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Abstract. Retinal fundus evaluation is learned through experience and training. This study aimed to determine the image presentation characteristics and the accompanying evaluation techniques, which led to the most accurate and efficient retinal pathology detection method. Phase I included 25 novice clinicians asked to evaluate 14 different pathologies using spatial versus temporal image presentations. Phase II included 25 different novice clinicians asked to evaluate five different simulated pathologies at three different pixel sizes presented in both spatial and temporal image presentations. Accuracy and speed of recognition were evaluated between the spatial and temporal presentations of the same simulated pathology. In phase I, subjects were significantly faster at simulated pathology detection using a temporal presentation with a 95% accuracy rate versus a spatial presentation with a 79% accuracy rate. In phase II, subjects demonstrated significant differences in speed of detection using the temporal technique at all 3 pixel number sizes with the greatest difference in detection times shown at the smallest retinal defects. Accuracy and speed of recognition in simulated pathology assessment were improved in a temporal presentation and the greatest improvements were demonstrated at the smallest pixel numbers. © 2015 Society of Photo-Optical Instrumentation Engineers (SPIE) [DOI: [10.1117/1.JMI.2.2.025502](https://doi.org/10.1117/1.JMI.2.2.025502)]

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1 Introduction

Retinal image evaluation is an integral part of monitoring the presence or progression of ocular disease. Traditionally, retinal image evaluation utilizes two or more images positioned adjacent to one another or spatially separated. In this evaluation technique, one of the images acts as a baseline image and all other images are compared against this baseline in order to identify retinal changes which may indicate the earliest indications of ocular disease onset or progression. Subtle retinal image changes can be inherently difficult to detect even for experienced clinicians. Ophthalmic conditions including optic neuropathies and nerve fiber layer defects are only a few of the numerous retinal pathologies to present challenges.^{1,2}

Retinal image analysis performed using a temporal separation of two fundus photos utilizes an identification technique first described in the literature by Bengtsson and Krakau.³ The two images are aligned in visual space to allow an examiner to use temporally alternated retinal image evaluation between the two fundus photos. The retinal images occupy the same spatial position while the user varies the temporal rate of presentation. Subtle retinal changes are recognized as flicker or apparent motion as the baseline and a corresponding follow-up photo are alternated. Heijl and Bengtsson⁴ studied temporally alternated serial fundus photos in the evaluation of early glaucomatous change. Their results demonstrated that flicker analysis was superior to traditional serial analysis of optic disk photographs in detecting early glaucomatous change.

Cymbor et al.⁵ also assessed a flicker versus spatial comparison of glaucomatous optic nerve progression. Their results found significant agreement among multiple graders using flicker-based evaluations and nonsignificant agreement using spatial analysis of optic nerve photos. Differences in time to decision between flicker and spatial evaluation were also nonsignificant. VanderBeek et al.⁶ studied the detection and agreement between spatial and flicker alternation evaluation of peripapillary atrophy (PPA) progression. Their findings also identified greater rates of PPA progression identification with significantly higher interobserver agreement using flicker alternation techniques. Syed et al.⁷ identified increased sensitivity in disk hemorrhage recognition in flicker alternation versus both two-image spatial separation and single-image evaluation, and this sensitivity difference was highest for hemorrhages that are most difficult to identify. Further, the increased sensitivity in detection was found across all levels of experience including medical students, residents, and attending physicians. Myung et al.⁸ evaluated vascular progression in retinopathy of prematurity utilizing wide-angle retinal imaging. Their results demonstrated significantly increased differences in time until decision and examiner confidence using flicker alternation versus side-by-side comparison techniques, although accuracy differences between the two techniques were nonsignificant. McGlynn et al.⁹ identified structural glaucomatous damage progression that was significantly associated with diastolic blood pressure using alternation flicker chronoscopy.

Previous studies of flicker alternation used in image evaluation have used primarily optic nerve photos in early glaucomatous damage.^{4–7} Additionally, the number of graders used in previous flicker alternation studies has been as few as two

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individuals⁶ up to a maximum of 10 individuals.⁸ Graders involved in each of these studies were trained, experienced clinicians using a proprietary software package with a fixed alternation rate of 2 Hz.⁵⁻⁸ Primary care optometric practice may derive great benefit from posterior pole retinal image analysis used as a screening technique for systemic disease processes including hypertension and diabetes. In particular, clinicians in-training and recent graduates may also find the greatest benefit using flicker alternation to enhance their own change detection sensitivity during retinal examinations.

Currently, no literature evaluating flicker alternation in image evaluation using novice clinicians and posterior pole retinal images can be found. Our comparison study of retinal image evaluation techniques using novice clinicians was designed in two phases. The first phase of the study evaluated differences in speed and accuracy of retinal pathology detection between spatial and temporal presentations of the same simulated pathology. The second phase evaluated differences in speed and accuracy of simulated pathology detection as a function of size measured as a total pixel number.

2 Methods

Phase I included 25 first and second year optometry students participating as study subjects. All subjects were 22 to 34 years of age with best corrected Snellen visual acuity of better than or equal to 20/25 OU. Written informed consent was obtained from each enrolled subject. All testing procedures were approved by the UMSL Institutional Review Board and followed the tenets of the Declaration of Helsinki. Deidentified clinical retinal photographs showing at least 1 of the 14 different pathologies were evaluated using Adobe Photoshop software for size (measured in pixel number), location within the fundus (intravascular versus extravascular) and color hue. A single, classic example of each retinal pathology was then selected and inserted into a standard, retinal photograph at appropriate clinical positions using Adobe Photoshop software to simulate 14 different retinal pathologies including vascular changes (e.g., Hollenhorst plaque, cotton wool spot, dot hemorrhage, vessel tortuosity) and optic nerve head changes (e.g., nerve fiber layer defects, optic nerve pallor, indistinct optic nerve margins). The simulated retinal pathologies were created by initially using a real clinical retinal photograph and using Adobe Photoshop to magnify the image and extract the pixel size and color grading. These "real" pathologies were then inserted into a control retinal photograph at nonrepeating locations as "simulated" pathology at locations consistent with their clinical diagnosis. Order effects were minimized through the use of three separate versions with different pathology sizes and type orders presented between subjects. Two catch trials (i.e., no difference between the images) were also created using the standard, retinal photograph with no inserted pathology. Each simulated pathology was displayed in a spatial and a temporal presentations using Microsoft PowerPoint software and the temporal presentation rate, or the rate of toggle between superimposed images, was controlled by the subject. No time limit was given for image presentation and sequence of image presentation was randomly generated to control for order effects. Examples for the simulated retinal pathology at three different pixel sizes are shown below (Fig. 1).

To begin each trial, the subject was comfortably seated in front of a 17 in. LCD desktop monitor using a chin and forehead rest assembly fixed at a 50-cm distance measured from the

cornea to the monitor face. Subjects were asked to keep both eyes open to maintain binocular viewing conditions during testing. A standard set of instruction was read to each subject describing the testing and the measured outcomes and a keyboard was provided for the subject, and required only the use of the left and right arrow keys to control the rate of slide presentation. Each simulated retinal pathology image pair consisted of a baseline and a follow-up images. All baseline images were unchanged and contained no retinal pathology. Follow-up images contained one of the 14 simulated pathologies or no change to act as a catch trial. For the spatial presentation, no slide changes were necessary because the baseline and follow-up retinal images were simultaneously visible on the same slide. For the temporal presentation, the right arrow transitioned the retinal image from baseline to follow-up and the left arrow transitioned the retinal image from follow-up to baseline. The rate of alternation between the two images was controlled by the subject. Four pairs of retinal images were shown to each subject as an introduction to the task. Two image pairs were spatially separated (shown on a single slide) and viewed simultaneously. Two image pairs were temporally separated (shown as a baseline image on one slide and a follow-up image on subsequent slide) and the subject was instructed to toggle between the images using the right and left arrow keys to become familiar with the technique. Location of retinal pathology was identified to each subject after no more than 60 s to assist in task familiarization. Once the subject completed the four pairs of practice images and clearly stated the task technique, the trial was started.

A title slide identifying the image pair number preceded each image pair, whether spatially or temporally separated, to allow for frequent subject breaks and time for the examiner to record both speed and accuracy of the subject's response. Time to decision was measured as the time between the subject pressing the right arrow key to view the spatially separated retinal image pair or the baseline image of a temporally separated retinal image pair and when the subject responded by stating "Change" or "No Change." If the subject responded "Change," the timer was stopped and the subject was asked to identify the location of the simulated retinal pathology. If the subject responded "No Change," the timer was stopped and the slide was advanced to the title slide of the next retinal image pair. The examiner recorded total time elapsed and accuracy status of the subject's response as positive or negative. No feedback regarding the accuracy of response was given to the subject. Three different versions of 14 simulated retinal pathologies spatially separated, 14 simulated retinal pathologies temporally separated, 1 spatially separated catch trial, and 1 temporally separated catch trial for a total of 30 slides were created. Presentation order of each trial was determined by a random number generator. Versions were assigned to subjects in sequential order and the trials lasted approximately 30 min, with the subject allowed to take breaks as necessary. Accuracy statistics were calculated as the total number of correct retinal pathology location determination out of 30 slides. Incorrect responses occurred when the subjects failed to locate the simulated retinal pathology. These incorrect responses were used in the calculation of the accuracy rate. All responses (correct and incorrect) were used in the time to decision calculations for each simulated pathology. Time to decision was evaluated as a paired *t* test between the spatial and temporal presentations of the same simulated pathology for all responses.

Fig. 1 Examples of the simulated retinal pathology shown at the three different pixel sizes (small, medium, large) presented to each subject. (a) The top image demonstrates a paramacular hemorrhage located inferior, temporal to the macula. (b) The middle image demonstrates a paramacular hemorrhage located inferior, nasal to the macula. (c) The bottom image demonstrates a paramacular hemorrhage located superior, temporal to the macula. Black arrows are used to indicate location of the simulated retinal pathologies. Phase I used simulated pathologies of the medium pixel size at varied positions. Phase II used simulated pathologies of three different pixel number sizes at varied positions.

Phase II included 25 first- and second-year optometry students participating as study subjects that did not participate as subjects in phase I. The purpose of phase II was to compare speed and accuracy of detecting simulated retinal pathology changes using spatial versus temporal presentation evaluations

as a function of simulated pathology size. Pathology size (measured in pixel numbers) was determined from five retinal pathologies in phase I which demonstrated a significant improvement in identification accuracy with temporal presentation. Pixel numbers were then increased 1 octave for large simulated

pathologies and decreased 1 octave for small simulated pathologies using Adobe Photoshop software. Each of the five retinal image pathologies was presented in three different pixel sizes at different locations. Three different pixel sizes (small, medium, large) of five simulated retinal pathologies spatially separated, three different pixel sizes (small, medium, large) of five simulated retinal pathologies temporally separated, two spatially separated catch trials, and two temporally separated catch trials for a total of 34 slides were created. Presentation order of each trial was determined by a random number generator. Versions were assigned to subjects in sequential order and trials lasted approximately 35 min, with the subjects allowed to take breaks as necessary. Testing protocols were the same as phase I. Accuracy statistics were calculated as the total number of correct retinal pathology location determination out of 34 slides. Incorrect responses occurred when subjects failed to locate the simulated retinal pathology. These incorrect responses were used in the calculation of the accuracy rate and time to recognition for each simulated pathology. Means and standard error of the means of accuracy and time to decision were assessed across the conditions. Time to decision was evaluated as a 2 (presentation: spatial or temporal) $\times$ 3 (size of simulated pathologies: small, medium, or large) repeated measures analysis of variance for main effects of presentation and size along with determining if there was an interaction (presentation $\times$ size).

3 Results

Phase I subjects performed best with temporal presentation on accuracy of correctly identifying the location of the retinal pathology using the temporal technique 95% of the time versus the spatial technique 79% of the time and were significantly faster at time to detection by an average of 34 s. Subtle retinal changes including sectoral nerve pallor, indistinct nerve margins, and nerve fiber layer defects demonstrated the greatest improvement in detection speed using a temporal evaluation technique versus a spatial evaluation technique. Table 1 provides the viewing technique used, mean time to decision, and standard error measurements (SEM) recorded in seconds for each of the 14 simulated retinal pathologies across all 25 subjects.

A Bonferroni correction was applied to reduce the likelihood of a type I error in multiple comparisons. Paired *t* test analyses of spatial versus temporal presentations found significant differences in time to decision across 6 of the 14 simulated pathologies ($p \leq 0.004$) and near-significance in 4 of the 14 retinal pathologies ($p \leq 0.01$). Table 2 shows the mean differences in time to decision between spatial and temporal evaluation techniques for the 14 retinal pathologies and the control images. Overall, subjects were significantly faster at time to decision using the temporal image presentation by an average of 34 s/paired image.

Phase II subjects showed the greatest differences at the smallest size pathologies, performing better using a temporal image presentation with an overall accuracy of 82.4% compared to the spatial image presentation at 71.2%, and demonstrated significantly lower time to detection during the temporal image presentation by an average of 25 s. Table 3 provides a summary of the viewing technique, mean time to decision, and SEM for the 25 subject sample for the five simulated retinal pathologies across the three defect sizes measured in pixel numbers. There was a significant effect for presentation type ($F = 65.31$, $df = 1, 24$, $p < 0.001$) with temporal evaluation of the images resulting in faster time to detection of pathologies.

Table 1 Table of descriptive statistics including viewing technique, mean time to decision (in s), and standard error measurements (SEM) for each of the 14 simulated retinal pathologies across all 25 subjects involved in phase I. Catch trials within the image analysis were reported as a control.

Simulated retinal pathology	Viewing technique	Mean time to decision	SEM
Sectoral nerve pallor	Spatial	63.74	7.40
	Temporal	3.38	0.32
Retinal vessel emboli (inferior, temporal)	Spatial	20.66	3.64
	Temporal	6.45	1.49
Cotton-wool spot	Spatial	10.75	3.51
	Temporal	4.89	0.63
Indistinct nerve margins	Spatial	43.03	9.14
	Temporal	1.73	0.35
Dot hemorrhage	Spatial	24.21	3.46
	Temporal	10.61	1.49
Branch retinal artery occlusion	Spatial	11.54	5.05
	Temporal	2.77	0.23
Retinal vessel emboli (superior, nasal)	Spatial	12.86	3.34
	Temporal	6.96	1.29
Paramacular hemorrhage	Spatial	20.65	6.41
	Temporal	6.59	0.77
Vessel tortuosity	Spatial	63.85	6.53
	Temporal	6.14	0.82
Microaneurysm	Spatial	80.51	12.66
	Temporal	23.80	3.23
Vessel inflection	Spatial	53.89	9.55
	Temporal	9.99	1.83
Nerve fiber layer defects	Spatial	80.10	14.98
	Temporal	2.79	0.21
Drance hemorrhage	Spatial	33.43	7.64
	Temporal	2.76	0.17
Retinal vessel emboli (superior, temporal)	Spatial	22.54	5.45
	Temporal	3.66	0.44
Control	Spatial	104.04	13.67
	Temporal	40.92	6.55
Overall mean	Spatial	43.05	2.58
	Temporal	8.97	0.74

Table 2 Paired *t* test analysis of time to decision speeds (in s) in spatial versus temporal presentations revealed statistical significance in the above pathologies and all pathologies combined. Catch trials within the image analysis are reported as control statistics. A Bonferroni correction was calculated requiring a $p \leq 0.004$ for significance.

Simulated retinal pathology	Paired differences (spatial–temporal)			
	Mean	SEM	<i>t</i> value	Significance
Sectoral nerve pallor	60.36	7.41	8.14	<0.001
Retinal vessel emboli (inferior, temporal)	14.21	4.23	3.36	<0.01
Cotton-wool spot	5.87	3.62	1.62	0.12
Indistinct nerve margins	40.15	8.98	4.47	<0.001
Dot hemorrhage	13.60	3.47	3.92	<0.01
Branch retinal artery occlusion	8.77	5.01	1.75	0.09
Retinal vessel emboli (superior, nasal)	5.90	2.92	2.02	0.06
Paramacular hemorrhage	14.06	6.46	2.18	0.04
Vessel tortuosity	57.72	6.49	8.89	<0.001
Microaneurysm	56.70	12.04	4.71	<0.001
Vessel inflection	43.89	10.06	4.36	<0.001
Nerve fiber layer defects	77.31	15.01	5.15	<0.001
Drance hemorrhage	30.66	7.71	3.98	<0.01
Retinal vessel emboli (superior, temporal)	18.87	5.53	3.41	<0.01
Control	63.12	11.48	5.49	<0.001
Overall spatial–temporal	34.08	2.66	12.79	<0.001

Comparisons of spatial image presentation versus temporal image presentation were found greater differences in time to decision in the simulated pathologies with the smallest size than larger simulated pathology sizes (significant main effect for size, $F = 47.34$, $df = 2, 38$, $p < 0.001$). Table 4 shows the greatest differences in time to decision between spatial evaluation and temporal evaluation were found at the smallest size. Overall temporal evaluation techniques were significantly faster in time to decision. Table 5 provides the overall comparison of spatial versus temporal techniques across the three retinal defect sizes. There was a significant presentation $\times$ size interaction effect in time to detection ($F = 11.25$, $df = 2, 48$, $p < 0.001$). Significance of the temporal technique in time to decision is demonstrated at the smallest sizes with the greatest difference in time to decision shown at the smallest retinal defects.

4 Discussion

Phase I subjects performed best with temporal presentation on accuracy of correctly identifying the location of the retinal pathology, using the temporal technique 95% of the time versus the spatial technique 79% of the time, and were significantly faster at time to decision. Phase II subjects showed the greatest differences at the smallest size pathologies performing better using a temporal image presentation with an overall accuracy of 82.4% compared to the spatial image presentation at 71.2%, and subjects demonstrated significantly lower time to decision

during the temporal image presentation. Significance of the temporal technique in time to decision is demonstrated at the smallest pixel sizes with the greatest difference in time to decision shown at the smallest retinal defects.

The technique of flicker chronoscopy for the assessment of change in serial optic nerve photographs was originally published by Goldmann and Lotmar.¹⁰ The original technique of alternation flicker required manual alignment of the optic nerve photos making it highly time consuming. Alternation flicker analysis incorporates monoscopic images only allowing highly sensitive motion cues to be the primary detection technique of change versus no change.¹¹ Existing software allowing precise matching of retinal landmarks using rotation and magnification transformations between retinal images can allow the image superimposition necessary for a temporal evaluation. Ideally, this same software would also be capable of correcting illuminance differences between images which may occur during image acquisition. Such algorithms used for automated detection of diabetic retinopathy have been reported in the literature.¹² In their review of 15 automated detection systems, the authors concluded that algorithms using the greatest number of retinal features provided the highest levels of detection. Such systems could be used to recognize and precisely match two retinal images that could be used in a temporal evaluation technique. The combination of precise automated retinal landmark matching along with a temporal evaluation technique by an experienced provider may provide the highest degree of sensitivity

Table 3 Table of descriptive statistics including viewing technique, mean time to decision (in s), and SEM for each of the five simulated pathologies at three different sizes for all responses across 25 subjects involved in phase II. Catch trials within the image analysis are reported as a control.

Simulated retinal pathology	Simulated retinal pathology size	Viewing technique	Mean time to decision	SEM
Microaneurysm	Small	Spatial	32.05	4.94
		Temporal	15.38	3.57
	Medium	Spatial	26.70	6.63
		Temporal	16.68	4.57
	Large	Spatial	15.44	5.20
		Temporal	6.68	1.36
Cotton-wool spot	Small	Spatial	54.77	6.99
		Temporal	18.28	1.90
	Medium	Spatial	21.23	4.26
		Temporal	6.93	1.19
	Large	Spatial	10.01	3.80
		Temporal	6.33	1.08
Paramacular hemorrhage	Small	Spatial	63.72	7.35
		Temporal	32.27	4.92
	Medium	Spatial	17.12	3.29
		Temporal	11.95	2.31
	Large	Spatial	19.46	4.20
		Temporal	8.95	2.49
Retinal vessel emboli	Small	Spatial	29.25	6.41
		Temporal	11.42	2.23
	Medium	Spatial	17.08	3.86
		Temporal	7.60	0.99
	Large	Spatial	22.67	5.31
		Temporal	5.13	0.84
Dot hemorrhage	Small	Spatial	57.66	4.96
		Temporal	33.27	5.24
	Medium	Spatial	37.51	6.21
		Temporal	22.46	3.46
	Large	Spatial	20.55	3.86
		Temporal	12.50	2.10
Control		Spatial	71.27	9.57
		Temporal	44.47	4.66

Table 4 Paired differences of time to decision in spatial versus temporal presentations (in s) across the five simulated pathologies for all responses. Catch trials within the image analysis are reported as a control.

Paired differences (spatial–temporal)			
Simulated retinal pathology	Simulated retinal pathology size	Mean	SEM
Microaneurysm	Small	16.68	4.00
	Medium	10.02	3.39
	Large	8.76	4.83
Cotton-wool spot	Small	36.49	6.99
	Medium	14.30	3.94
	Large	3.69	3.46
Paramacular hemorrhage	Small	31.45	7.10
	Medium	5.17	3.34
	Large	10.50	4.69
Retinal vessel emboli	Small	17.83	6.31
	Medium	9.48	4.02
	Large	17.54	4.89
Dot hemorrhage	Small	24.39	5.23
	Medium	15.05	5.48
	Large	8.05	3.47
Control		26.80	9.06

Table 5 Paired differences of mean time to decision (in s) for spatial versus temporal presentations across the three simulated pathology sizes for all responses.

Paired differences (spatial–temporal)		
Simulated retinal pathology size	Mean	SEM
Small	25.37	2.75
Medium	10.81	2.40
Large	9.71	2.11
Overall	15.29	1.84

and specificity in diabetic retinopathy possible. Although automated detection holds promise, retinal evaluation by a licensed provider remains the standard of care.

Joachim et al.¹³ published an observational study using participants from the Blue Mountain Eye Study. Retinal photographs were taken at 5, 10, and 15 year follow-up examinations and were assessed for early age-related macular degeneration (AMD) changes and resulting geographic atrophy. Their conclusions suggested that early AMD changes were strongly associated

with an increased long-term risk of developing geographic atrophy even when age, smoking history, and genetic susceptibility were controlled for. These results underscore the importance of accurate and highly sensitive retinal image detection practices which may be provided by a temporal evaluation technique.

A number of retinal pathology assessments including choroidal nevus,¹⁴ retinopathy of prematurity,¹⁵ and retinal drusen¹⁶ would likely show enhanced sensitivity in detection and progression monitoring with temporal image evaluation. Perhaps the greatest contribution of temporal image evaluation would be recognized through telemedicine or centralized image reading centers. Regions without specialty and subspecialty consultation services may be able to integrate software using retinal landmark matching in conjunction with temporal evaluation techniques to provide a highly sensitive early detection of retinal disease.

Our results have expanded the scope of the existing literature through a number of differences. First, recent studies have utilized a proprietary software application from EyeIC (Norberth, PA).⁵⁻⁸ This application creates a fixed temporal alternation rate of 2 Hz whereas our experimental design allowed subject control of the toggle rate. Second, previous studies used as few as 2 graders⁶ up to 10 graders.⁸ Our protocols called upon 25 naïve graders for phase I and 25 separate naïve graders for phase II. Third, with the exception of the retinopathy of prematurity study,⁸ studies of flicker comparison versus spatial comparison have utilized optic nerve photos. Our design incorporated posterior pole images and subjects instructions to identify any changes across the fundus.

Enhanced image analysis through temporal techniques is not limited to retinal photographs. Any type of imagery that has a baseline or time zero and a subsequent follow-up may demonstrate increased sensitivity to change detection when evaluated using temporal techniques. Possible uses for enhanced retinal image evaluation through temporal evaluation techniques include red-free photos, autofluorescence, fluorescein angiography, as well as other multimodal imaging techniques.¹⁷ A comprehensive review of the capabilities and limitations of the use of alternation flicker in the detection of glaucoma progression was published by Syed et al.¹⁸

Our findings agree with previous studies that temporal retinal image evaluation is a more sensitive method for detecting subtle retinal changes than spatial image evaluation. Both accuracy and time to decision in simulated retinal pathology assessment were improved in a temporal presentation compared to a spatial presentation, and the greatest improvements were demonstrated at the smallest pixel numbers. The improved efficiency and accuracy in subtle retinal pathology change may hold great promise in a primary care optometric practice. Temporal image evaluation may be the most effective evaluation strategy for early detection of retinal pathology. Potential limitations of the study include the use of simulated pathology in the comparison of retinal image analysis. To establish that the significance in detection accuracy and time to decision is also present in a clinical setting, a similar experimental design using documented retinal changes in clinical patients should be accomplished. Another potential limitation is whether the image analysis technique of traditional side-by-side retinal image evaluation versus alternation flicker evaluation is influenced by poor visual scanning techniques. The next phase of study will evaluate gaze patterns during retinal fundus evaluation. Differences in fundus evaluation patterns will be assessed in terms of accuracy and time until correct response in order to identify the most efficient

and repeatable method. Further study involving experienced clinicians as subjects in the comparison spatial versus temporal image evaluations is warranted. Additional assessment of retinal fundus evaluation patterns between experienced and novice clinicians may yield insight into the determination of the optimal scanning pattern.

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