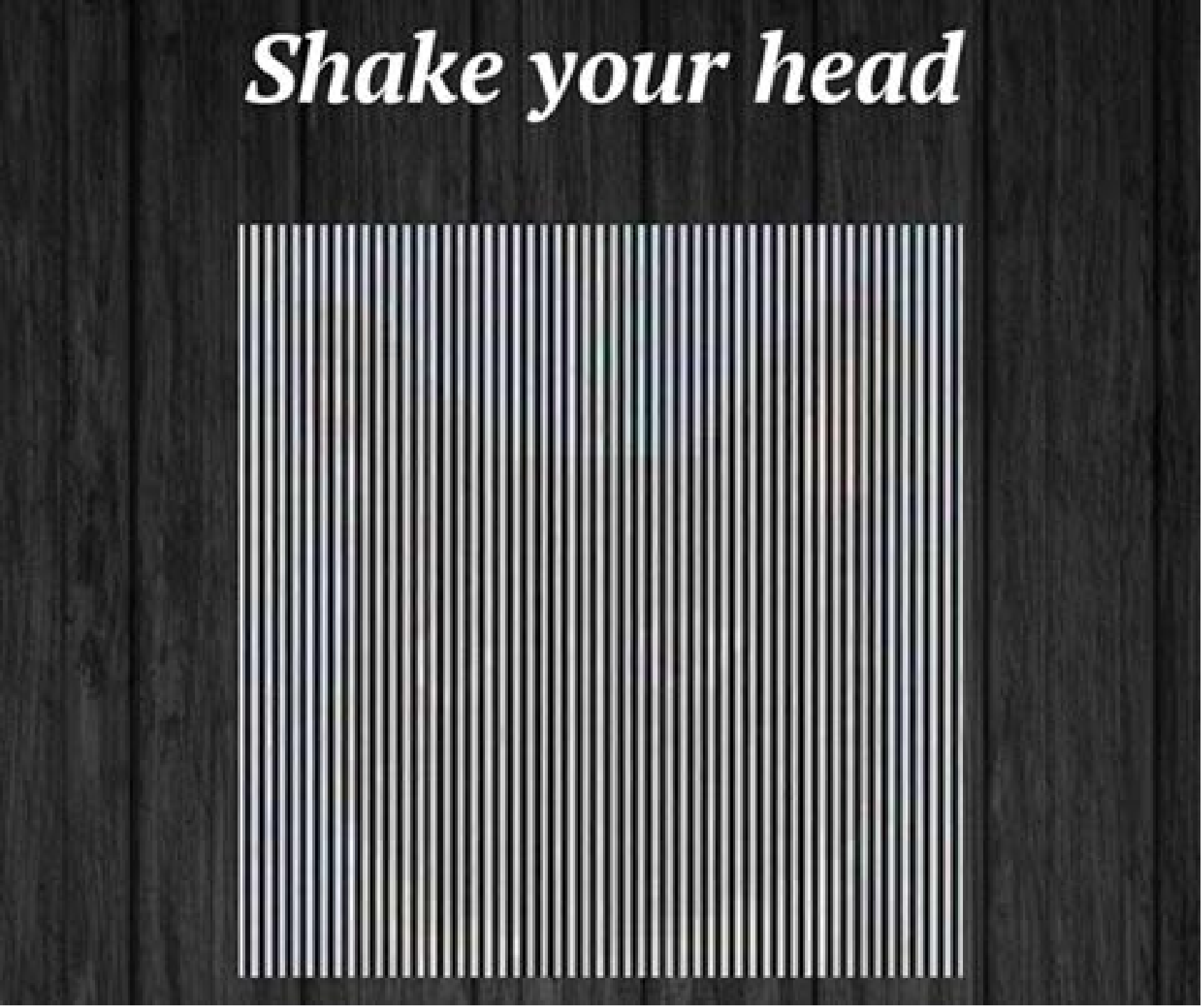
Vision Therapy for Concussion Rehabilitation

Joseph F. Clark, Ph.D.
Professor of Neurology
University of Cincinnati

Acknowledgements and Disclosures.

- Thanks to many people who help make this work a reality. Here are just a few.
- Jon Divine, Kim Hasselfeld, Bob Mangine, Aaron Himler, Jim Ellis, Mike Donaworth, Angelo Colosimo, Jerry Holloway, Jon Vincent, Enna Salmanovic, Nicole Giordano, Bradley Jacobs, Pat Graman and others.

- JFC has no financial disclosures.



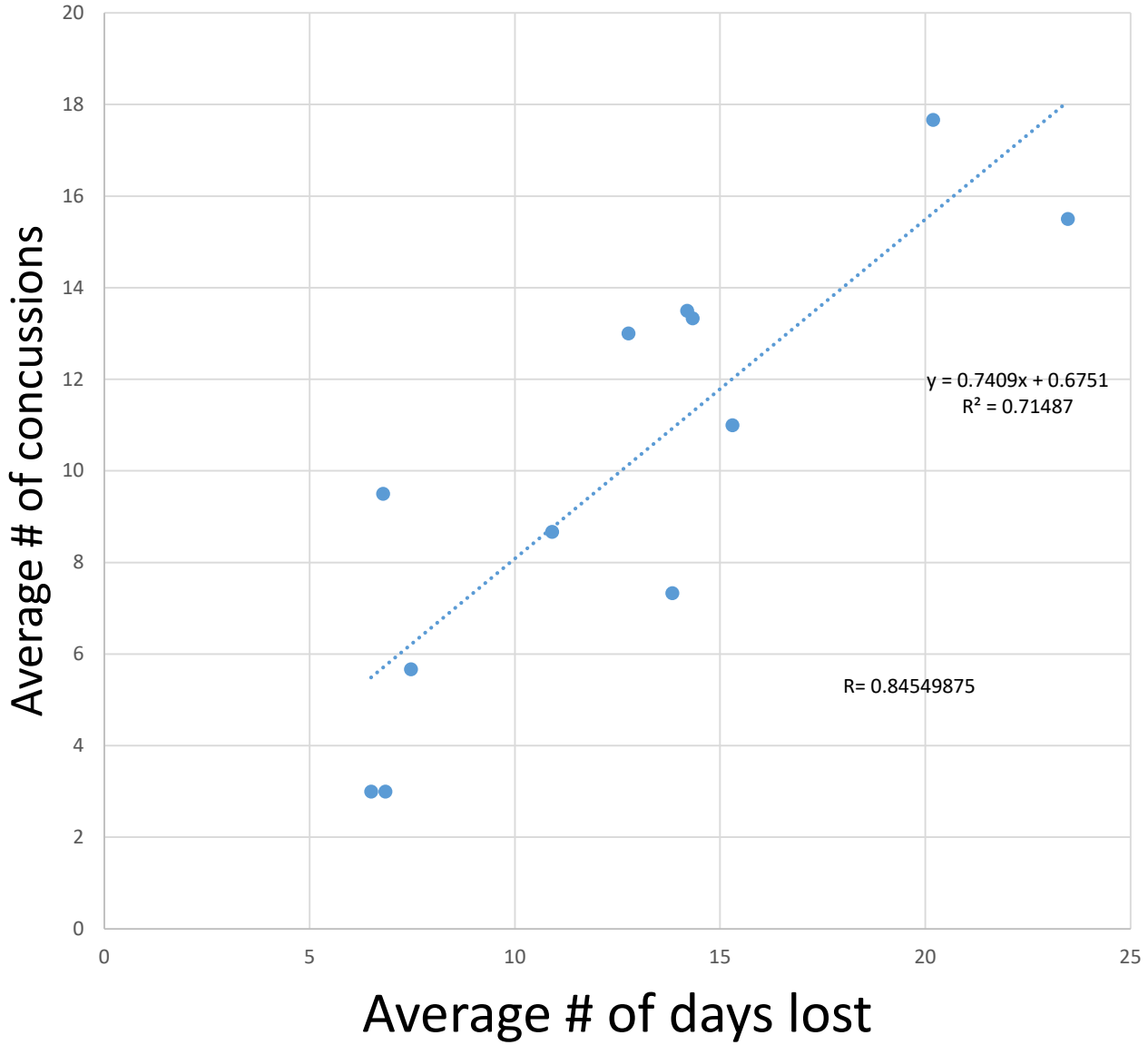
- Seeing something and the brain perceiving it are two completely separate processes.
- 80% of the sensory information to the brain comes from the eyes.
- The brain works to reconcile that sensory information and when disrupted; problems will follow
- Neurosensory disturbances post mTBI are common and often difficult to manage.

We get our mTBI athletes back to play faster.

- For 3 football seasons the AAC, including UC, have tracked concussions. The UC program is associated with fewer concussions compared to other teams in our conference and faster return to play.
- Mean of Total Concussions: AAC 10.5±5.62 compared to UC 3±1 is significantly different P=0.037.
- Mean Return to play: AAC 13.1±6.44 days compared to UC 6.5±0.5 days is significantly different P=0.037.
- We have fewer concussions and when we have concussions that get better faster.
- Concussions reported per season thanks to the Tulsa Group.

Year	Number of concussions	Coach that year
2006	9	Coach 1
2007	8	Coach 2
2008	7	Coach 2
2009	11	Coach 2
2010*	1	Coach 3
2011	3	Coach 3
2012	1	Coach 3
2013	1	Coach 4
2014	3	Coach 4
2015	4	Coach 4
2016	2	Coach 4
2017	10	Coach 5
2018	2	Coach 5

Do other teams “count” less severe injuries as concussion?



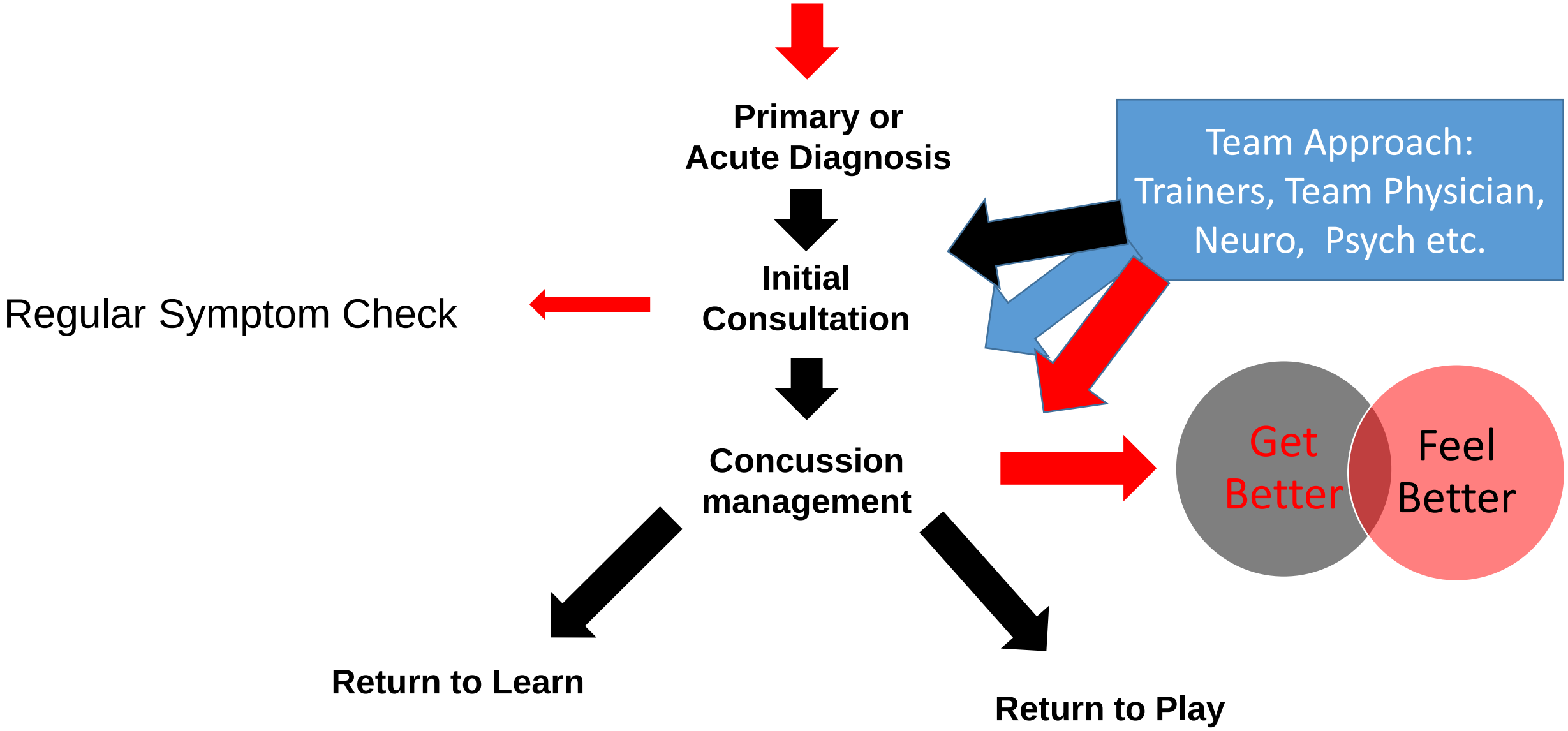
- In the AAC there is a positive correlation between number of concussions and duration of days lost.
- So more reported concussions is not a matter of finding and reporting more “mild” concussions.
- We believe (UC) this is a matter of pre and post concussion management.
- So; a little about what makes us different.

“There is emerging evidence supporting the use of vision training, including light board training tools, as a concussion baseline and neuro-diagnostic tool and potentially as a supportive component to concussion preventative strategies” (Clark, 2015)

We believe that these same strategies can be applied to rehabilitation post concussion to aid in more rapid recovery. Post sports concussion this equates to faster return to play.

There are data suggesting that a strong predictor for good outcome post concussive injury is the perception that the patient is being helped.

Sports mTBI Mitigation and Management



Feel better Strategy.
Photophobia and Frequency Specific Photophobia

Clark JF., K. Bigsby, K. Hasselfeld, J. G. Divine. **Colored Glasses Reduce Photophobia Symptoms Post Traumatic Brain Injury.** Journal of Athletic Training. 2017

Summary of results for mTBI patients and frequency specific photophobia

28/37 73% had photophobia	22/26 85% with photophobia had relief with colored glasses
Green 10 Blue 7 Purple 5 Magenta 4 Red 4	Violet 3 Orange 2 Indigo 3 Rose 2 Aqua 1 Pink 1

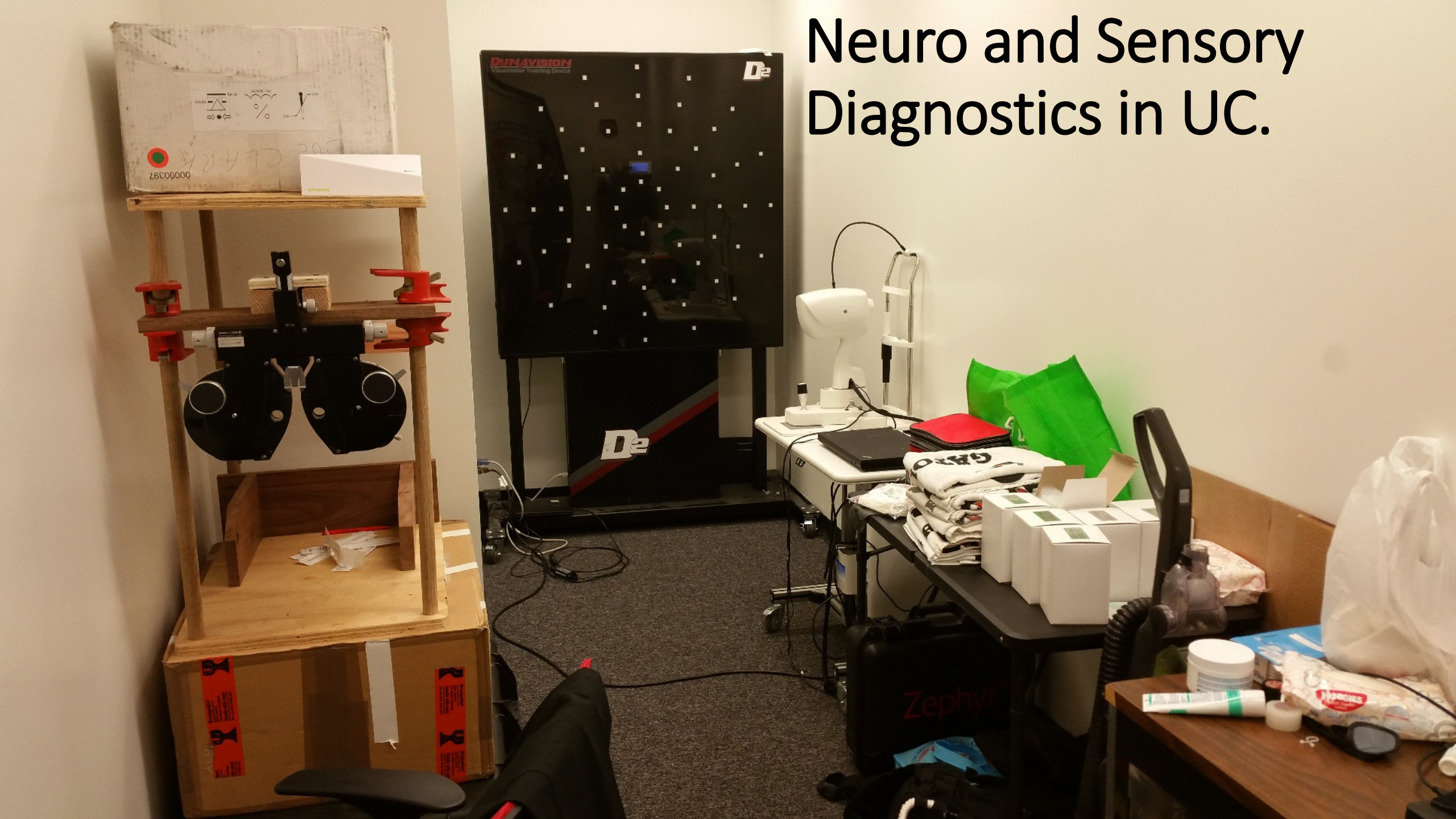
UNIVERSITY OF Cincinnati

Neurovisual issues and TBI

- Post concussion or traumatic brain injury (TBI) patients often experience headache, photophobia, difficulty with reading, difficulty with concentrating and other symptoms.
- There are multiple neurodiagnostic and rehab methods for the mTBI patient with neurovisual issues.
- We do neurodiagnostic evaluations to assess brain deficiencies as well as to guide in the formation of a rehabilitation strategy. This can take time though with an exam lasting 1.5 hrs or more.
- Part of the goal of the exam is to determine how to initiate the “get better” strategy and design rehab for the patient.

UNIVERSITY OF Cincinnati

Neuro and Sensory Diagnostics in UC.



Neuro and Sensory Diagnostics and Performance in UC's Training Room.


Xtreme
PERFORMANCE LAB
SAMSUNG
QLED
GAMI
MONI
P4
C4
O2
T6
T4

How do we approach Vision Rehab post TBI

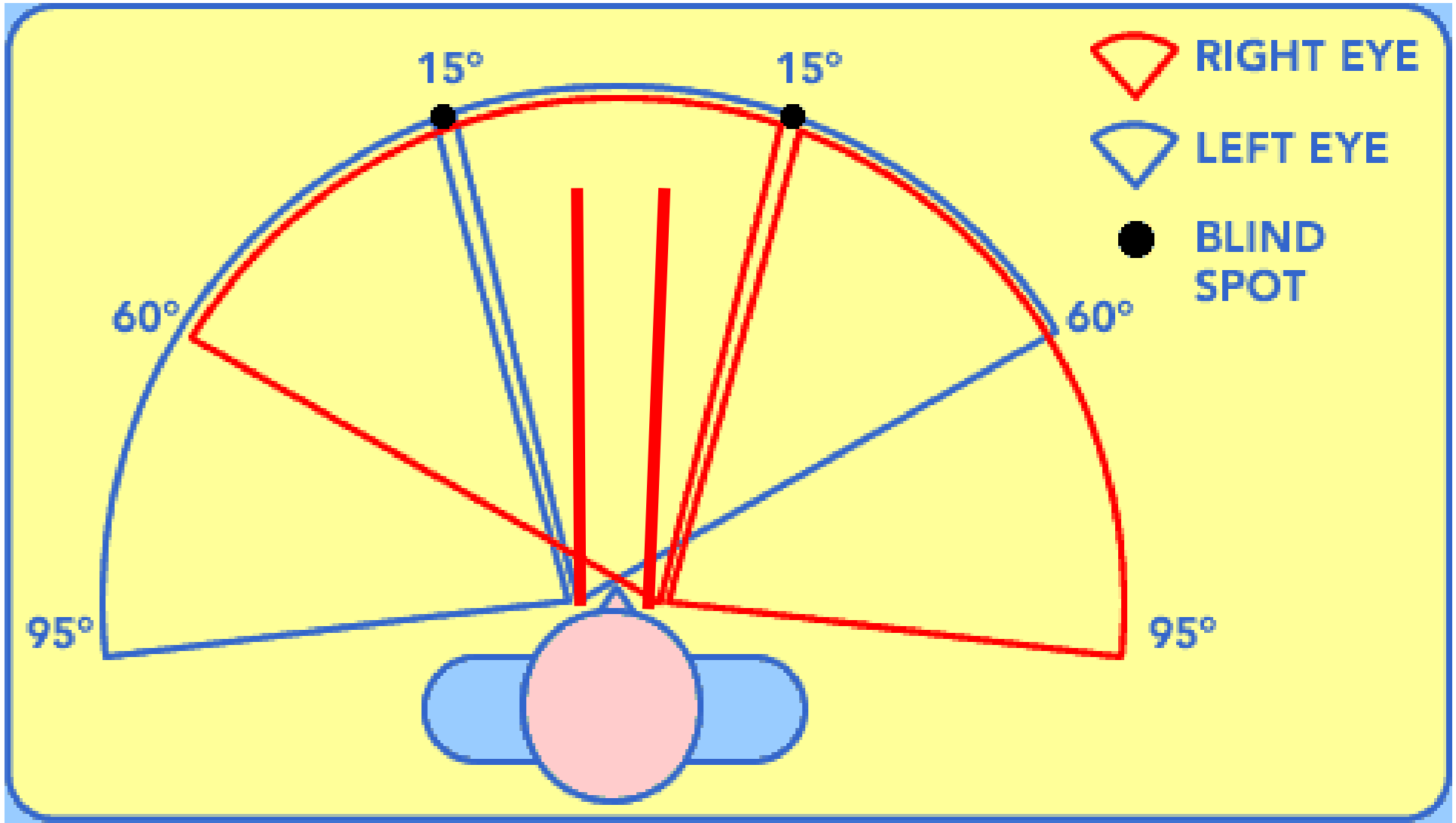
- We try to cover the 3 pillars of vision training with our vision rehab with the overall vision training program.
- **I want to cover these three pillars of vision training:**
  - Ocular motor performance (speed, precision and endurance)
  - Eye discipline (precision, muscle memory and stabilization)
  - Processing (speed and efficacy of the brain to control the eyes and process visual information. Also includes peripheral vision; the brain helps *trust* peripheral vision.)
- If these three are addressed regularly the vision training, neurovisual training, program will take hold.

Phorias:

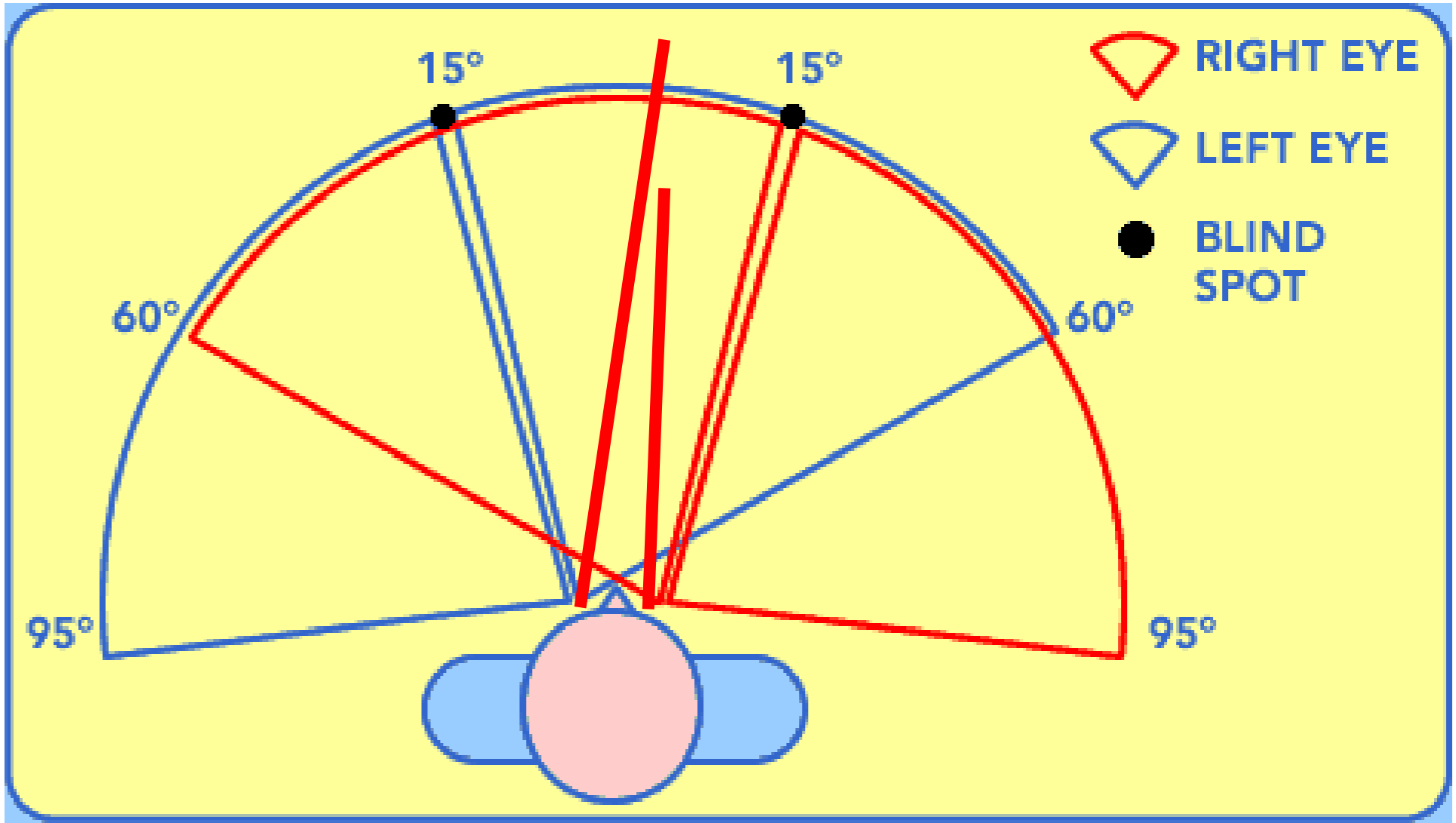
- Phoria. If or how well the eyes line up.
  - Extra ocular muscles move the eyes left, right, up and down.
- Phorias impact patients post mTBI. Difficulties associated with a phoria deficiency can be difficulty reading, school work, headache, fatigue and difficulty with memory.
- If the eyes are not matching up, the brain tries to reconcile the difference.
- Exercising the eye muscles can be performed to aid in recovery.
  - This falls into; feel better and get better exercises.

UNIVERSITY OF Cincinnati

Zero phoria, eyes straight and level; Called Ortho.



Eso-phoria, one or both eyes turned in. Over ADDucting of left eye shown.



Phorias can be measured using a phoroptor

- The phoroptor on the left is big and bulky and used by many eye care professionals.
- The risley prism on the right is compact and inexpensive and can be used as a quick assessment for visual phoria diagnostics.
- Both have a strong medical history with established norms.
- Rehab can be done with eye exercise or even using the phoroptor.

UNIVERSITY OF Cincinnati

Central and Peripheral Vision Reaction Times are Slowed Post Concussion

Fatigue and fog post concussion has been described as being like going from a high-definition TV to a standard TV, or that that the patients feel one step behind themselves.

Those two metaphors; visual loss of fidelity and temporal delay are telling. It implies a visual dysfunction as well as a change in timing or the perception of time. We have found that these two phenomena may be present in concussion patients.

Traditional reaction time measures have been performed and found to be impacted post concussion, but peripheral vision.

We have methods for training and quantifying central and peripheral visual field reaction times. These were validated using healthy subjects and then applied to concussion patients.

These work on both get better and feel better.

UNIVERSITY OF Cincinnati

Clark, J. F. J. K. Ellis, T. M. Burns, J. M. Childress, J. G. Divine**. Central and Peripheral Vision Reaction Times are Prolonged Post Concussion.** Clinical Journal of Sports Medicine.

Objective and Methods

23 consecutive concussion patients, 11 males & 12 females, compared to 30 controls, with vision issues.
Measured central visual reaction time compared to the visual reaction time in the periphery (≈ 45° off center)
Visual reaction times were assessed using the Dynavision D2 light board (Westchester Ohio).

UNIVERSITY OF Cincinnati

Results of some of our data

Non-Concussion Subjects

Central 0.29 ± 0.04 s

16.3%* Slower

Peripheral 0.34 ± 0.05 s

Concussion Subjects

Central 0.36 ± 0.12 s

36.0%* Slower

Peripheral 0.48 ± 0.15 s

* Significantly different ($p<0.001$)

The average age was 30.2 ± 15.2.

UNIVERSITY OF Cincinnati

Reaction Time Discussion

We believe that a 0.48 second delay in sensory information from the visual system may cause or contribute to fog perceived by concussion patients.

It is quite possible that a sensory and or processing mismatch could lead to the perception of fog, which might be useful as a diagnostic for assessing concussion.

Because we measured the central vs peripheral vision reaction times and found that the fall in peripheral reaction time was greater in concussion patients this test could be used as an objective biomarker on concussion patients.

The left right asymmetry could be involved in vestibular and balance issues.

More work is needed on a prospective study.

UNIVERSITY OF Cincinnati

Neuro plasticity and rehab post mTBI

- Brain training with other rehabilitation methods.
  - Vision training plus brain training
  - Physical conditioning plus brain training
  - Balance training plus brain training
  - Balance training plus vision training
- To follow are a smattering of modalities we use to stimulate brain plasticity in the mTBI patient.

UNIVERSITY OF Cincinnati

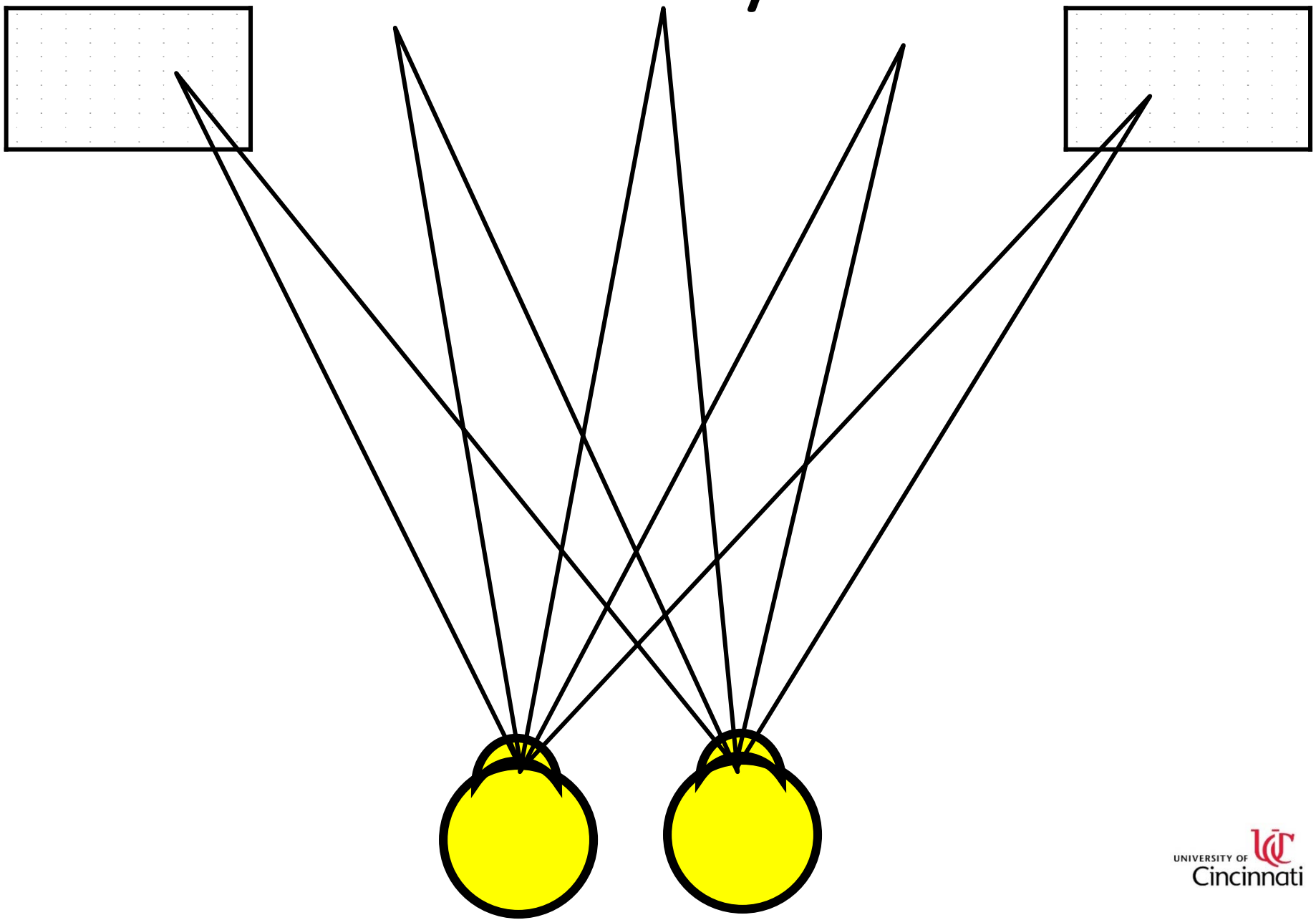
Brain Training and Saccades

- Saccades are great. But how do you add brain training?
- Scanning is great but your brain needs to take in that info.

N	S	T	P	C	X	N	O	G	N
N	D	A	R	E	N	U	G	E	C
B	U	S	D	H	N	O	N	O	K
A	B	T	X	S	E	C	C	E	P
K	C	O	C	O	R	E	H	Y	P
D	D	A	L	A	W	T	M	L	I
R	O	I	Y	I	U	S	S	T	O
C	B	A	R	D	Q	S	R	U	K
I	A	I	N	S	L	U	F	E	S
N	T	N	E	G	E	E	I	4	D

UNIVERSITY OF Cincinnati

Saccades – saccadic eye movement



UNIVERSITY OF Cincinnati

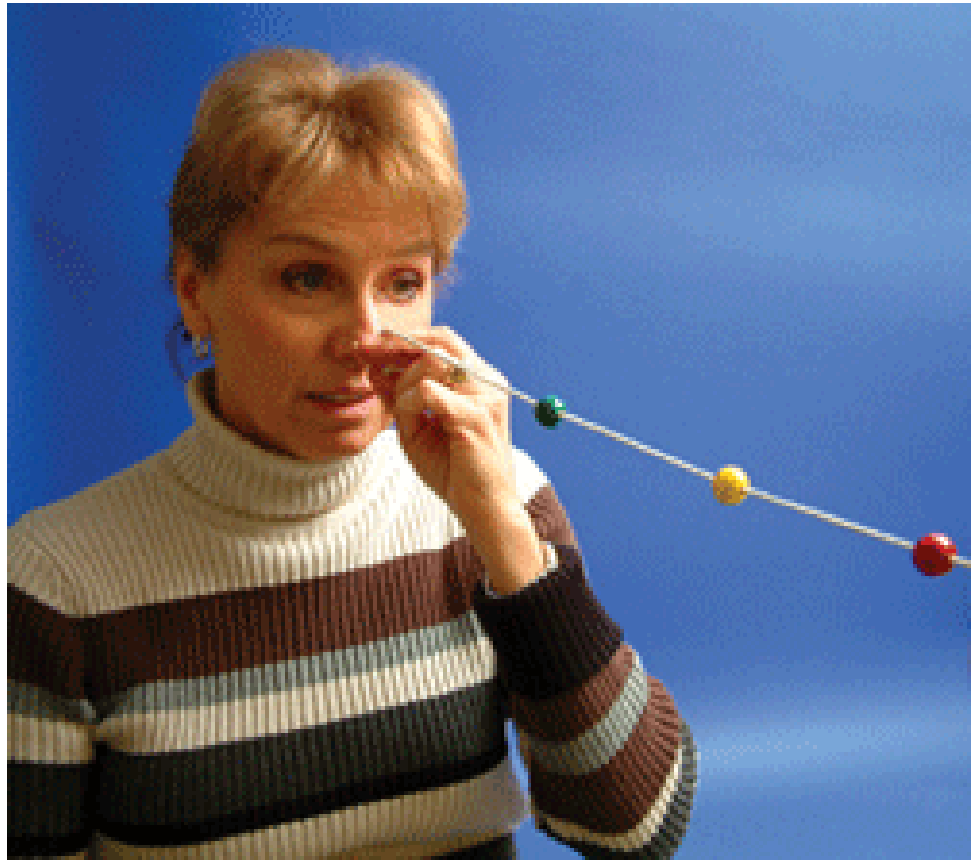
Word finding saccades

N	S	T	P	C	X	N	O	G	N
N	D	A	R	E	N	U	G	E	C
B	U	S	D	H	N	O	N	O	K
A	B	T	X	S	E	C	C	E	P
K	C	O	C	O	R	E	H	Y	P
D	D	A	L	A	W	T	M	L	I
R	O	I	Y	I	U	S	S	T	O
C	B	A	R	D	Q	S	R	U	K
I	A	I	N	S	L	U	F	E	S
N	T	N	E	G	E	E	I	4	D

I	O	R	A	Z	E	E	R	R	O
E	I	N	A	C	O	R	A	C	O
L	M	I	O	O	Z	S	I	V	E
C	A	I	I	L	B	I	C	R	E
8	K	N	A	V	A	N	E	P	S
I	O	N	L	K	N	I	I	O	R
E	R	M	O	A	V	T	T	Q	C
T	E	T	A	E	G	R	Y	E	S
O	S	O	G	I	E	L	A	N	O
S	3	S	7	N	M	?	L	U	A

UNIVERSITY OF Cincinnati

How to assess vs separate near / far suppression?



- Brock string for convergence and ocular motor training. The subject is instructed to hold the 10ft string to his or her nose and to focus on each of the 5 beads one at a time before moving on to the next bead.
- Reproduced from www.bernell.com

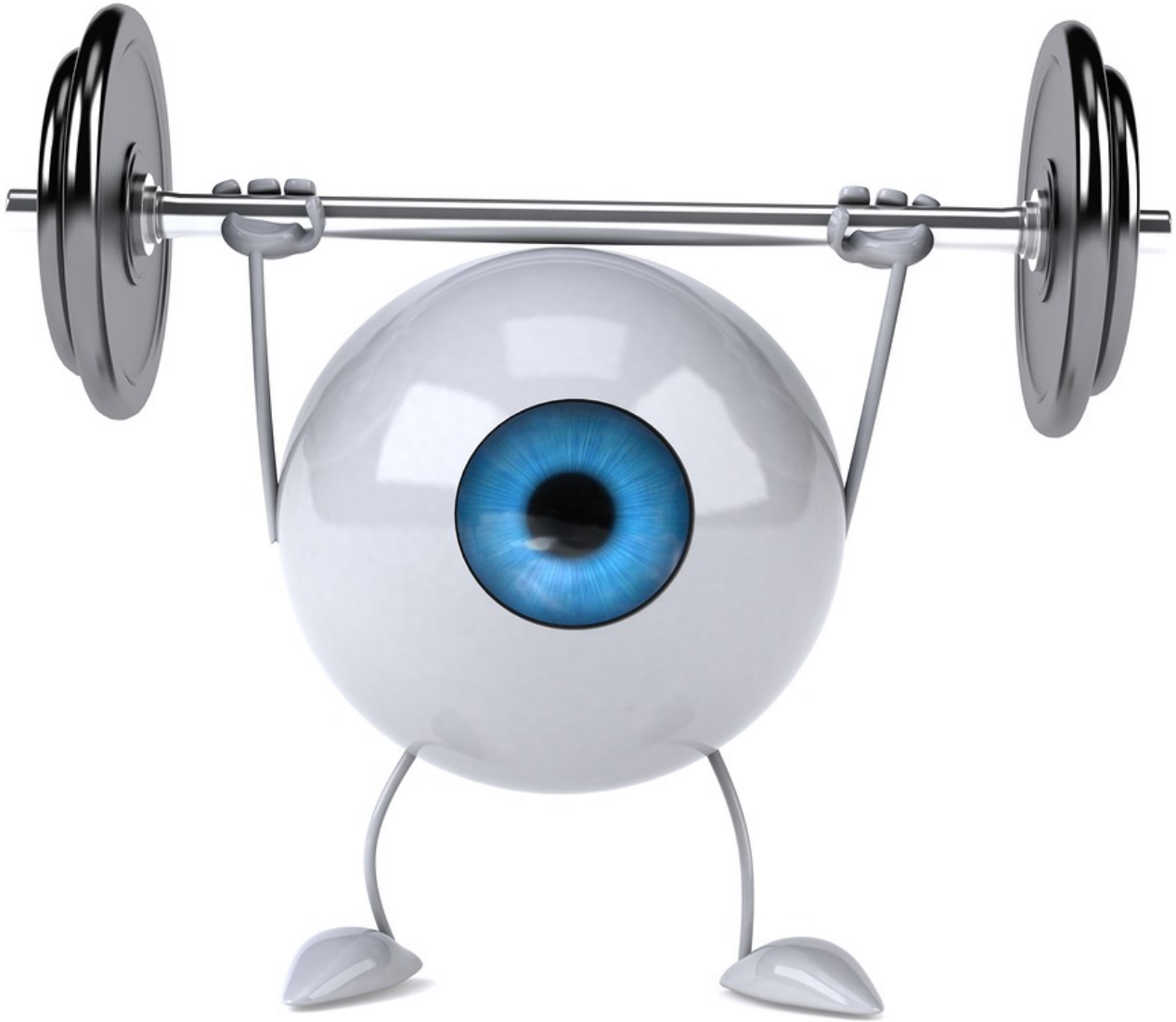
- The subjects should see something like the above image when both eyes are working together.
- Reproduced from; http://visionhelp.wordpress.com/robyns-rules-for-visual-disorder-8-guiding-principles-for-parents/

Thumb Thing for Distance Suppression

UNIVERSITY OF Cincinnati

Exercise Escalation (ocular motor pillars above)

- Frequency (How Many Reps)
- Duration (How Long)
- Range (How Far)
- Speed (How Fast)
- Multi tasking
- Left eye, Right eye, Both eyes
- Brain / cognitive overlay (3rd Pillar)



For this exercise, watch the screen to see the picture flashed on the screen. Find and write down the number seen in the picture. You will have a few seconds to write this. Then the picture will show again for a few seconds – mark down and keep track of your score. Next the screen will say ready, watch carefully for the flashed picture and repeat until told to stop or finished. Press space once to start. Hit space at any time to advance to the next slide.

READY

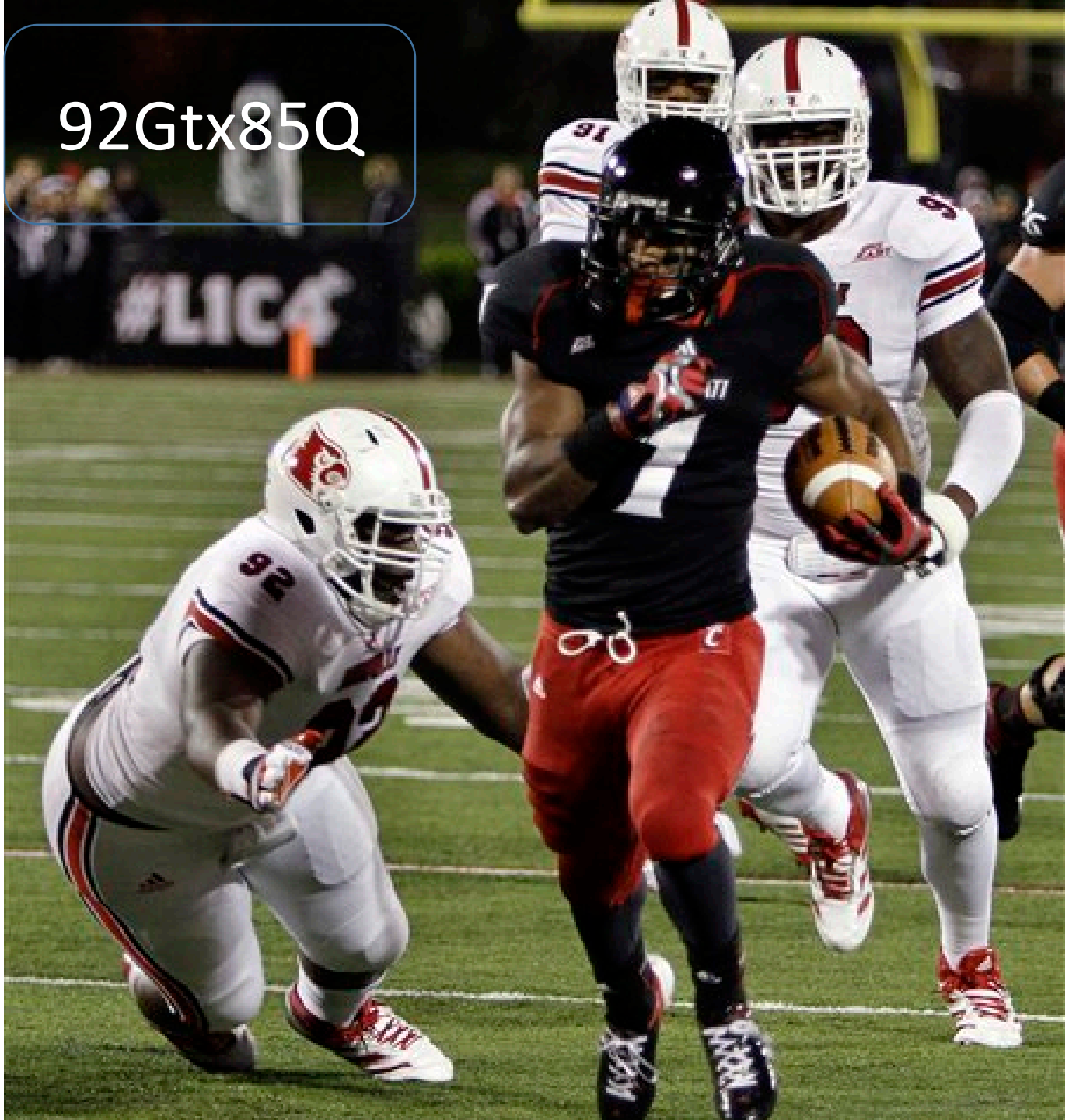

1234

1234

What is the number of the player on the left?

READY

92Gtx85Q



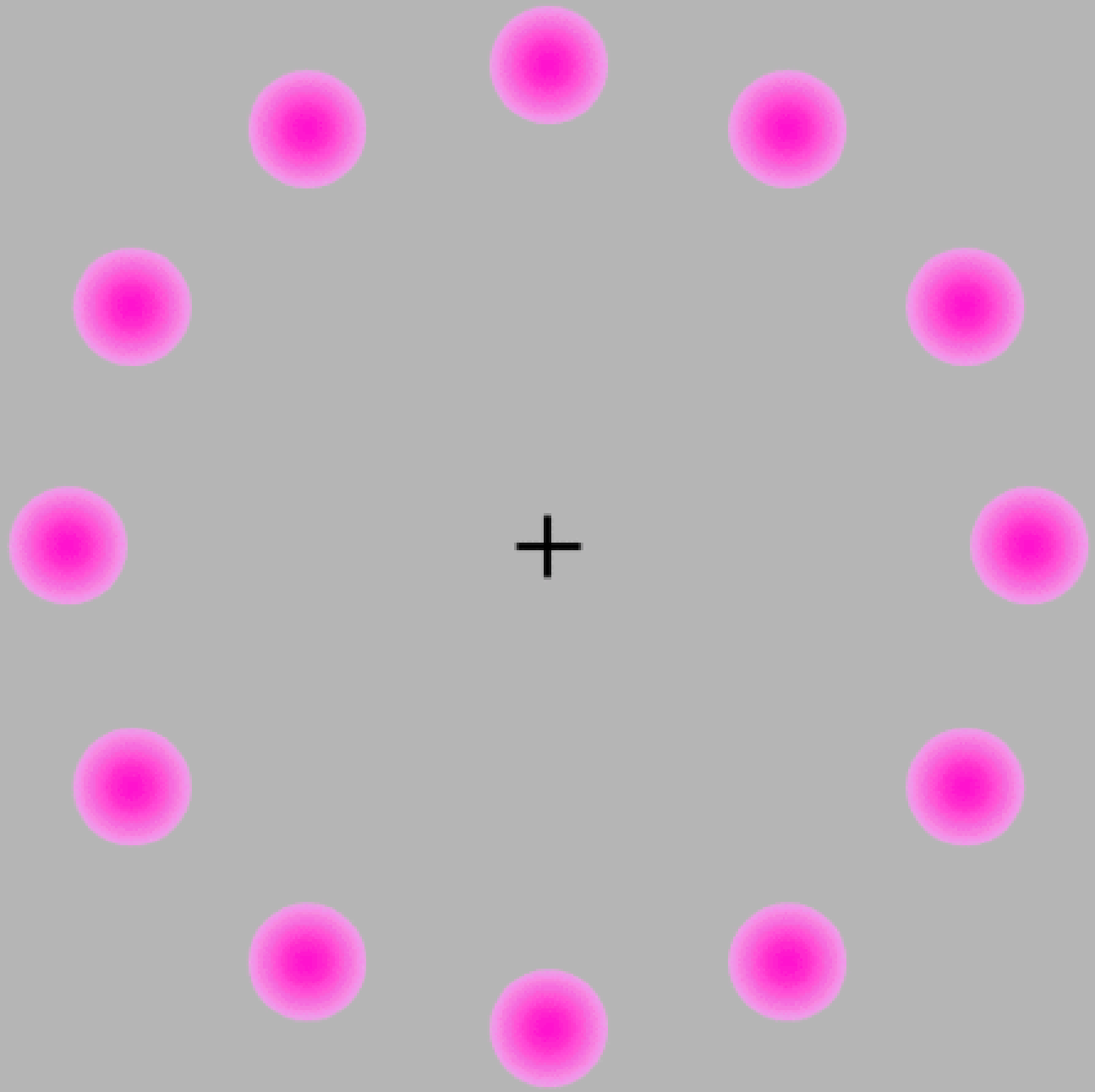
92Gtx85Q

Where is the ball?

Name two player numbers.

Eye Discipline ™ with Retinal Retention Training

UNIVERSITY OF Cincinnati

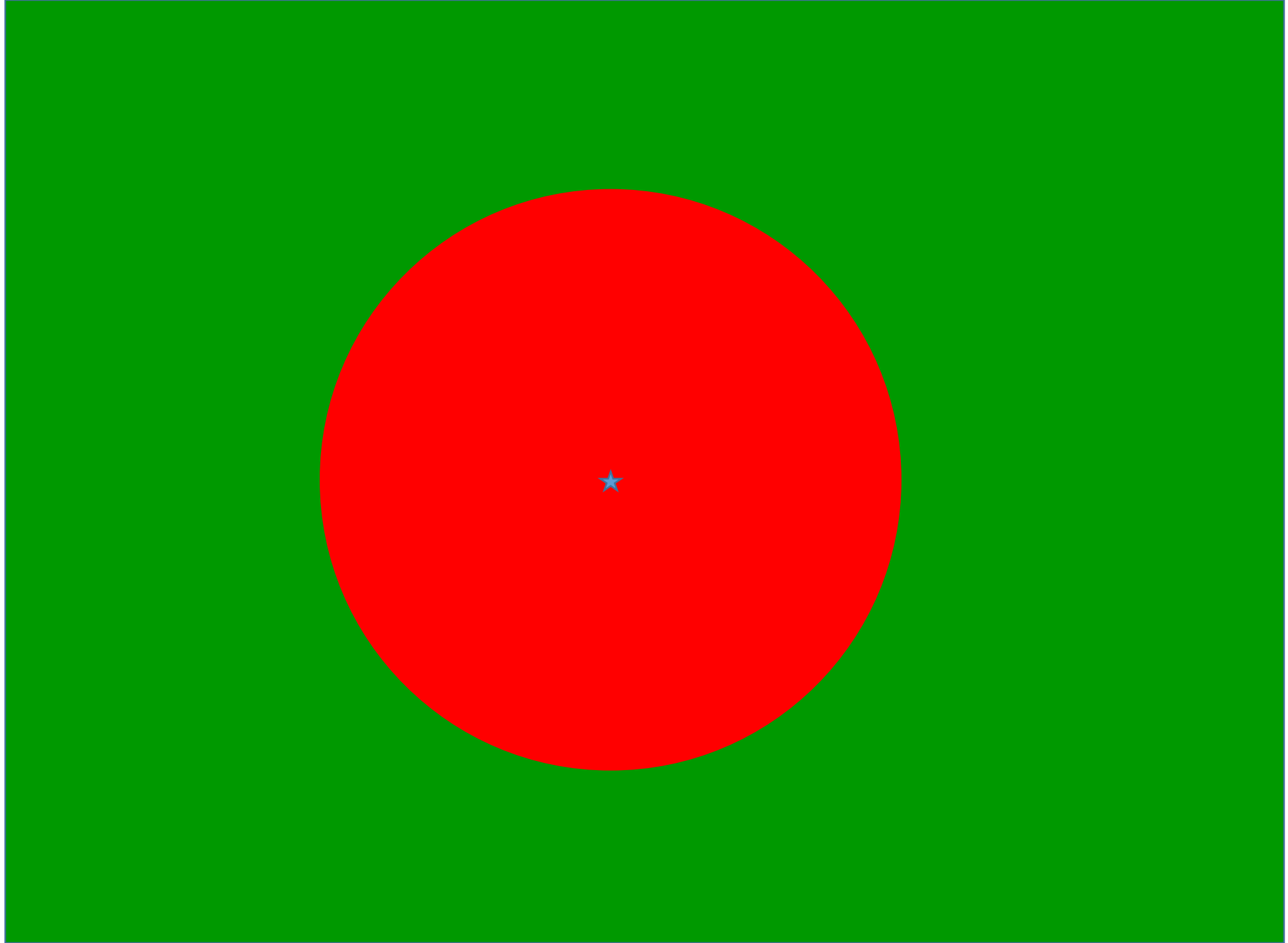


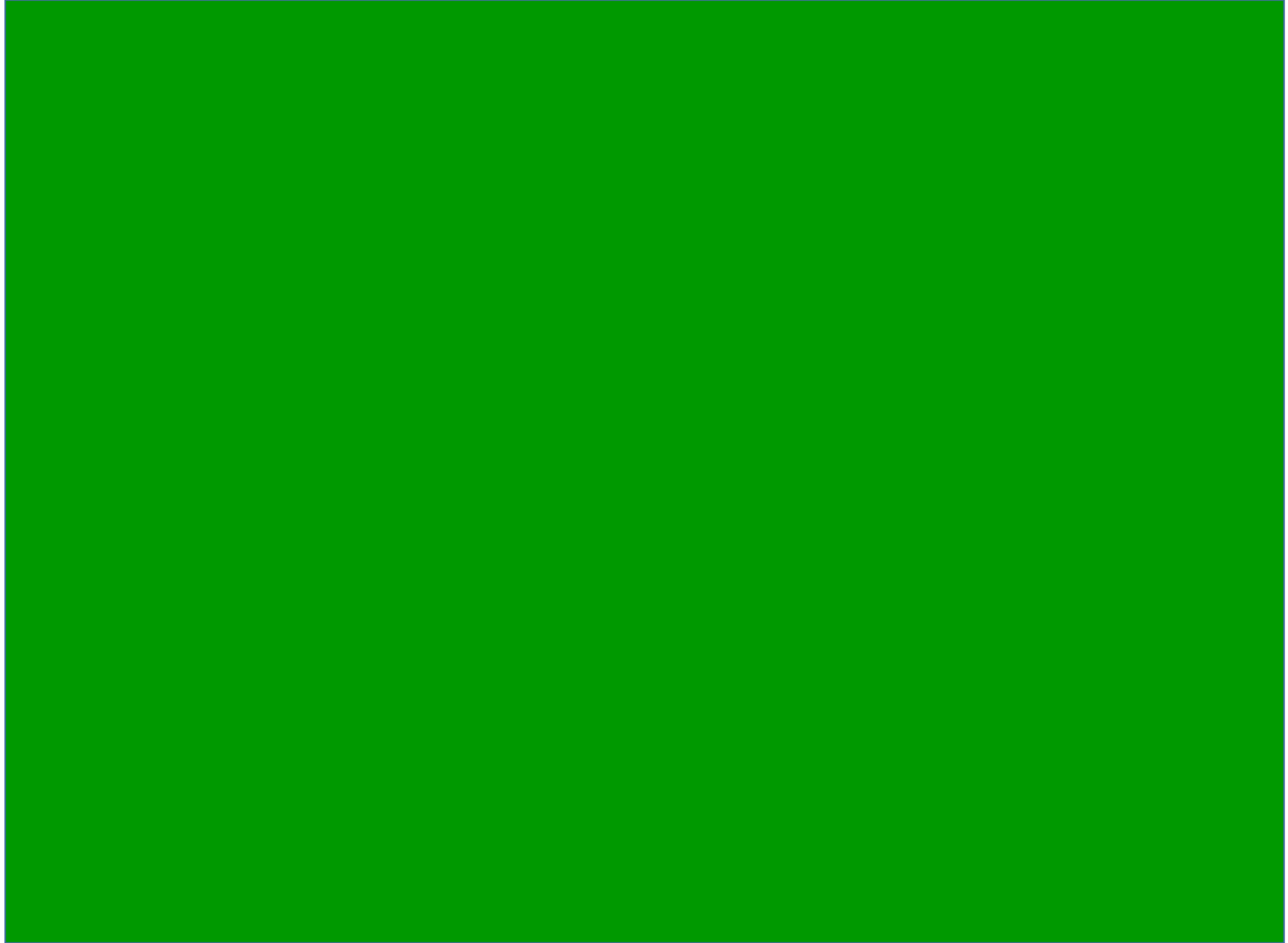
UNIVERSITY OF Cincinnati

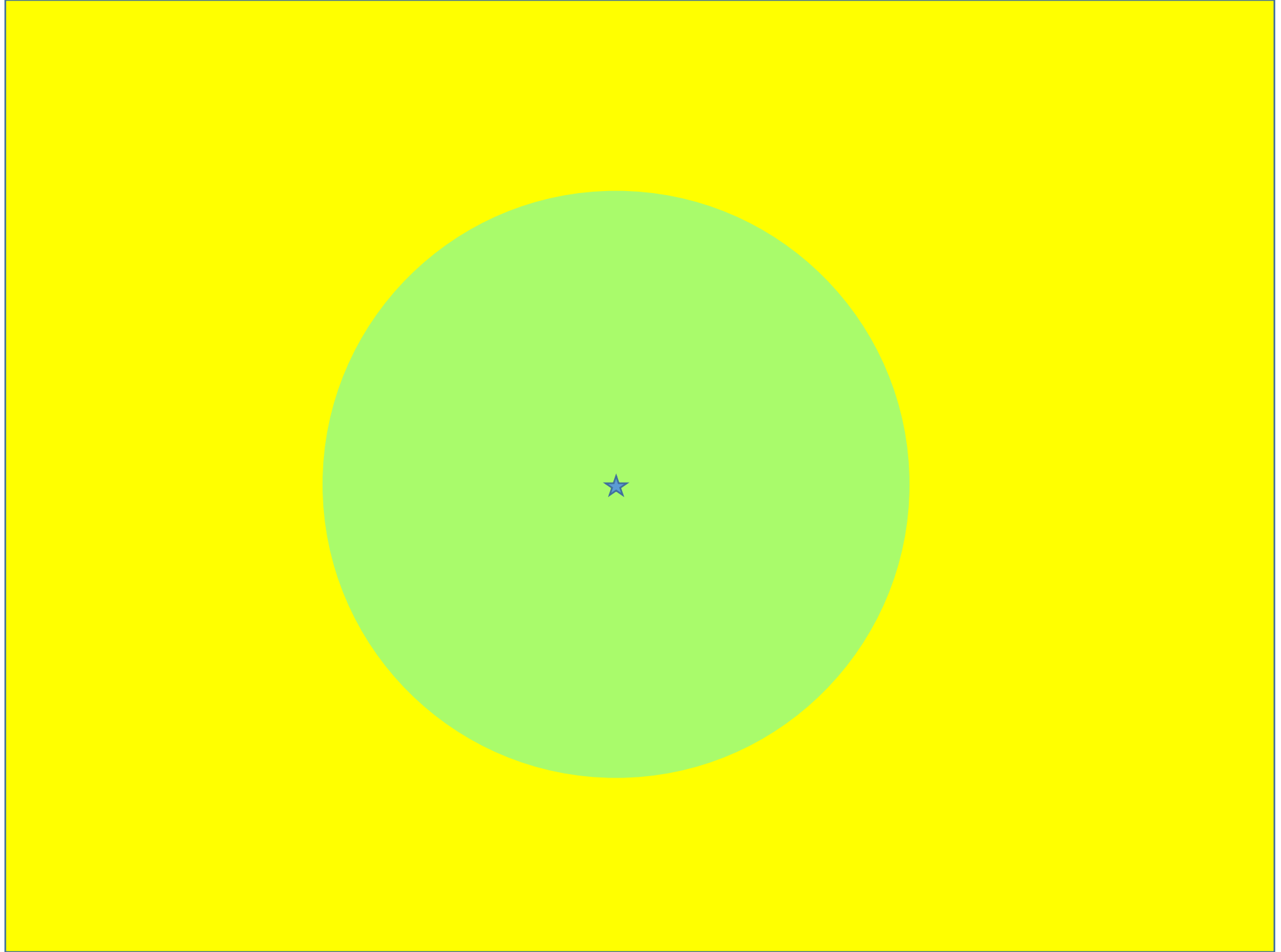
Instructions for Eye Discipline ™.

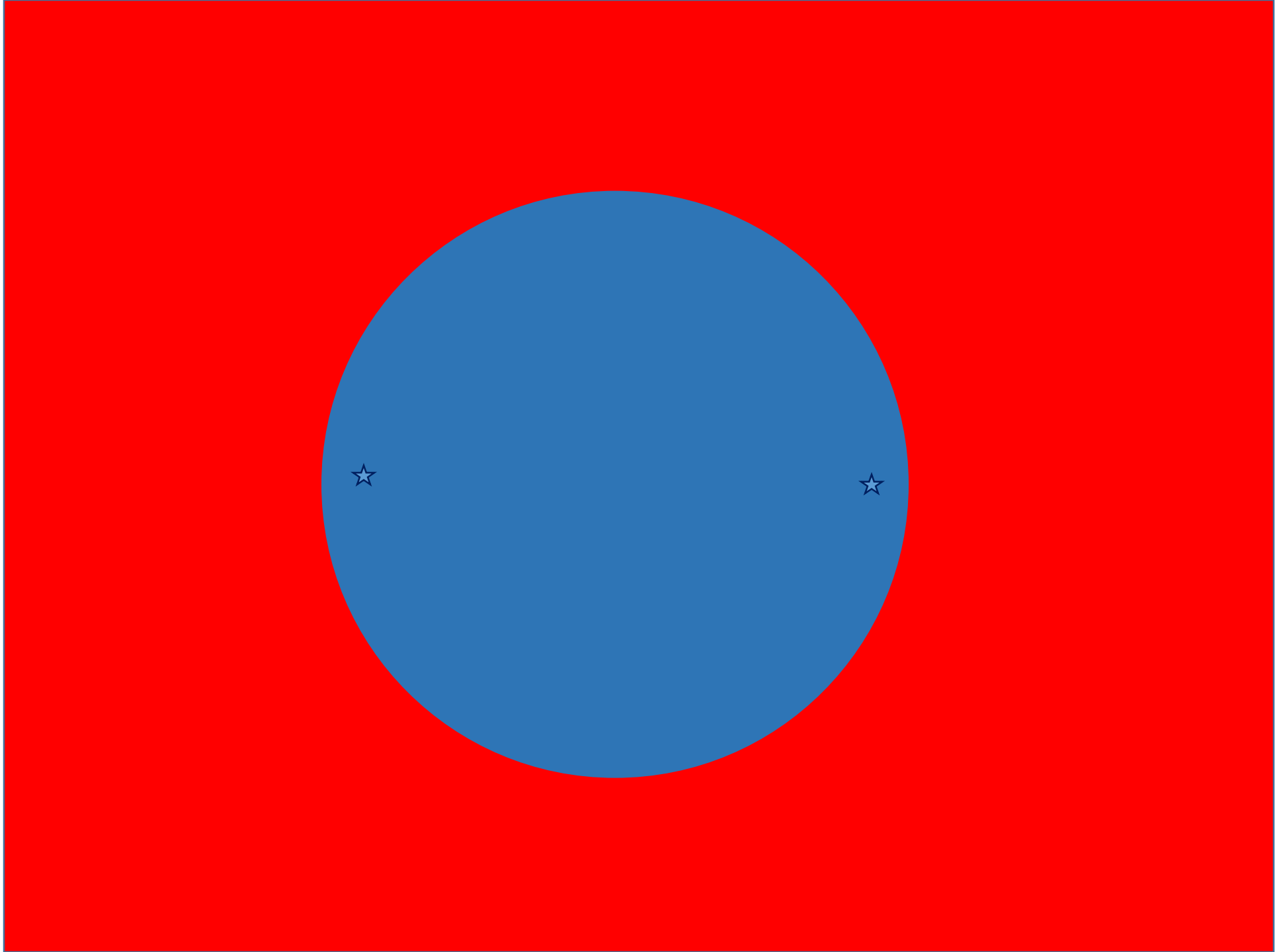
- **Stare at the image using slide show mode.**
- **Stare at one spot for 10 seconds.**
- **Page down and DO NOT move your head or eyes.**
- **Make a mental note of the after image observed.**
- **Plus this progresses to peripheral vision.**

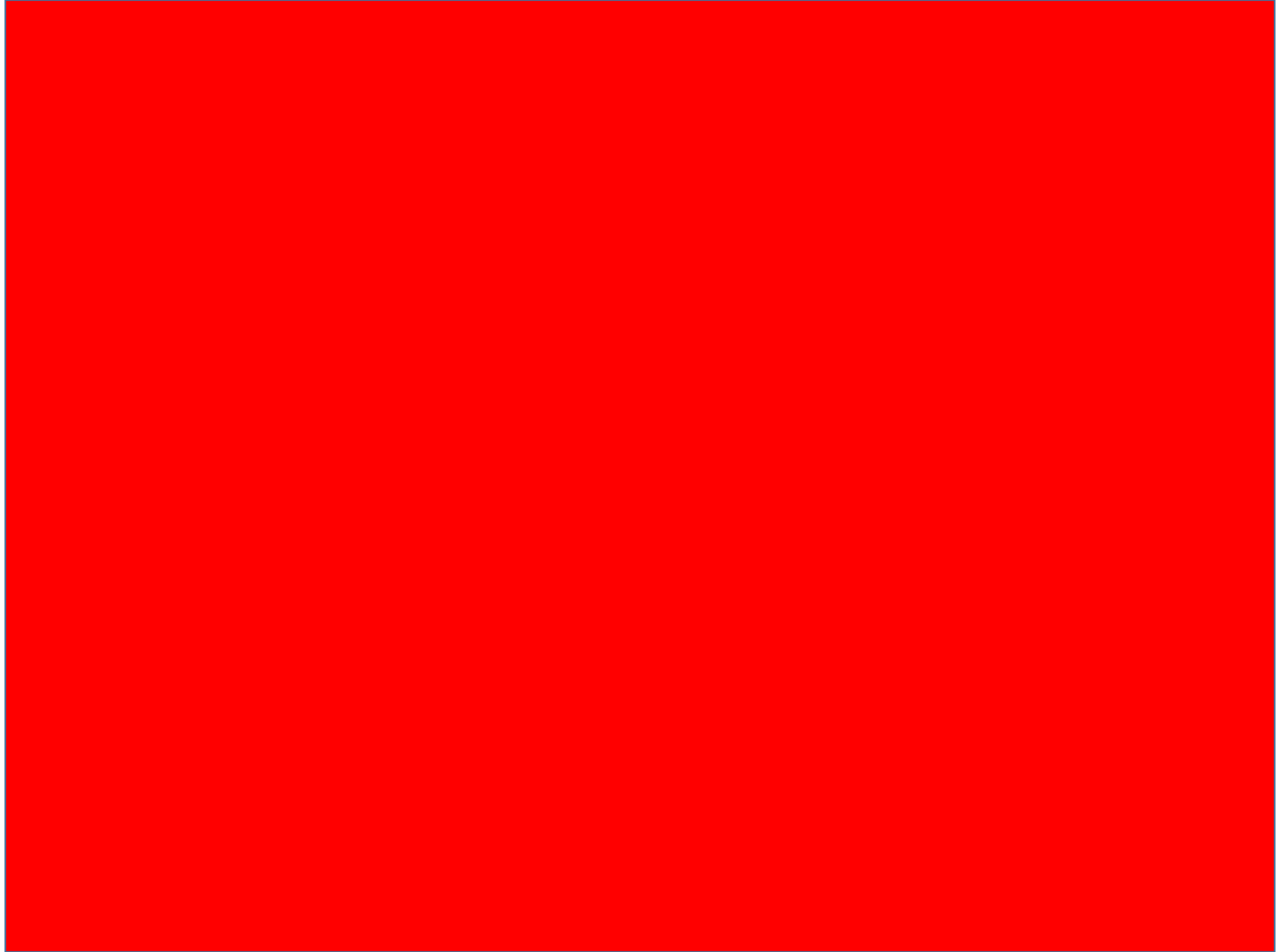
UNIVERSITY OF Cincinnati



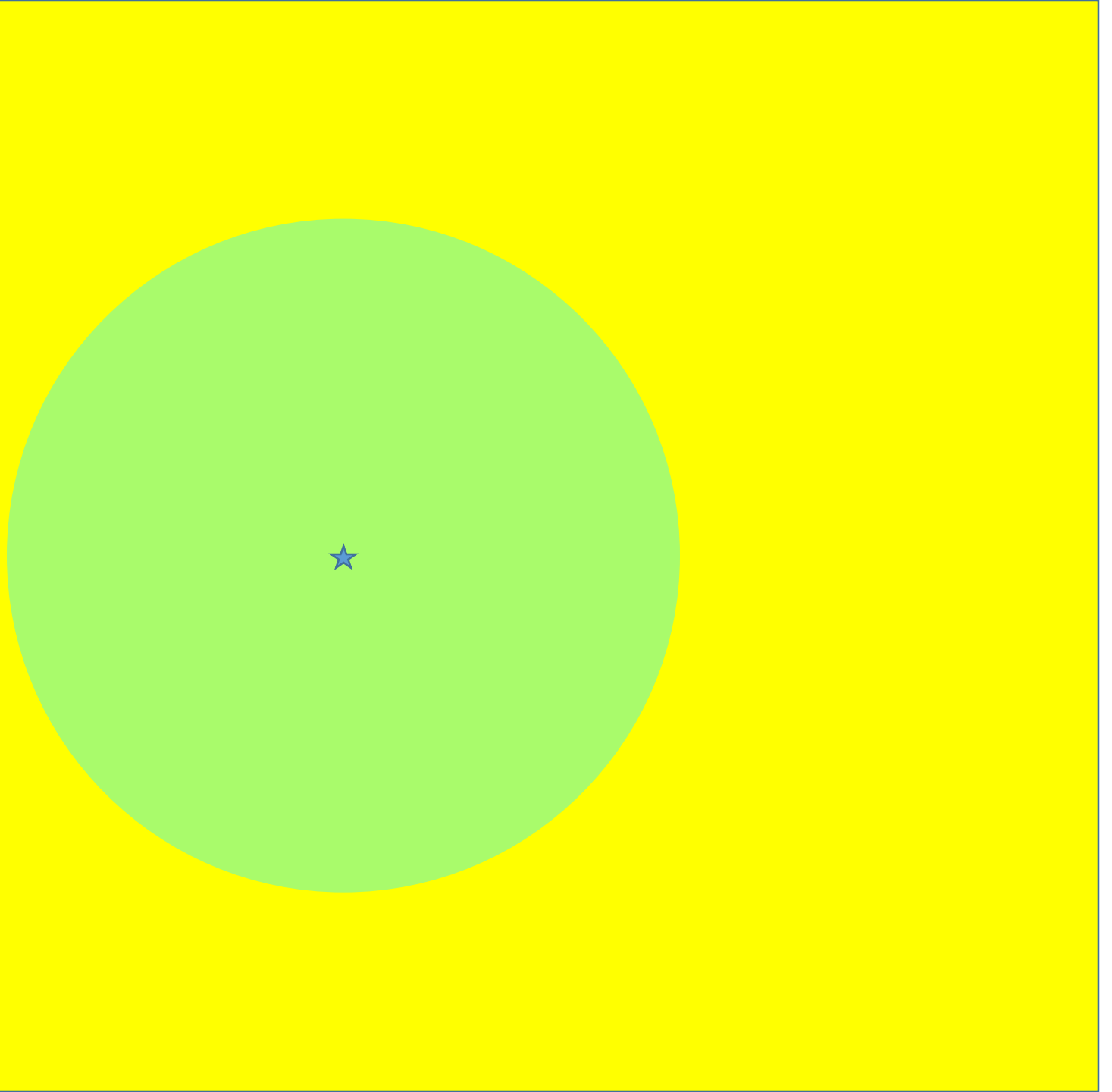


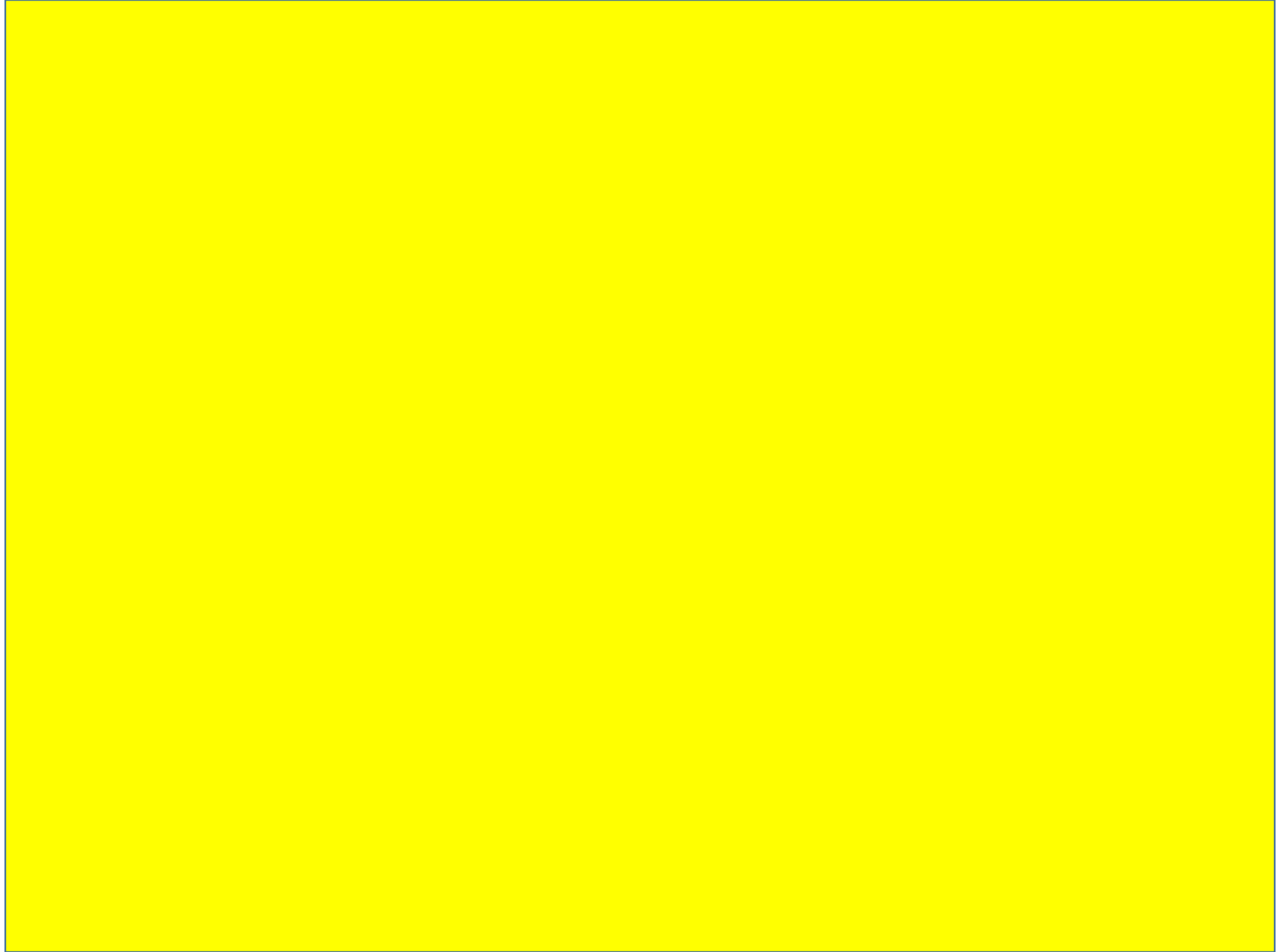


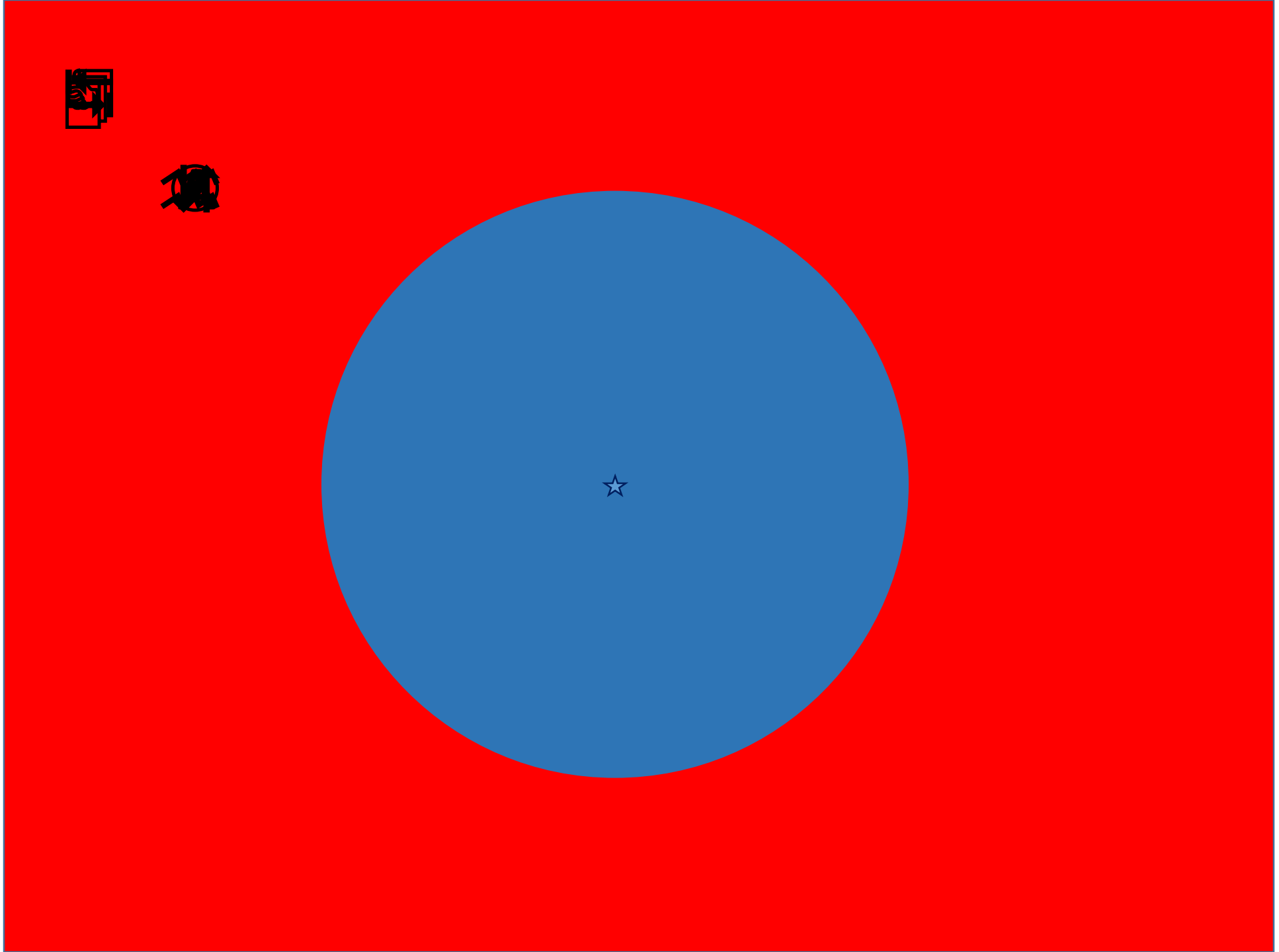


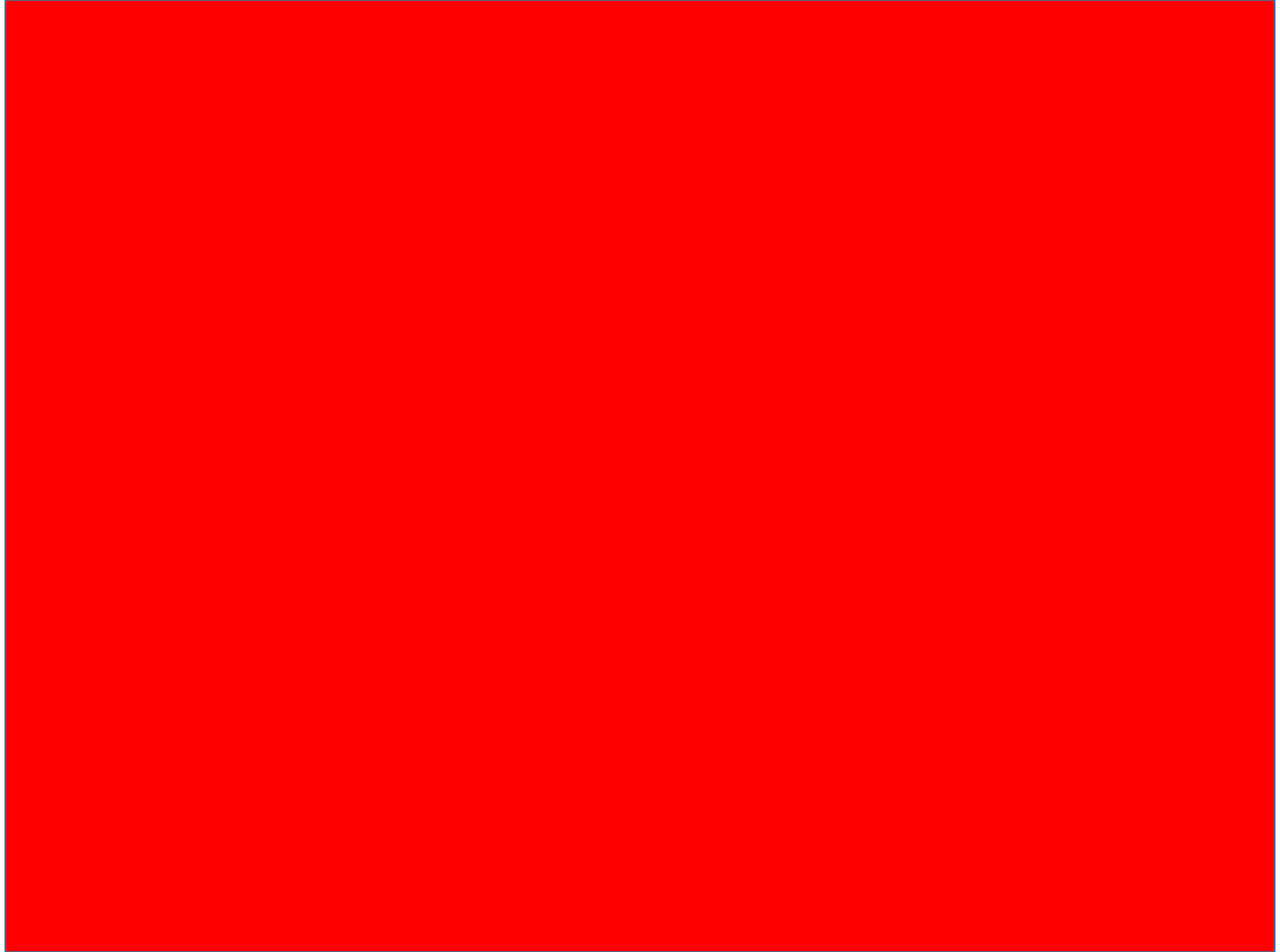


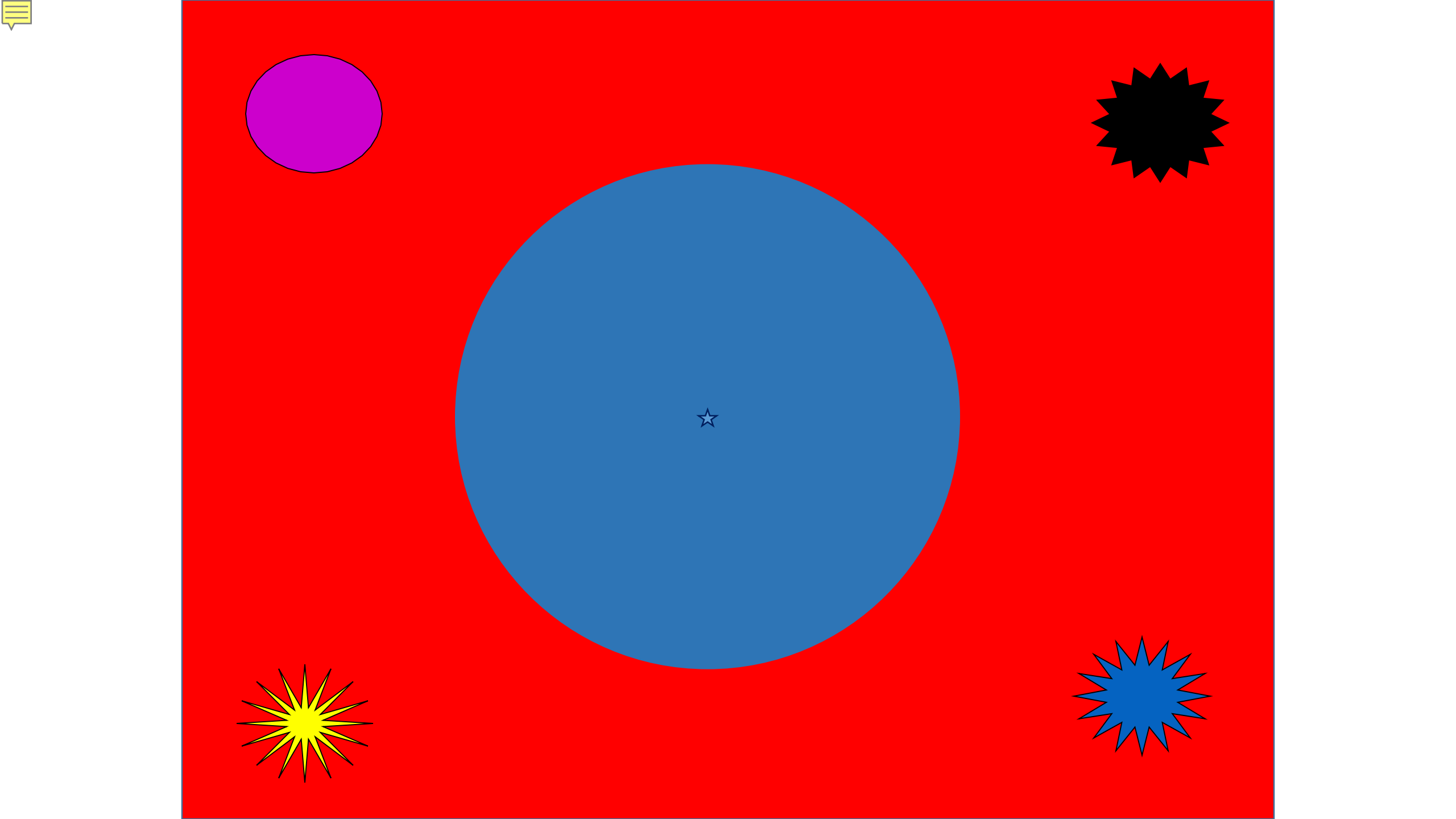
B

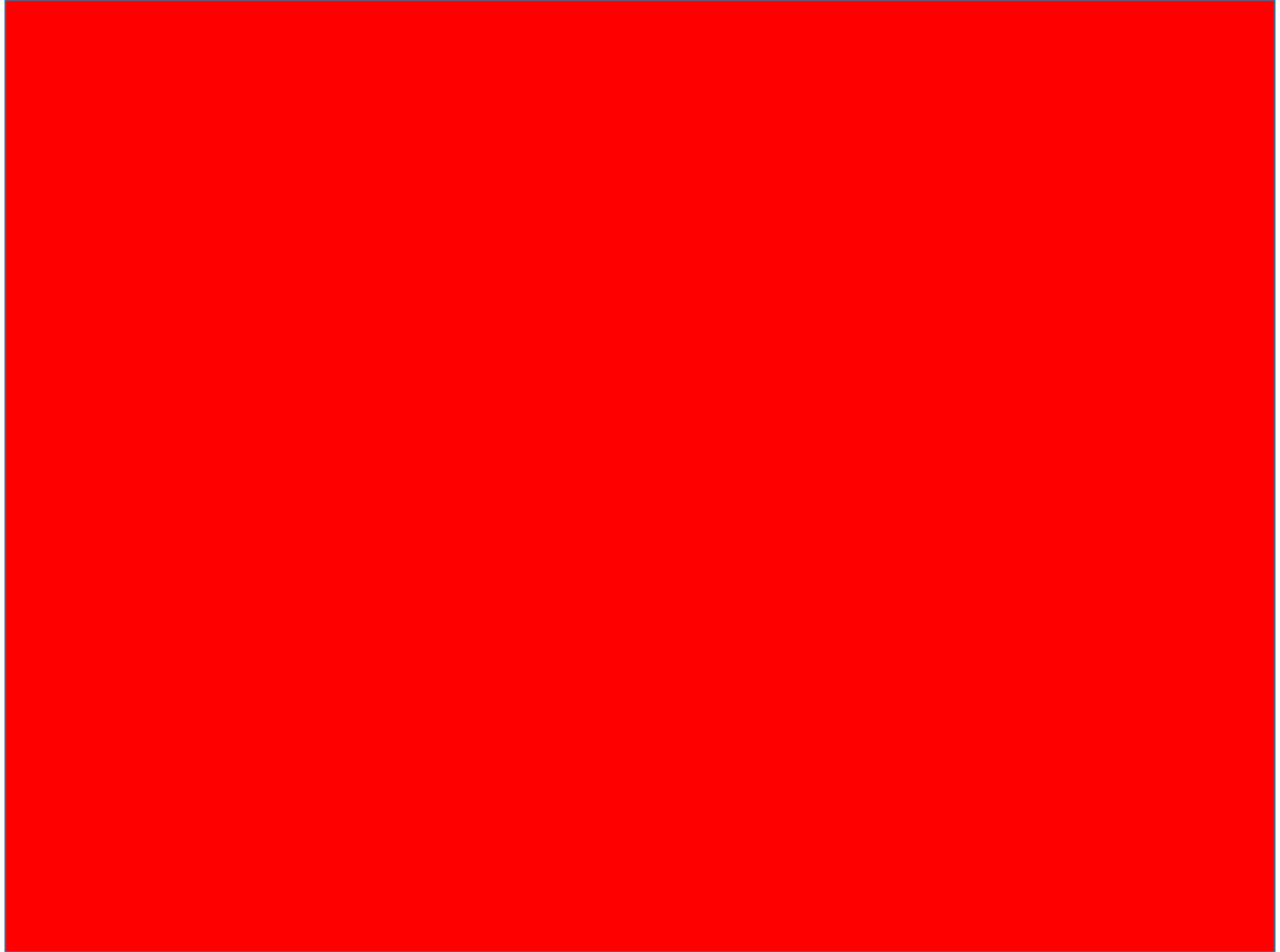


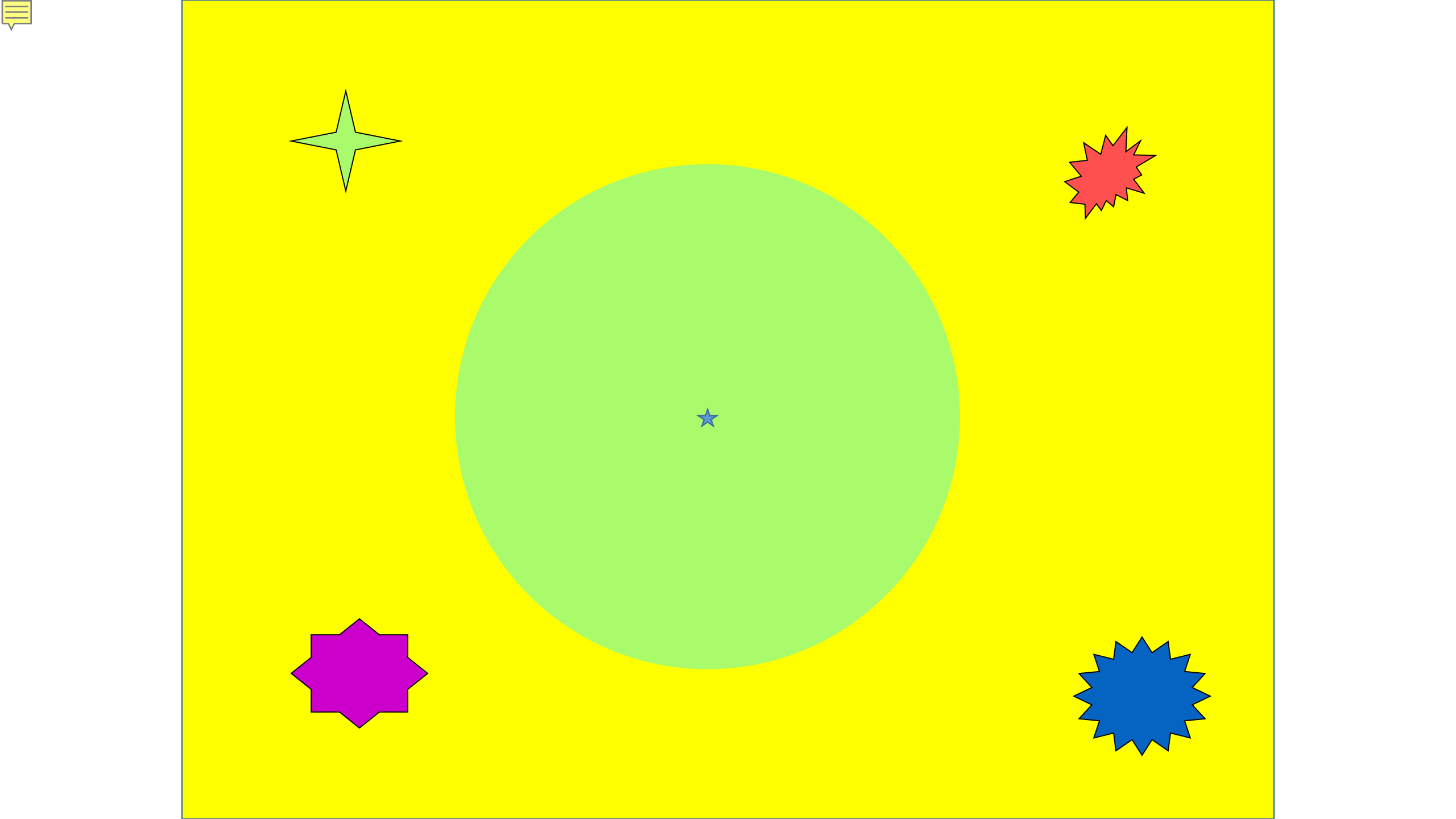












Overall Conclusions

- There are diagnostic methods that have quantitative numbers as well as FDA record for their use.
- Many of the above methods can be used for management as well as rehab.
- Exercise as a cornerstone of rehab and methods to assess exertion levels.
- Brain training; Eye discipline, Tachistoscope, memory, multitasking.
- There is a critical need for constant communication between the rehab specialist and the management team.

UNIVERSITY OF Cincinnati


CONCUSSION
THANK
CREW
YOU

References

- Clark JF, Colosimo A, Ellis JK, Mangine R, Bixenmann B, Hasselfeld K, Graman P, Elgendy H, Myer G, Divine J. Vision training methods for sports concussion mitigation and management. J Vis Exp. 2015 May 5;(99). doi: 10.3791/52648. PubMed PMID: 25992878.
- Kauffman DC, Clark JF, Smith JC. The influence of sport goggles on visual target detection in female intercollegiate athletes. J Sports Sci. 2014 Dec 24:1-7. [Epub ahead of print] PubMed PMID: 25537065
- Bixenmann B, Bigsby K, Hasselfeld KA, Khoury J, Mangine RE, Pyne-Geithman GJ and Clark JF (2014) Retinal and Balance Changes Based on Concussion History: A Study of Division 1 Football Players. Int J Phys Med Rehabil 2: 234. doi:10.4172/2329-9096.1000234
- K. Bigsby, J. F. Clark, B. Bixenmann, J. T. Rauch, A. W. Susaret, A. J. Colosimo, R. E. Mangine. Effects of Postural Control Manipulation on Visuomotor Training Performance: Comparative Data in Healthy Athletes. Published International Journal of Sports PT. 2014. 9; 436-446
- J. F. Clark, A. Middendorf, K. A. Hasselfeld, J. K. Ellis, J. Divine. Rehabilitation Pathway Targeting Concussion Symptoms: Illustration with A Case Study. Brain Disorders and Therapy. 2014, 3:4 (doi:10.4172/2168-975X.1000131)
- J. F. Clark, P. Graman, J. K. Ellis, R. E. Mangine, J. T. Rauch, B. Bixenmann, K.A. Hasselfeld, J. G. Divine, A. J. Colosimo, G. D. Myer An Exploratory Study of the Potential Effects of Vision Training on Concussion Incidence in Football. Optometry and Visual Performance. 3 116-125, 2015
- J F. Clark, P. Graman and J. K. Ellis. Possible Stereopsis Enhancement in Collegiate Baseball Players with Vision Training. Optometry and Visual Performance. 3, 106-115 , 2015
- J.F. Clark, J.K. Ellis, J. Bench, J. Khoury and P. Graman. High Performance Vision Training Improves Batting Statistics for University of Cincinnati Baseball Players. PLoS ONE (7)1: e29109, 2012, PMCID: PMC3261847.

UNIVERSITY OF Cincinnati

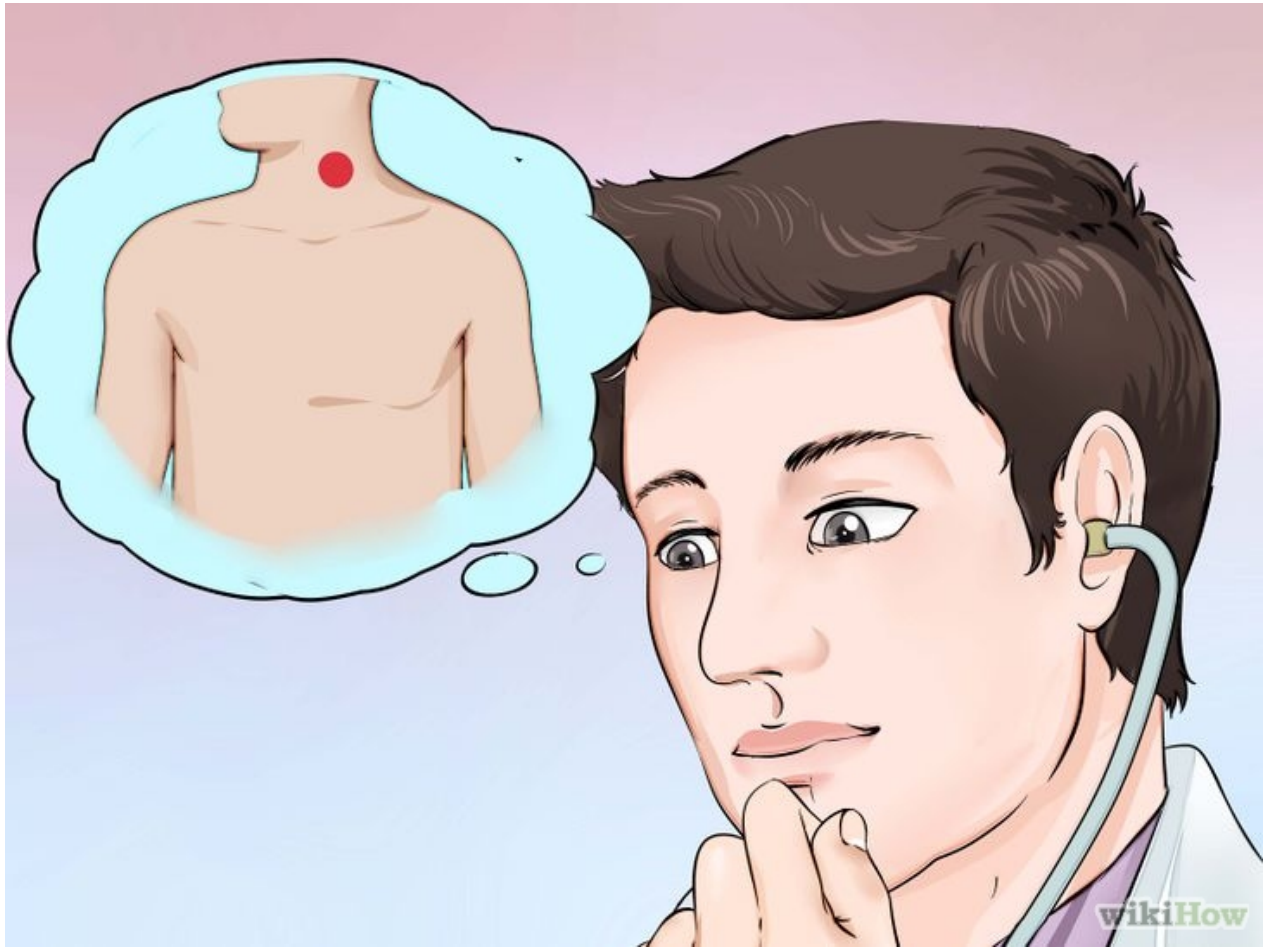
Summary of results for mTBI patients and frequency specific photophobia

28/37 73% had photophobia	22/26 85% with photophobia had relief with colored glasses
Green 10 Blue 7 Purple 5 Magenta 4 Red 4	Violet 3 Orange 2 Indigo 3 Rose 2 Aqua 1 Pink 1

UNIVERSITY OF Cincinnati

Exertion, exercise and return to play post mTBI

- Bruit. Bruit is often considered a cardiovascular/cerebrovascular pathology. But, flow murmur like bruit, occurs as a flow control mechanism for the brain.
- A flow murmur can be heard when the heart rate gets high during exercise.
- The murmur is heard at lower heart rates in the mTBI patient.



Clark JF, D N. Caudell-Stamper, S. W. Dailey, J. G. Divine. Can a Transient Exertion-Related Carotid (TERC) Murmur Heard During a Symptom-Limited Exercise Test Be Used as a Means for Managing Sports Concussion? Medical Hypothesis 93 (2016) 11–15

Bruit or TERC Murmur Methods

- Listen at both carotids for “bruit” at rest. Establish a lack of Bruit.
- Record heart rate.
- Have the subject start on an exercise bike and measure HR and monitor for “bruit” at either carotid.
- When noise is heard during exercise we call this **Transient Exertion-Related Carotid (TERC) Murmur,** to distinguish it from the pathological “bruit.”
- Correlate TERC Murmur to heart rate.
- A physician can set cardiovascular exercise limits based on heart rate from the TERC murmur test.

UNIVERSITY OF Cincinnati

TERC Murmur Results

- Eight subjects with diagnosed concussions had a TERC murmur heard at an average HR of **121.6 ± 12.6** bpm.
- Nine non-injured , age-matched subjects and with no history of concussion had a TERC murmur heard at significantly higher average HR of **149.6 ± 11.6** bpm. (p=0.0002 using an un-paired T test.)
- We have successfully used the TERC murmur as a means to limit exertion (keep heart rate below the Murmur rate) and as a means to demonstrate safe to return to play/exertion.
- Monitor for other symptoms as well as ensure the person is otherwise appropriately fit to exercise.
- Athletes who want to be able to exercise can be depressed when sedate. Enabling safe exercise helps their recovery.

UNIVERSITY OF Cincinnati

Males were 4 times more likely to have their eyes open when heading the soccer ball. 22% of males and 5% of females had their eyes open during headers.

Clark et al., 2017)

Woman's Soccer Results.

Pre and post vision training team record:
2013; 8-11-1, 2012; 4-13-1, 2011; 6-9-4 2010; 8-10-2 pre VT. 26-43-8 record.
2017; 12-4-3, 2016; 11-5-4, 2015; 13-6-5, 2014; 10-8-2 with VT 46-23-14 record.
In 2015 woman's soccer won our division.
Women's Soccer (typically 4 concussion per year).
Now we average 0.5 concussions per year.
We used to average 1 medical DQ per season for concussion. We have had 1 since 2014.
Sustained GPA above 3.5.

UNIVERSITY OF Cincinnati