wore a pair of powerless red and blue filter glasses modified with lens wells to hold loose trial lenses in front of each filter. The red filter over the left eye had a transmittance of 24.5%, while the blue filter over the right eye had a transmittance of 9.5%. The modified glasses were used for training and testing. Room illuminance throughout the experiment was held constant at approximately 2.0 lm/m^2.

The Stereopsis program was initiated for testing. The testing battery began with a uniform pink screen that produced a lustrous background when observed through the red and blue filters. The program flashed the word "Ready" for 1 second, followed immediately by a fixation cross to direct the subjects' gaze to the location of the target presentation. After a 0.125 second pause, the testing target of four rings was presented in a diamond formation, subtending five degrees at the one meter test distance. Three of the rings were solid black, while the fourth ring provided crossed-disparity information by presenting laterally overlapping red and blue rings separated by 75 arc seconds. The crossed disparity created the apparent "float" of the ring. A programmed random number generator determined which target position contained the crossed disparity. Following the target presentation, the screen returned to the blank pink background. Subjects were then shown four larger circles in the same configuration as the test targets. The duration period of the larger circles was indefinite; they remained on the screen until the examiner selected the one circle that corresponded to the test ring perceived to "float" as reported by the subject. Subjects were instructed to respond to the target demonstrating relative depth and were encouraged to guess if they were uncertain which ring had the depth cues. After selection of a target, the "Ready" prompt was again shown to begin the next target presentation sequence. Subjects were instructed to keep body movements to a minimum and were allowed to pause testing at any time during the session.

A training session using only the red and blue filters was used to familiarize the subject with the program. The float effect was demonstrated by presenting five trials, each with two second presentation times. Next, the computer program was modified to produce two presentations at each testing time of 1000 msec, 250 msec, 62 msec and 15 msec exposures.

The experimental design included five presentations at each of the four variable times (1000 msec, 250 msec, 62 msec and 15 msec). At each time variable, four different aniseikonic conditions were tested. The four different aniseikonic conditions were as follows: 0% (no lens in place), 1%, 3%, and 5% size lenses. Each subject completed 13 training and 80 testing presentations.

Studies by Fendick and Westheimer (1983) and Kumar and Glaser (1993) demonstrated improvement in stereomobilization tasks with learning and practice. Consequently, a Latin Square design was used to present conditions in a pseudo-random order. The Latin Square method of randomization eliminated learning and/or fatigue effects between subjects. Table 1 summarizes the order of the Latin Square presentation for each group.

Table 1. Latin Square design depicting order of exposure duration and size difference.

	Order			
Group	1	2	3	4
A	a	b	c	d
B	b	d	a	c
C	c	a	d	b
D	d	c	b	a

For exposure durations, a=1000 msec, b=250 msec, c=62 msec, d=15 msec
For size difference, a=0%, b=1%, c=3%, d=5%

Subject's baseline aniseikonia was measured with an A. O. Space Eikonometer. The eikonometer measures aniseikonia in three quantities: horizontal (axis 090) image size difference, vertical (axis 180) image size difference and declination error in degrees (image size difference in oblique meridians). Of the subjects tested, 62.5% had 0% baseline aniseikonia. All other subjects had baseline aniseikonia in one or more of the eikonometer quantities. The aniseikonic ranges were divided into 0.01 to 0.5%, 0.51 to 1.0%, 1.01 to 1.5% and 1.51 to 2% baseline aniseikonia with corresponding frequencies of 17.5%, 5%, 5% and 10% for the above ranges, respectively. Of the subjects with aniseikonia, none presented with any complaints or problems normally associated with aniseikonia. All testing conditions were assessed against the 0% aniseikonia baseline. Each subject served as his or her own control. Consequently, absolute size changes were not gathered for the aniseikonic lenses.

To ensure that subjects were blind to the next presentation condition, subjects were instructed to close their eyes as the researcher picked a lens and time presentation called for by the Latin Square design. Due to a computer system default that showed the presentation time after a selection was made, the computer operator held a clipboard over the computer screen until the fixation cross re-appeared on the screen. The clipboard was removed to allow an unobstructed view of the computer screen upon appearance of the fixation cross. The computer operator entered the selections and placed a clipboard over the area where the time prompt occurred to minimize any distractions that could affect "float" detection.

RESULTS:

Table 2 contains the correct test response per time presentation and induced aniseikonia.

Table 2. The mean correct responses and standard deviations for exposure duration and aniseikonia for 40 subjects.

Time exposure	% aniseikonia	mean correct (out of 5)	% correct	Standard deviation
1000 msec				
	0%	3.175	63.50	1.91
	1%	3.000	60.00	1.77
	3%	3.000	60.00	1.69
	5%	2.200	44.00	1.56
250 msec				
	0%	2.225	44.50	1.75
	1%	2.475	49.50	1.54
	3%	1.875	37.50	1.34
	5%	1.400	28.00	1.08
62 msec				
	0%	1.750	35.00	1.30
	1%	1.725	34.50	1.24
	3%	1.475	29.50	1.11
	5%	1.425	28.50	0.96
15 msec				
	0%	1.975	39.50	1.21
	1%	1.700	34.00	1.18
	3%	1.775	35.50	1.21
	5%	1.325	26.50	1.02

A repeated measures analysis of variance of aniseikonic effects on stereomobilization was then performed on the collected data. The aniseikonic effect on stereomobilization was significant, $F(3,117) = 12.87$, $p = 0$. The effect of presentation time on stereomobilization also was significant, $F(3,117) = 22.08$, $p=0$. However, the interaction effect between aniseikonia and presentation time was not significant, $F(9,351) = 1.71$, $p=0.086$ The learning effect was assessed by comparing data combined from the A and B groups to data combined from the C and D groups. The analysis of variance resulted in no significant difference in percentage correct responses between these groups, $F(1,38) = 2.80$, $p = 0.098$, indicating that learning and fatigue did not affect the results. Figures 1 and 2 are graphical representations of the data in Table 2.

Figure 1. The mean correct responses and standard deviations for aniseikonic lenses for 40 subjects.

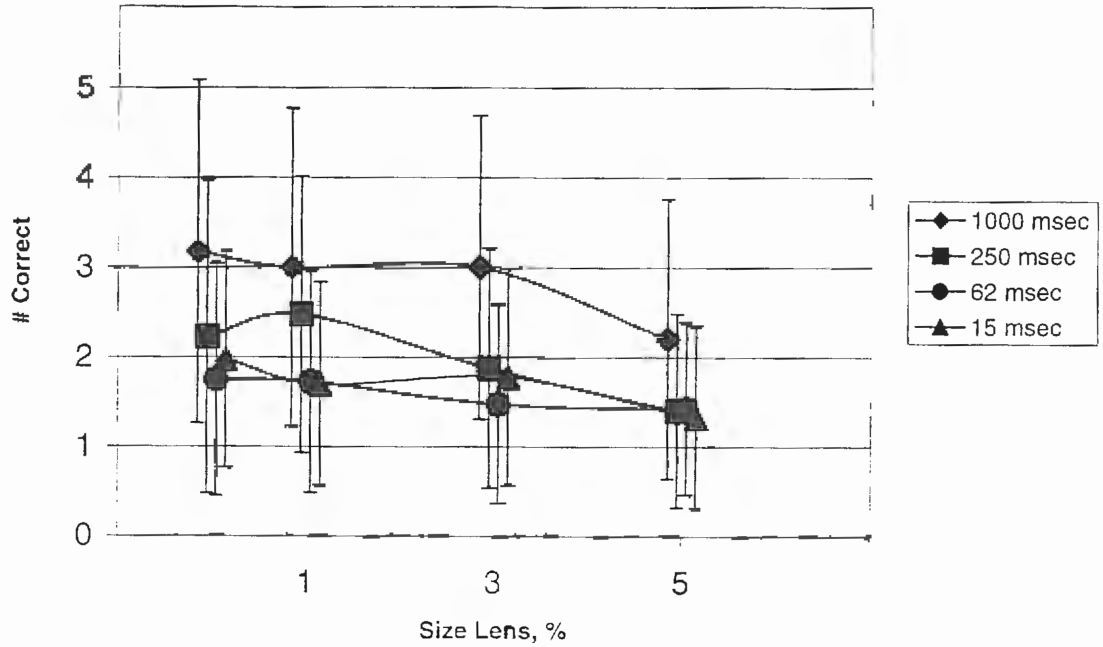
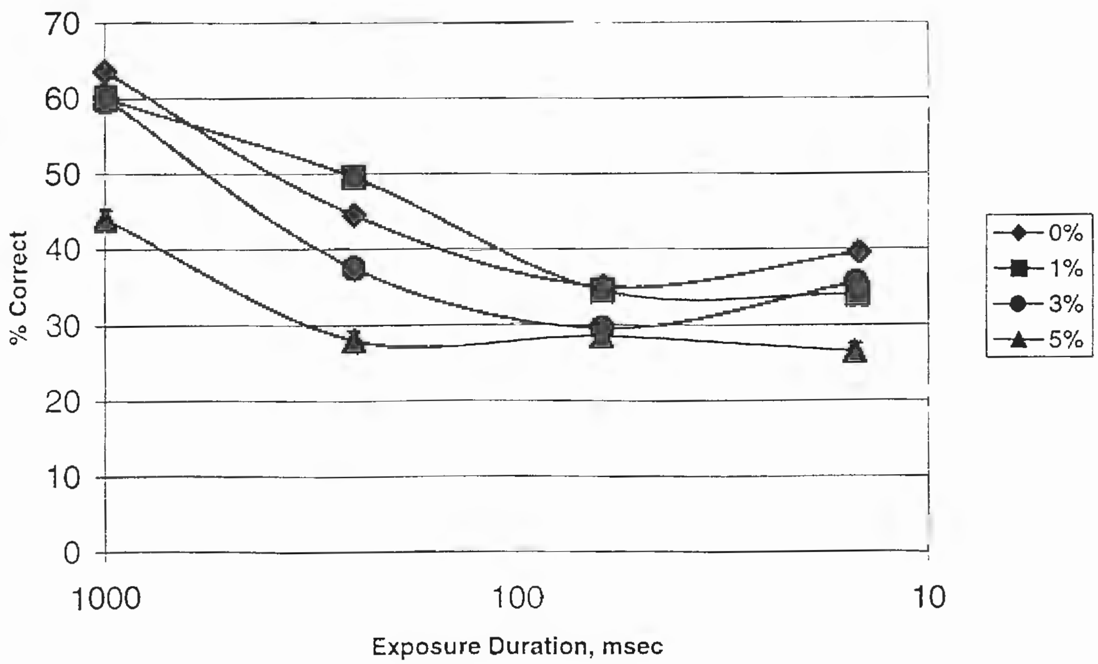


Figure 2. The percentage of correct responses for different exposure durations for 40 subjects.



DISCUSSION:

The results indicate that increasing induced amounts of aniseikonia reduces stereomobilization ability. Furthermore, they support previous studies (Thompson and Yudcovitch, 1996; Chretien and Lindberg, 1997) indicating that shorter presentation times do reduce stereomobilization ability. However, the interaction effect between aniseikonia and presentation time was not significant. This may be a result of the varying data, as indicated by the standard deviations shown in Table 2.

The perception of stereopsis commonly can be maintained up to 5% aniseikonia or less without disturbances in binocular function (Katsumi et al., 1992). Central fusion may be impossible for aniseikonia greater than 5% (Griffin and Grisham, 1995) which leads to binocular disturbances. Consequently, this study looked at aniseikonic levels of 5% and less to try to maintain binocular function.

Several factors may have influenced the results. The disparity chosen for the stereomobilization may have been too small. Some subjects had difficulty perceiving the stereo target even with the 1000 msec presentation time. Subjects remarked about the difficulty of the task, and reported choosing the target that they perceived as the darkest. Perhaps monocular cues were being used to make selections. Larger disparities would allow stereopsis to be perceived more easily. The fine disparity was chosen to remain consistent with previous research conducted by Chretien and Lindberg (1997).

Conflicting information exists in the literature on the effects that luminance has on stereo abilities. Studies indicate that abnormal stereo thresholds are associated with large inequalities in monocular contributions to brightness under binocular conditions (Bogdanovich et al., 1986). Literature supports that anaglyphic materials can introduce significant inequalities in retinal illuminance. Differences as small as 0.1 log unit, or 26% difference, may distort visual space (Bogdanovich et al., 86). In the present study, monitor luminance through the unequal filters was maintained at levels just above photopic threshold. The difference in filter transmittance was 61.2%, which was not compensated for in the study to keep the present study consistent with the previous studies of Thompson and Yudcovitch (1996) and Chretien and Lindberg (1997).

Matsumoto et al. (1983) contend chromatic differences can reduce stereoacuity. They propose chromatic differences induced by red-green filters create refractive conditions similar to aniseikonia and anisometropia. Cornforth et al. (1987) indicated chromatic imbalances created by red-green filters significantly increased stereo judgment errors. Based on the axial chromatic aberration of the eye (Wald and Griffen, 1947) the peak wavelength transmitted by the red filter is approximately 0.25 diopters behind the yellow focus whereas the peak wavelength transmitted by the blue filter is approximately 0.25 diopters in front of the yellow focus. The study therefore has approximately 0.50 diopters of induced chromatic difference. This information conflicts with a study done by Scharff and Geisler (1992) which indicates chromatic luminance has little effect on stereomobilization. It may be prudent to repeat the experiment using a neutral density filter to balance the filter transmittance and a plus lens to balance chromatic refractive difference between the two filters.

REFERENCES:

Bogdanovich G, Roth N, Kohl P. Properties of anaglyphic materials that affect the testing and training of binocular vision. J Am Optom Assoc 1986; 57(12):899-903.

Chretien J, Lindberg G. The effects of artificially induced anisometropia on stereomobilization. Thesis submitted for the degree of Doctor of Optometry, Pacific University, Forest Grove, Oregon 1997.

Cornforth L, Johnson B, Kohl P, Roth N. Chromatic imbalance due to commonly used red-green filters reduces accuracy of stereoscopic depth perception. Am J Optom & Physiol Optics 1987; 64(11):842-5.

Fendick M, Westheimer G. Effects of practice and the separation of test targets on foveal and peripheral stereoacuity. Vision Research 1983; 23(2):145-150.

Griffin, JR., Grisham DJ. Binocular anomalies: diagnosis and vision therapy. 3rd ed. Newton: Butterworth-Heinemann, 1995.

Grosvenor, T. Primary Care Optometry. 2nd ed. Newton: Butterworth-Heinemann, 1989.

Katsumi O, Miyajima H, Ogawa T, Hirose T. Aniseikonia and stereoacuity in pseudophakic patients. Unilateral and bilateral cases. Ophthalmology 1992; 99(8):1270-7.

Kumar T, Glaser DA. Initial performance, learning and observer variability for hyperacuity tasks. Vision Research 1993; 33(16):2287-2300.

Larson WL, Faubert J. Stereolatency: a stereopsis test for everyday depth perception. Optometry and Vision Science 1992; 69(12):926-30.

Lovasik J, Szymkiw M. Effects of aniseikonia, anisometropia, accommodation, retinal illuminance, and pupil size on stereopsis. Invest Ophthalmol Vis Sci 1985; 26(5):741-50.

Matsumoto ER, Johnson CA, Post RB. Effects of x-chrom lens wear on chromatic discrimination and stereopsis in color-deficient observers. Am J Optom Physiol Opt 1983; 60:297-302.

Polasky M. Aniseikonia Cookbook. Columbus, Ohio: The Ohio State Univ School of Optom; 1974.

Ryan VI. Predicting aniseikonia in anisometropia. Am J Optom. 1975; 52:96-105.

Sharff LV, Geisler WS. Stereopsis at isoluminance in the absence of chromatic aberrations. J Opt Soc Am 1992; 9(6):868-76.

Simons H, Grisham J. Binocular anomalies and reading problems. J Am Optom Assoc 1987; 58(7):578-87.

Thill, E. Z. Theory and practice of spectacle correction of aniseikonia. Duane's Clinic. Ophthalmo 1986, V 1, Ch 47.

Thompson G, Yudcovitch L. Temporal effects on stereoacuity: A normative study. Thesis submitted for the degree of Doctor of Optometry, Pacific University, Forest Grove, Oregon 1996.

Wald G, Griffen D R. The change of refractive power of the human eye in dim and bright light. J Opt Soc Am. 1947; 37: 321.

Appendix:

Table A. Subject characteristics.

Sub ject	Group	Age	Gen der	Rx OD	OS	Stereo acuity arc sec	Near VA 20/?	Dominant Eye Right/Left
1	A	22	F	-3.50	-3.75	40	20	R
2	B	22	F	-3.50	-4.00	40	20	R
3	C	43	M	-4.25	-3.00	20	20	L
4	D	24	M	plano	plano	20	20	L
5	D	22	F	-1.75	-2.00	20	20	L
6	B	24	F	plano	plano	20	20	R
7	A	24	M	-1.25	-1.50	20	20	R
8	B	22	M	-5.00	-5.50	20	20	L
9	C	27	M	-2.75	-2.75	20	20	R
10	D	28	F	-3.75	-5.50	20	20	R
11	A	23	F	-2.75	-2.75	20	20	R
12	B	23	F	-3.00	-3.25	20	20	R
13	C	24	F	plano	plano	20	20	R
14	D	23	M	-6.50	-7.00	20	20	R
15	A	22	M	1.75	1.00	20	20	L
16	B	23	F	-2.75	-3.00	20	20	R
17	C	30	M	-1.75	-1.50	20	20	R
18	D	23	M	-6.00	-6.00	20	20	L
19	B	29	M	-8.50	-8.50	20	20	R
20	C	26	M	1.00	1.00	20	20	R
21	A	28	F	-1.00	0.50	20	20	R
22	A	33	M	-2.00	-2.00	20	20	R
23	A	26	M	plano	plano	20	15	R
24	B	24	M	-3.25	-3.25	20	20	L
25	C	24	M	plano	plano	20	20	R
26	A	25	M	-3.00	-2.50	20	20	R
27	A	30	F	-3.00	-4.00	20	20	R
28	B	22	F	-3.00	-3.00	20	20	L
29	B	25	F	-5.00	-4.50 -1.00 x010	20	20	L
30	B	23	F	plano	-1.50	20	20	L
31	C	23	F	0.50	0.75	20	20	R
32	C	23	F	-1.25	-0.25	20	20	L
33	C	27	M	-2.25	-2.25	40	20	R
34	C	23	F	-0.75	-0.25	20	20	R
35	D	23	F	-1.25	-1.25	20	20	L
36	D	24	M	plano	plano	20	20	L
37	D	26	M	-5.25	-5.25	20	20	L
38	D	23	M	-6.00	-4.75	20	20	L
39	D	39	M	plano	plano	20	20	L
40	A	33	F	-4.50	-5.50	20	20	L

Table B. Total number of correct responses for five presentations for each test condition for each subject.

Time (msec)	10 00				25 00				62				15			
% size change	0	1	3	5	0	1	3	5	0	1	3	5	0	1	3	5
subject																
1	0	0	1	1	0	1	1	3	2	2	1	1	0	1	3	0
2	4	5	3	4	5	5	2	2	3	3	2	2	2	3	3	0
3	4	2	4	2	0	1	2	3	3	1	2	1	2	1	1	0
4	5	4	1	1	2	3	1	1	2	2	3	2	2	1	1	1
5	4	4	4	2	0	1	1	1	1	1	0	1	2	4	1	2
6	5	4	4	3	1	3	4	1	3	3	2	2	3	1	4	1
7	1	2	1	1	1	1	2	0	0	2	1	0	2	3	3	1
8	1	1	0	2	0	2	0	0	0	2	1	1	1	1	3	1
9	1	2	2	0	1	3	1	1	0	2	3	0	2	1	1	1
10	0	1	1	0	1	0	3	2	2	1	1	1	0	0	1	1
11	5	5	5	3	5	5	4	1	3	3	0	2	3	2	3	2
12	1	2	0	0	1	0	2	0	0	1	0	2	1	2	0	2
13	0	0	0	1	2	1	1	1	2	0	1	1	3	2	2	1
14	1	1	0	1	2	1	1	1	1	0	3	2	1	1	1	2
15	3	4	4	4	3	4	2	2	3	1	0	2	2	0	0	0
16	5	5	5	5	5	5	4	3	5	5	4	3	5	5	3	3
17	3	0	2	0	1	1	0	1	1	0	2	1	2	1	3	1
18	5	5	4	4	3	2	3	0	0	1	1	1	2	2	2	0
19	3	3	4	3	4	2	3	1	3	3	2	4	2	3	1	1
20	3	2	3	2	1	1	0	0	0	1	1	4	1	0	1	1
21	5	4	4	4	4	3	4	2	1	1	2	1	5	5	3	4
22	5	4	3	4	2	2	1	0	1	5	1	2	3	1	2	3
23	5	5	5	2	5	5	4	2	3	2	2	2	3	1	2	2
24	5	5	4	4	2	2	1	1	0	3	2	2	1	1	2	1
25	4	1	4	1	2	4	2	1	1	1	2	0	0	3	3	1
26	0	4	5	3	0	1	1	2	2	1	2	1	1	1	1	1
27	5	5	5	4	5	5	4	2	2	4	1	1	4	3	2	3
28	0	1	0	1	1	3	1	0	1	1	0	0	2	1	1	1
29	3	2	2	1	2	2	3	0	2	0	1	2	2	1	1	2
30	4	1	4	0	4	2	2	0	2	2	1	1	1	2	1	1
31	2	1	0	1	1	1	1	3	0	1	1	1	1	1	1	2
32	0	1	3	1	0	2	0	2	2	0	2	1	1	2	0	1
33	5	4	2	3	3	5	0	3	0	3	0	1	2	1	0	0
34	2	4	4	1	2	1	2	3	3	1	3	3	3	2	3	1
35	4	4	4	0	0	3	1	0	2	1	0	1	1	1	1	1
36	5	5	4	3	5	4	4	2	4	2	4	2	2	2	1	1
37	5	5	5	5	5	5	4	3	3	2	3	1	4	2	1	4
38	4	4	4	3	1	3	1	1	1	2	1	0	1	1	4	2
39	5	5	5	4	3	2	1	3	3	1	1	1	2	1	1	0
40	5	4	4	4	4	2	1	2	3	2	0	1	1	2	2	1