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Research on visual fatigue when playing games

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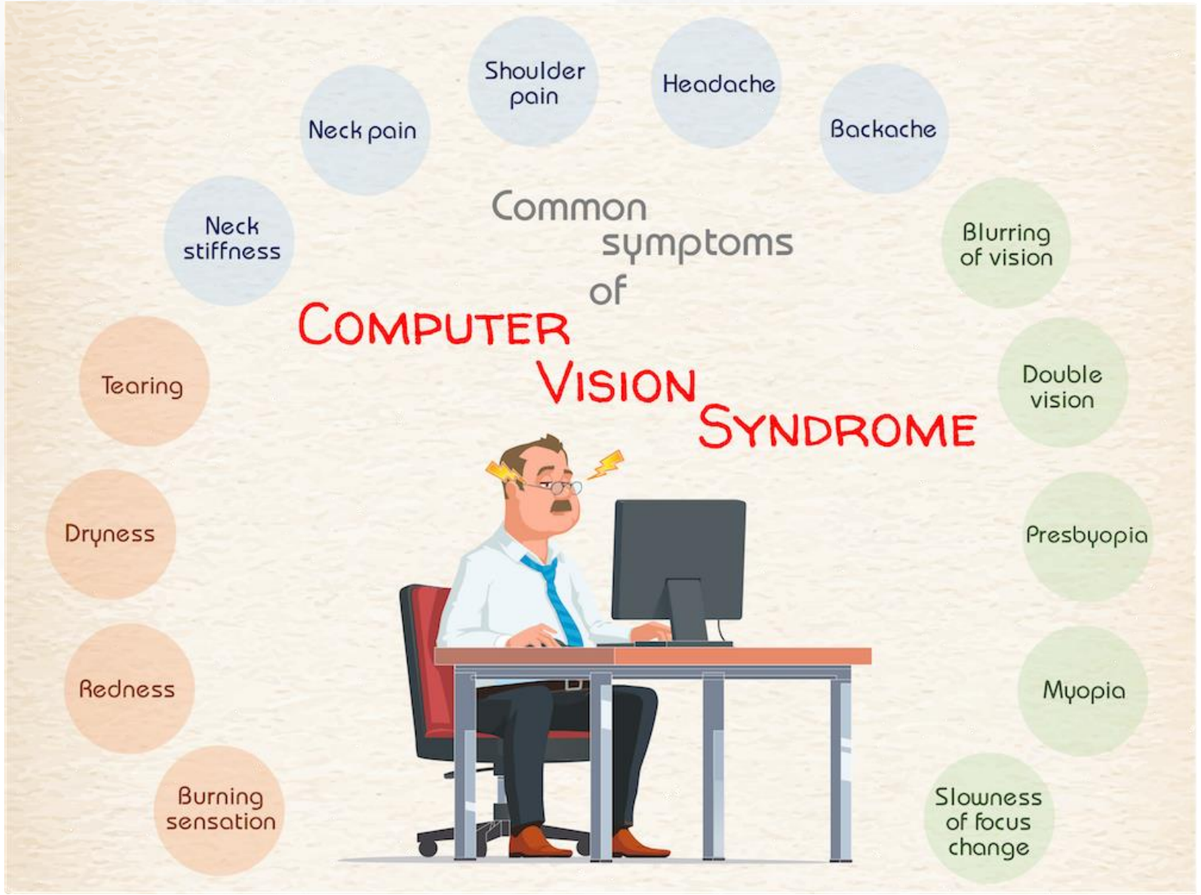
Content

- **Background**
  - Review of visual fatigue induced by screens
- **Experimental Studies**
  - We conducted two experiments to investigate visual fatigue when playing mobile games
- **Tips for Game Designers**
  - Some common cause of visual fatigue and how to detect and relief it

01

Background

Background



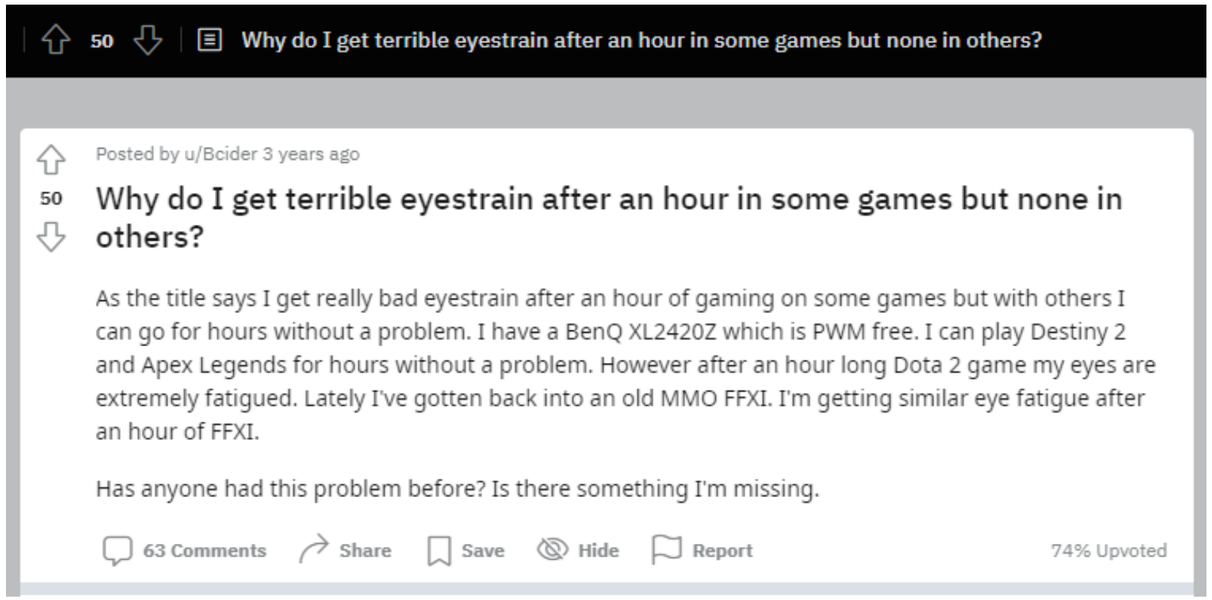
Using screens for long time might lead to a series of symptoms:

- Eyestrain
- Headache
- Blurred vision
- Dry eyes
- …

Background

Background

- We concern on players' experience and health when playing games:
  - Does visual fatigue caused by playing games different from other exposures?
  - Are there difference between games?
  - What can game designers do to avoid or relief visual fatigue?

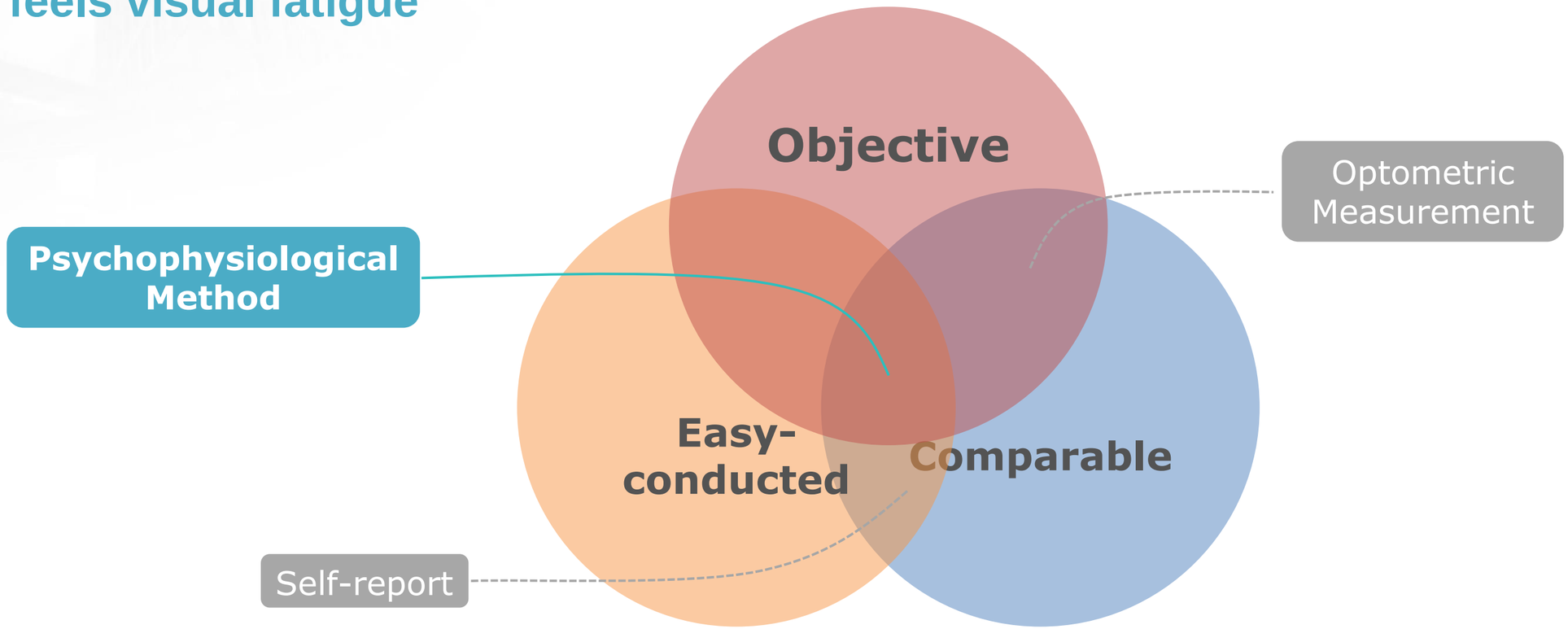


02

Experimental Studies

Study 1: Find an effective indicator

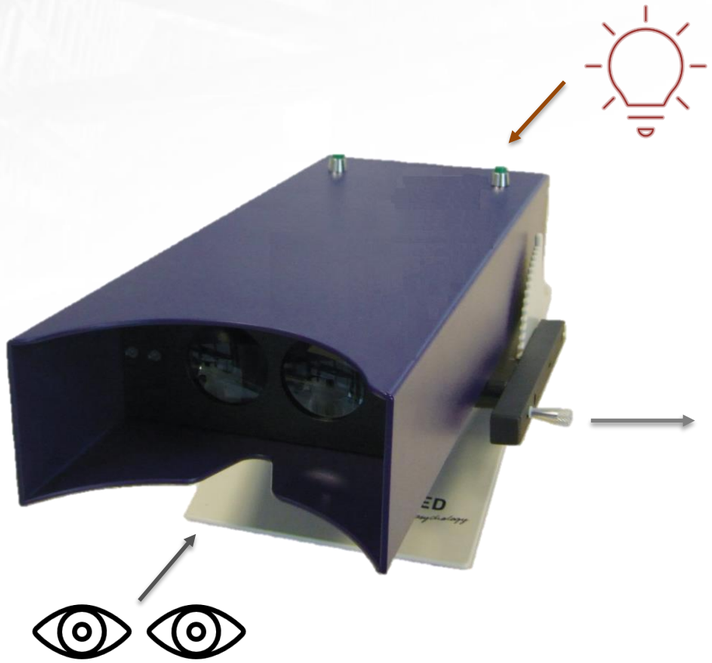
- An assessment tool or indicator to help designers knowing **whether or not, and to what extent players feels visual fatigue**
  - Objective
  - Easy-conducted
  - Comparable



Study 1: Psychophysiological methods

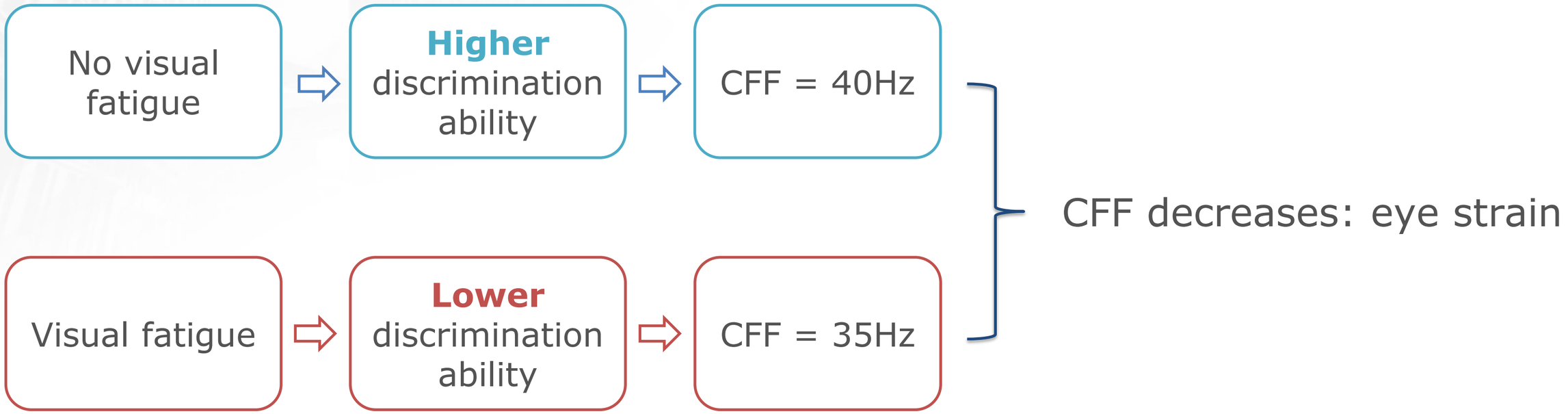
CFF: Temporal sensitivity

- **CFF** (Critical Flicker/Fusion Frequency) is the **transition point** for an intermittent light of increasing temporal frequency, where **the flickering ceases and the light is perceived as continuous**.



Adjust flashing frequency

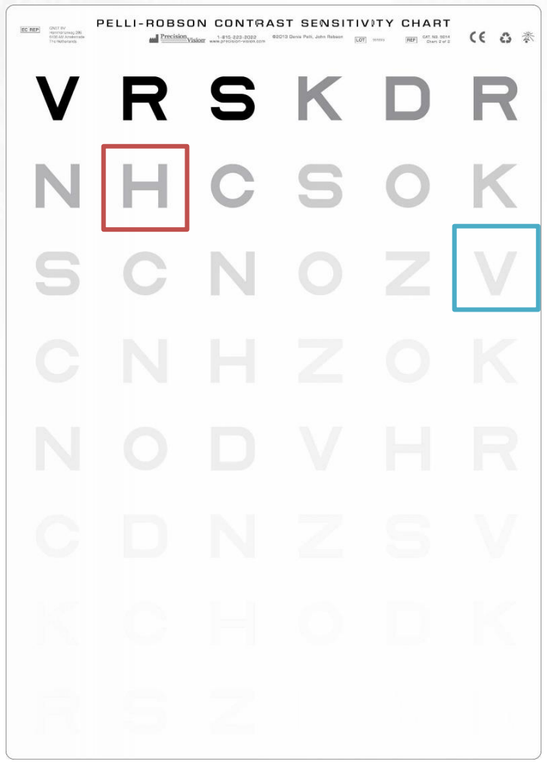
CFF: Why CFF works?



CFF: Critical Flicker/Fusion Frequency

Contrast sensitivity

- Another psychophysiological measurement is **Contrast Sensitivity** (CS), which is the ability to distinguish between an object and the background.



No visual fatigue → **Higher** discrimination ability → V

Visual fatigue → **Lower** discrimination ability → H

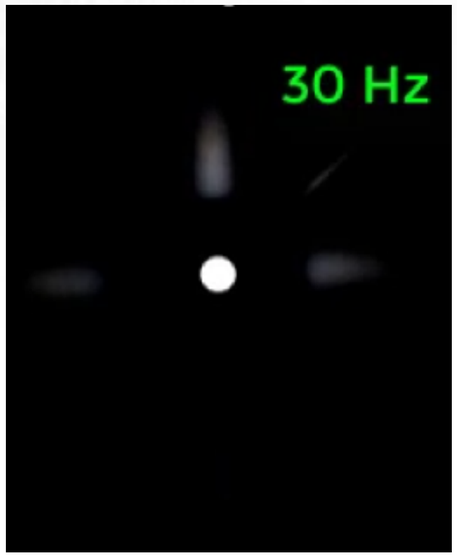
Self-Report: validity

- We also asked players reporting subjective experience of visual fatigue

	1-None	2-Mild	3-Moderate	4-Severe	5-Very Severe
Ache					
Strain					
Headache					
Double vision					
Blur					
Tearing					
Burning					
Irritation					
Dryness					
Generally					

Indicators summary

Critical Flicker/Fusion Frequency

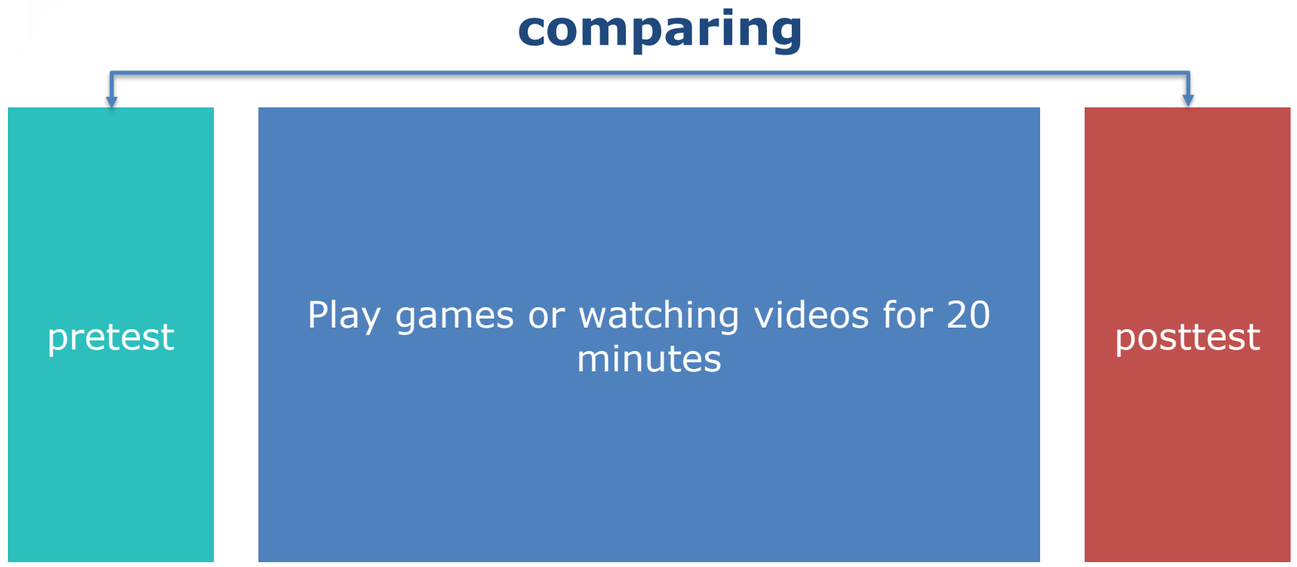


Contrast Sensitivity

Self-report Questionnaire

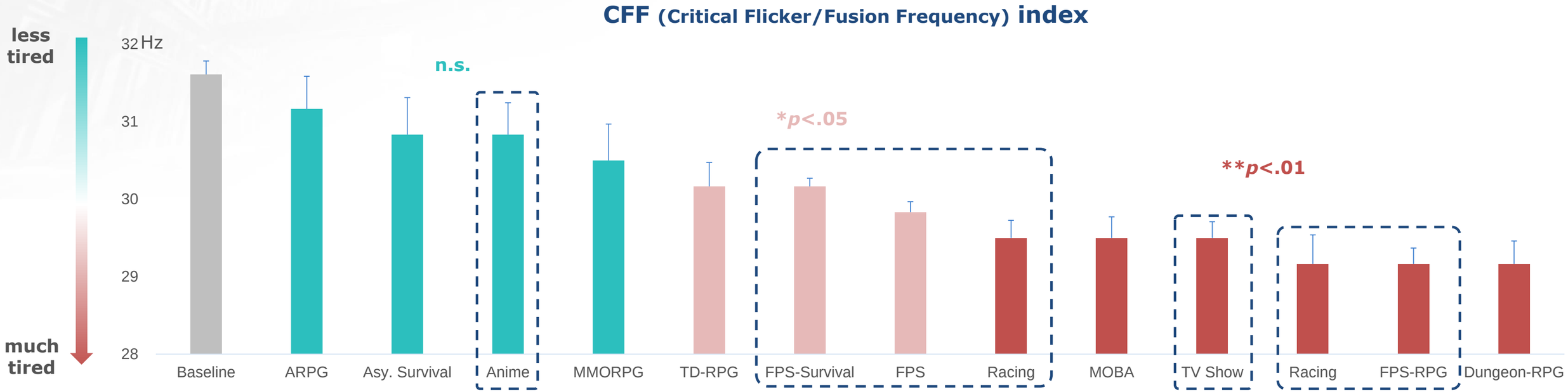
Procedure & Results

- 36 players participated Experiment 1, they played games or watched videos on iPhone X for 20 minutes.
- Psychophysiological measurements and self-report questionnaire were conducted before and after screen viewing.



Procedure & Results

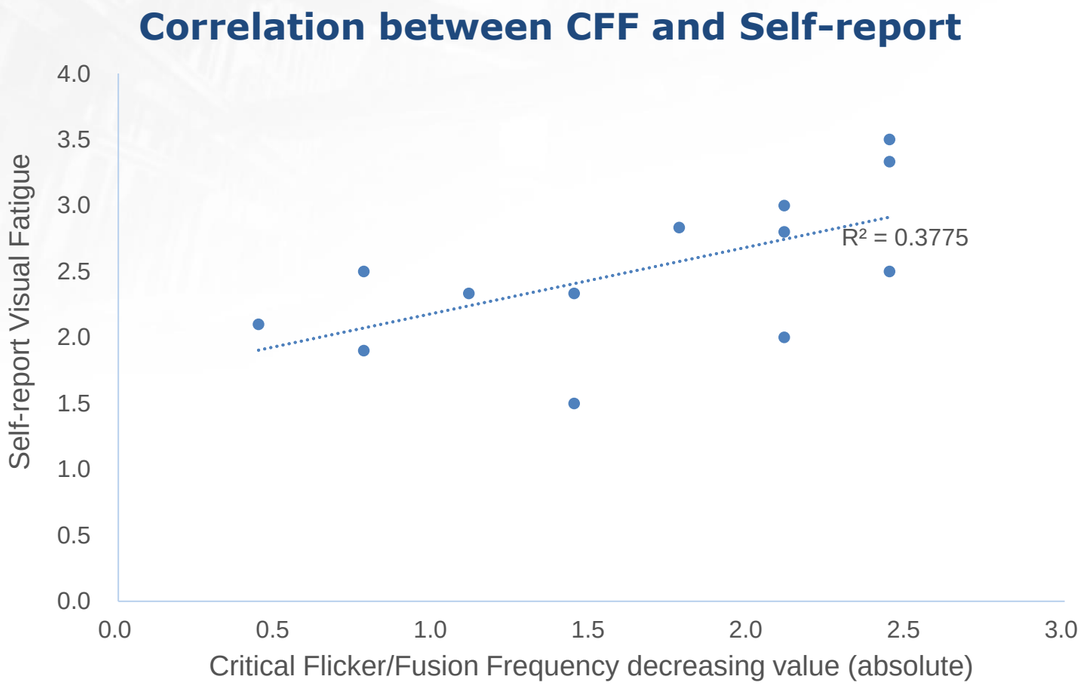
- **CFF decreased** after viewing screen for 20 minutes.
- Playing games did not necessarily induce more severe visual fatigue than passively watching videos.
- **FPS and racing games** impacted much than other game genres.

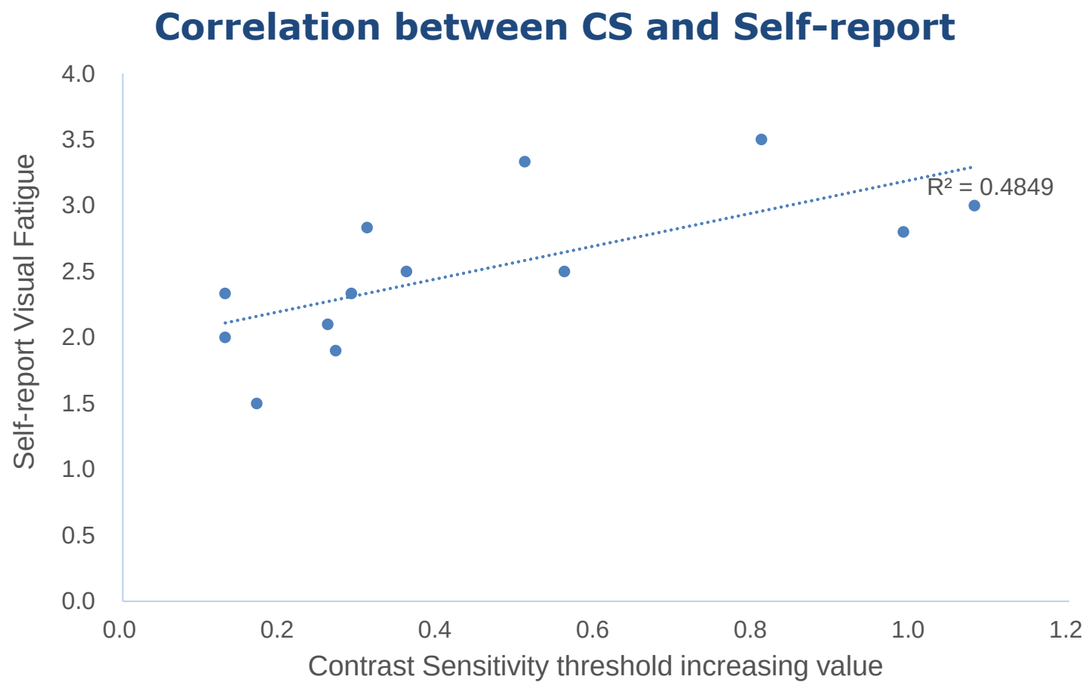


Note: Error bar represents S.E.. Each game/video contains 12 participants.

Procedure & Results

- We also found **moderate correlations** between Critical Flicker/Fusion Frequency, Contrast Sensitivity and self-report visual fatigue (*rs* > .61).





Insights

- CFF and CS are objective and effective indicators of visual fatigue.
- These indicators can be used as examination tools in game designing, such as A/B test.

Looting in a house

bright room

dim room

*Snapshot from **Knives Out**, published by NetEase Games*

Insights

- An example of A/B testing, all data shown are for illustration only.

	Critical Flicker/Fusion Frequency	Contrast Sensitivity Threshold	Self report
	Higher	Lower	Mild
	Lower	Higher	Severe

Conclusion

- We find effective indicators of visual fatigue:
  - CFF: Critical Flicker/Fusion Frequency
  - Contrast sensitivity
  - Self report

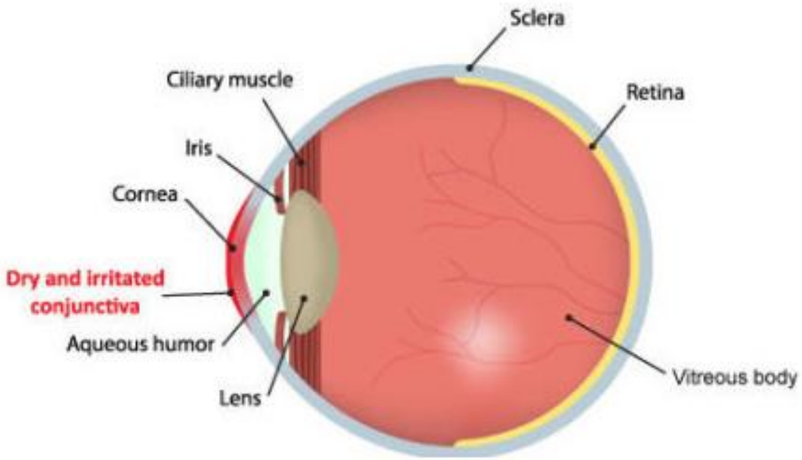
- FPS and racing game players are vulnerable to visual fatigue

Study 2: Further understand the mechanism

- We chose FPS and racing mobile games to further study visual fatigue.
- We also investigated whether playing games would lead to ophthalmic changes.

Optometric Measurements

- By reviewing literatures, we focused on following optometric measurements:
  - **Tear breakup time (TBUT)**: a clinical test used to assess for evaporative dry eye disease
  - Anterior Chamber Depth (ACD) and Accommodation Power (AP): indexes correlate to the refractive and focus power of the eye



TBUT shortening implied that eye dryness and discomfort might occur.

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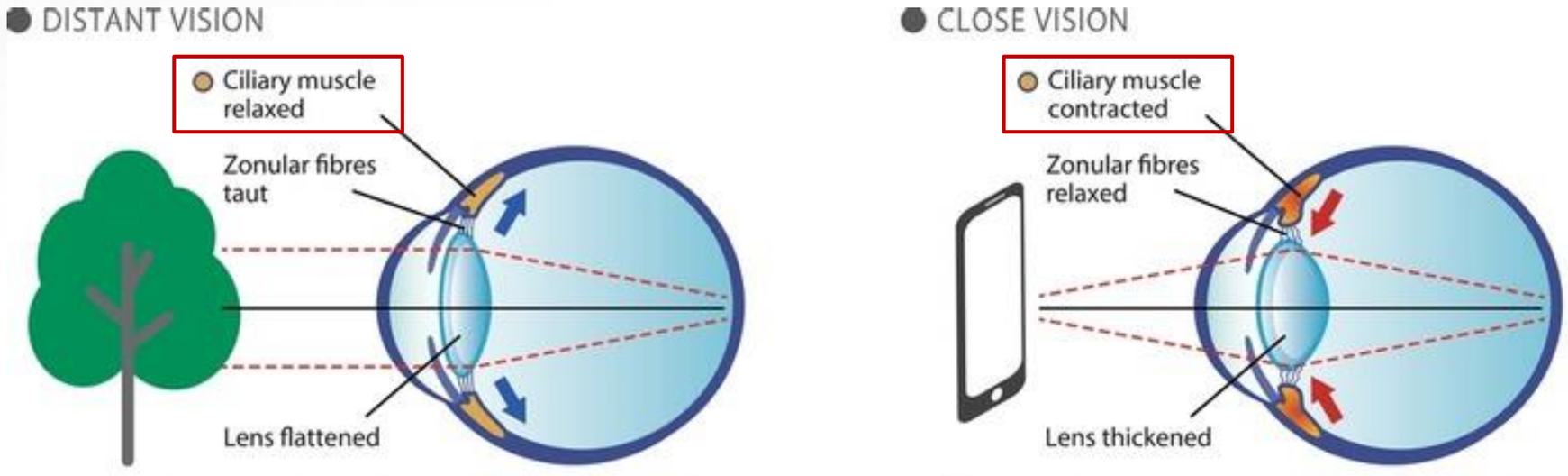
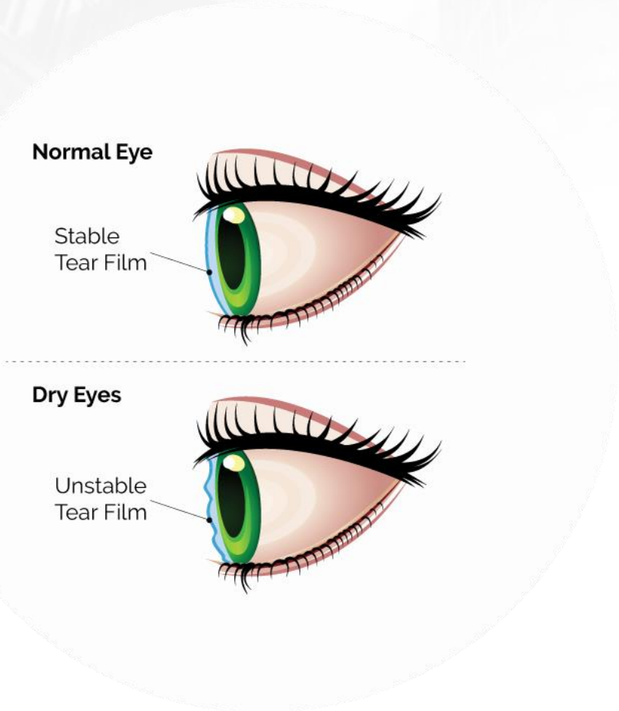


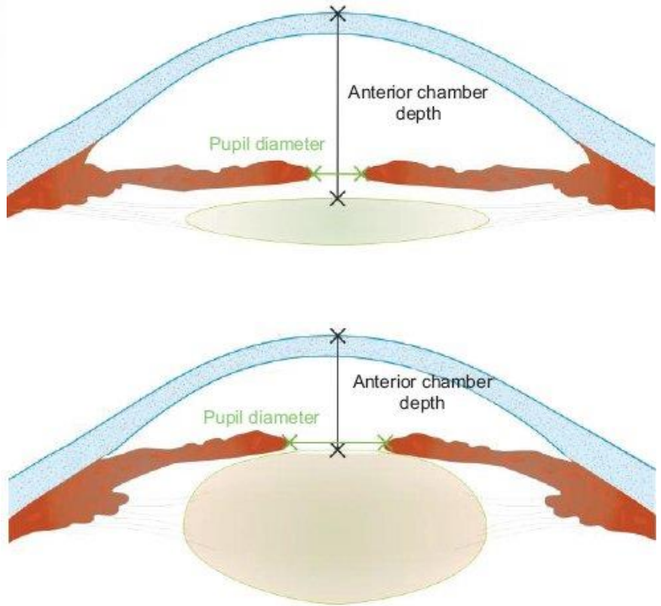
Changes of ACD and AP reflected implied that ciliary muscle got tire and might lead to blurred vision.

Indicators summary

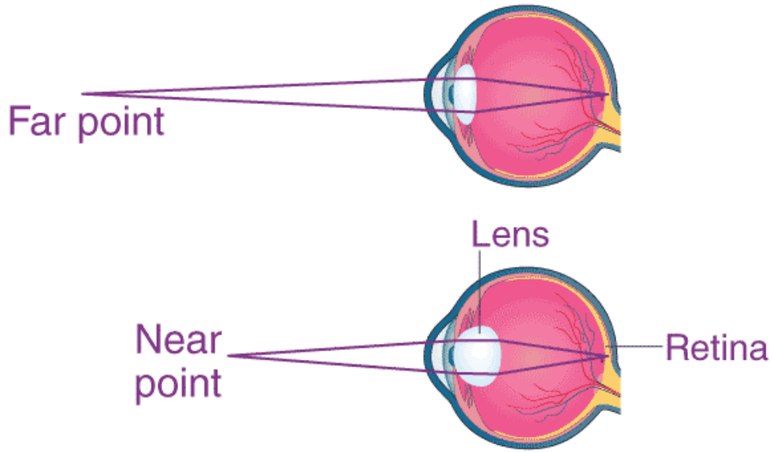
Tear Breakup Time



Anterior Chamber Depth

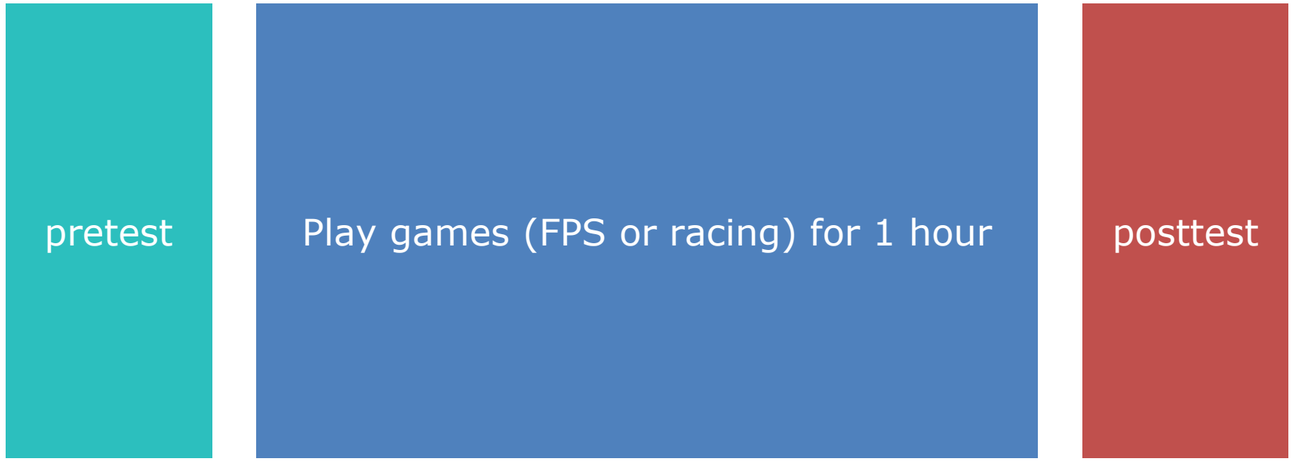


Accommodation Power



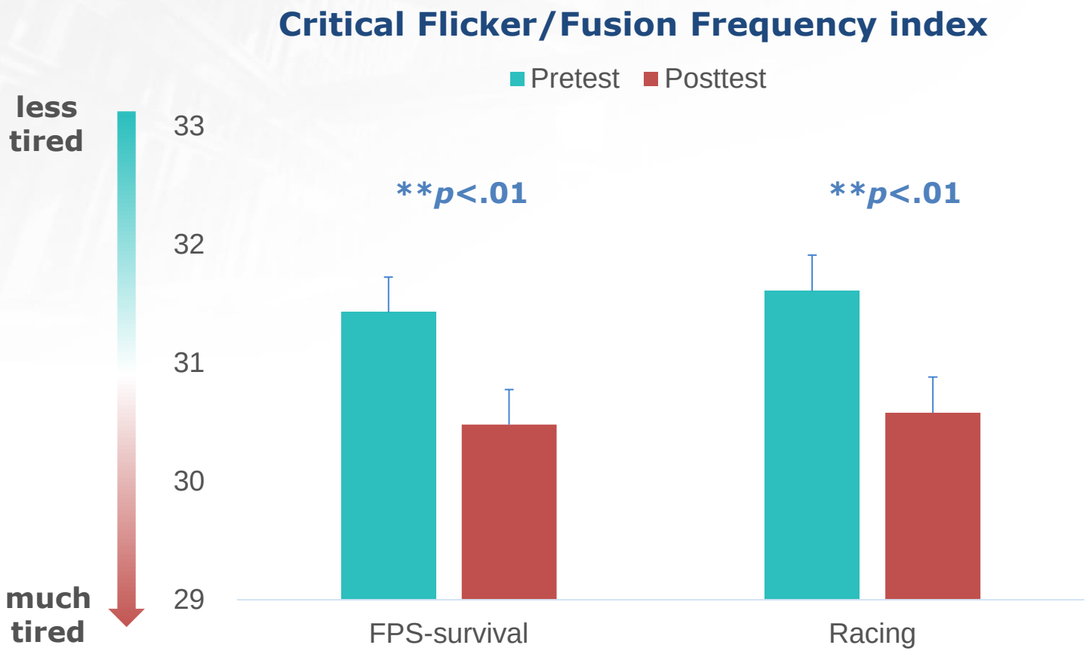
Procedure & Results

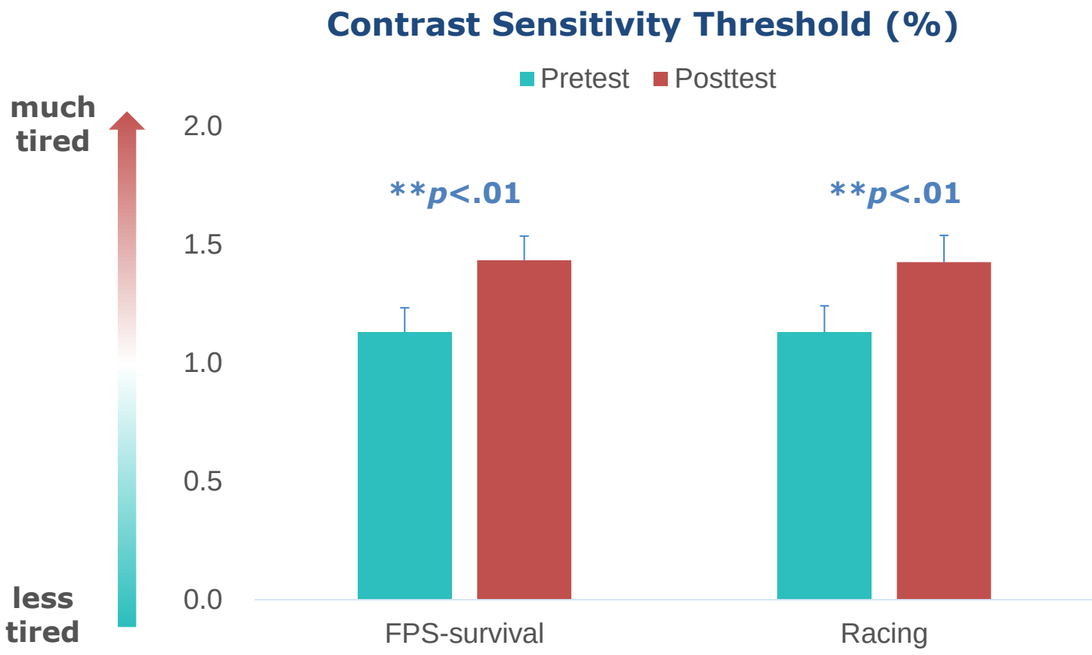
- The procedure was similar as Study 1, which including pretest, game playing, and posttest.
- 19 players participated Experiment 2.



Procedure & Results

- As expected, after playing both games, visual fatigue was reflected on CFF index and contrast sensitivity. FPS and racing game showed no difference in these two indicators.

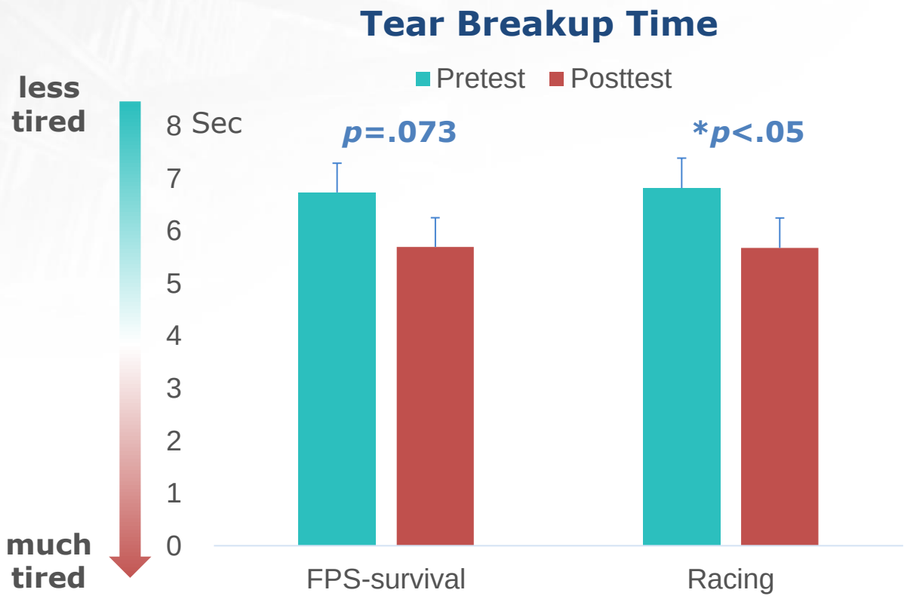




Note: Error bar represents S.E.. Each game contains 19 participants.

Procedure & Results

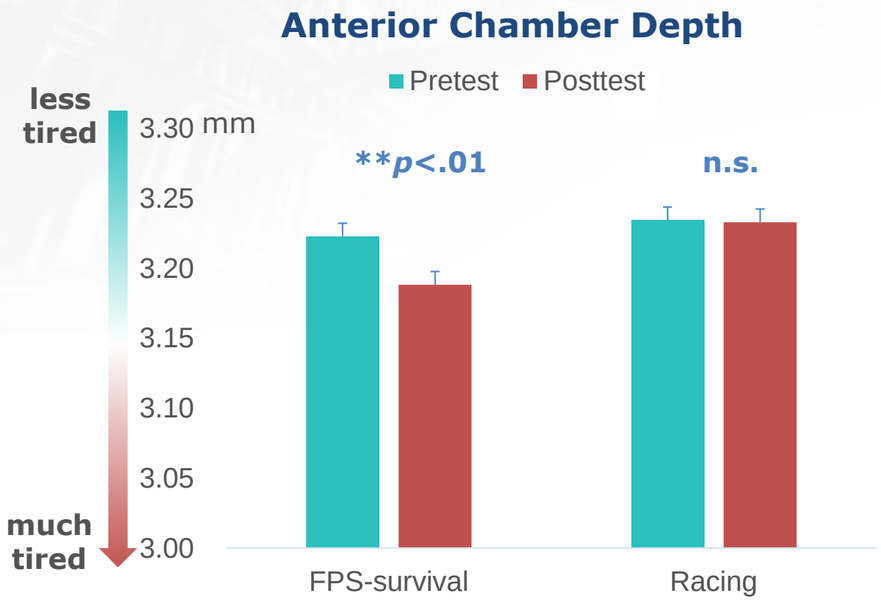
- TBUT decreased after playing both games, which was in accordance with previous studies.

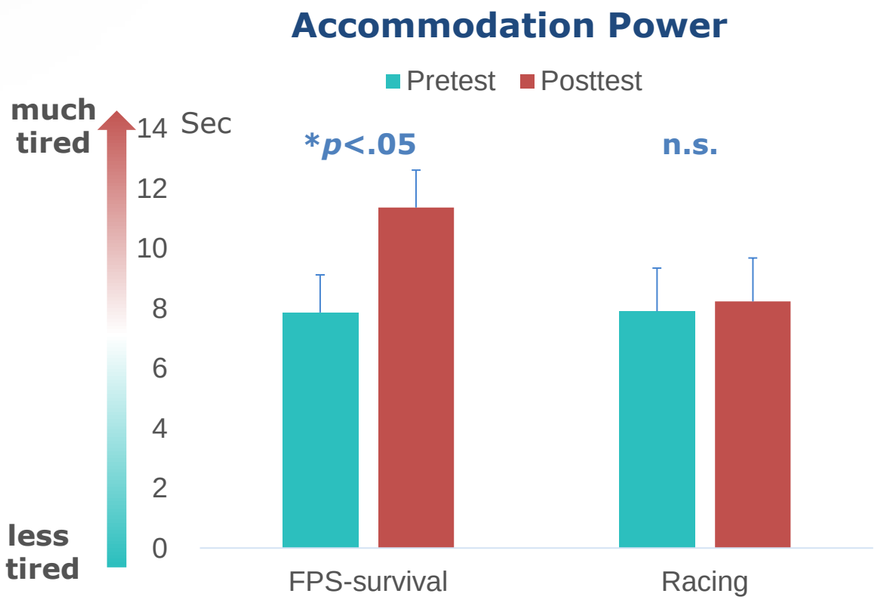


TBUT shortening implied that eye dryness and discomfort might occur after 1-hour exposure to screen.

Procedure & Results

- However, ACD and AP was impacted only in FPS-survival game but not in racing game, suggesting that the underlying mechanism of visual fatigue might be different.





Changes of ACD and AP implied that refractive power and lens focusing ability were affected significantly after playing FPS game.

Insights

- **General effect**: Exposure to screen might lead to eye dryness.
- **Specific effect:** Playing FPS game might further let ciliary muscle get tired. It might be due to the visual discrimination demanding, rapid eye movement, and frequently shift of focus.

*Snapshot from **Knives Out**, published by NetEase Games*

Conclusion

- Visual fatigue induced by FPS games may be different from other game genres:
  - Highly visual demanding is much frequent in FPS games
  - Refractive and accommodation ability were impacted temporally after playing FPS games

- However, long time exposure to screens will also induce eye dryness in other game genres

03

Tips for Game Designers

Common cause of visual fatigue

- **High Brightness**

Alpha Test

Official Launch

*Snapshot from **LifeAfter**, published by NetEase Games*

Common cause of visual fatigue

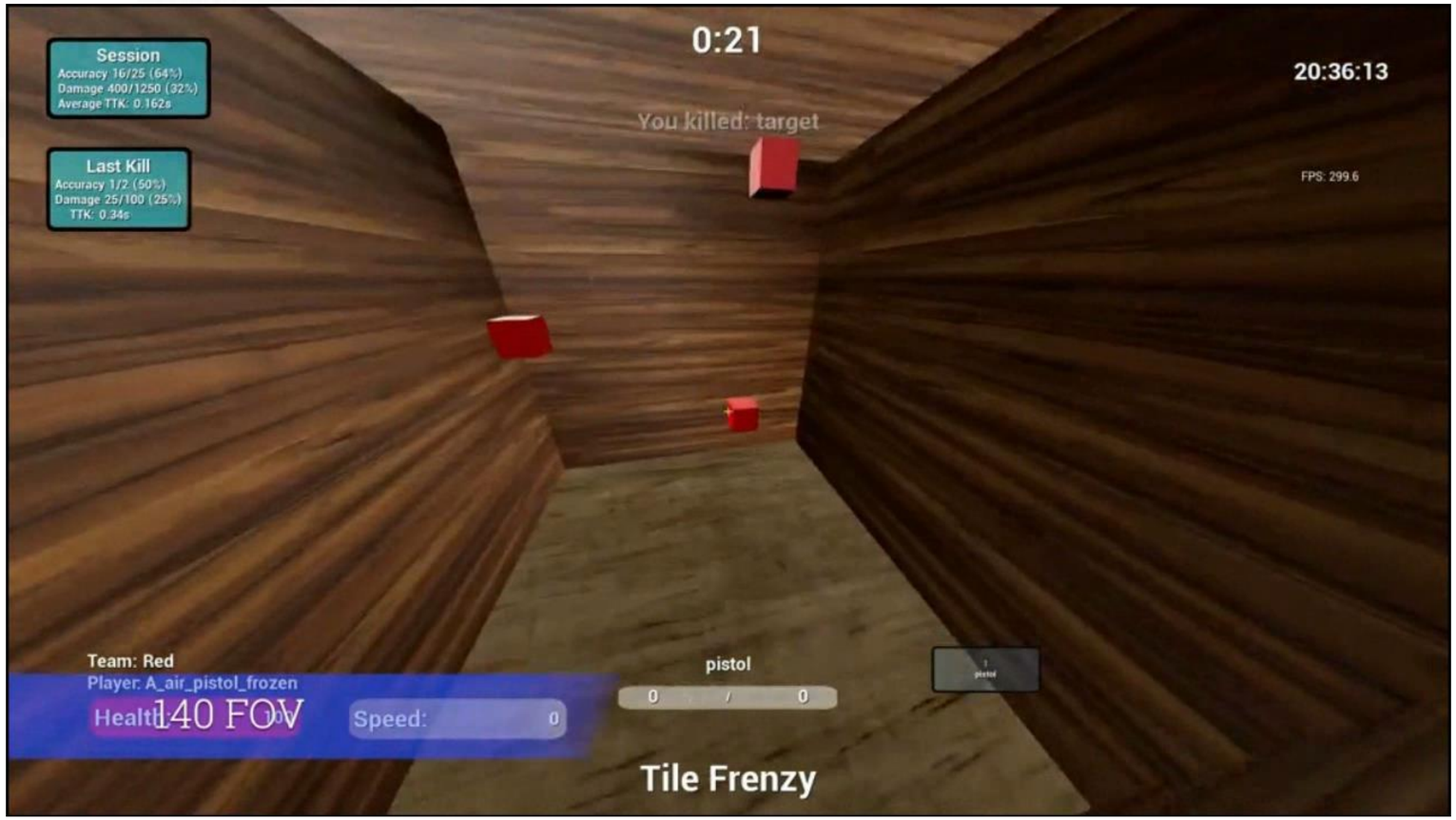
- **Low Contrast**

Low Contrast

High Contrast

Common cause of visual fatigue

- **FOV and Camera Sensitivity**

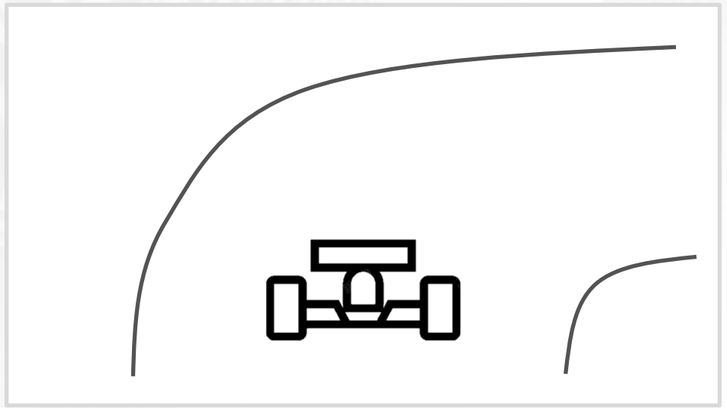


Common cause of visual fatigue

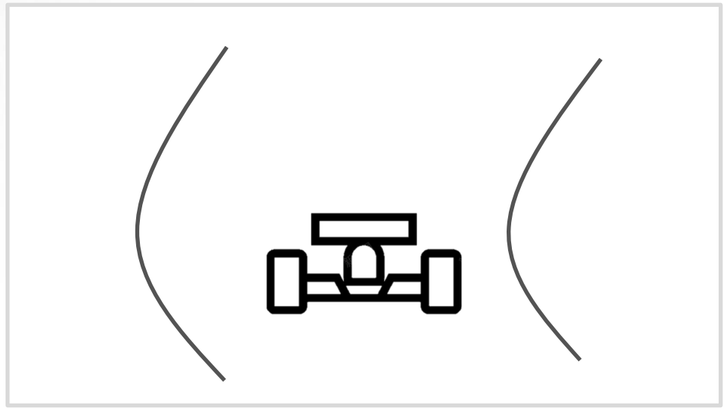
*Clip captured from **Ace Racer**, published by NetEase Games*

Common cause of visual fatigue

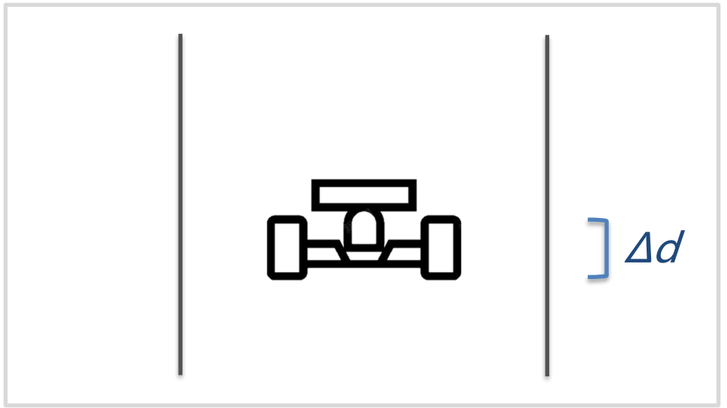
- **Shaky Cam**



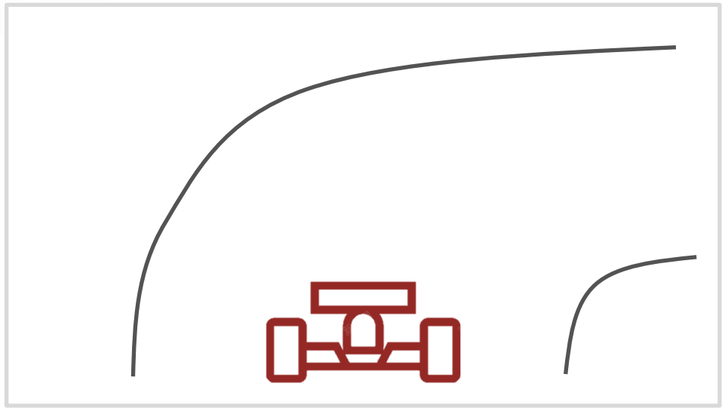
-1G

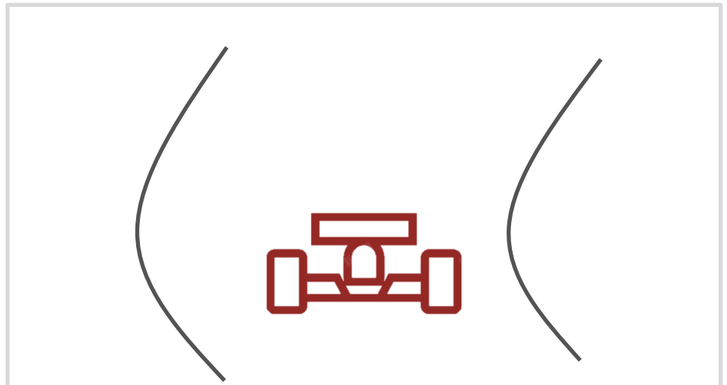


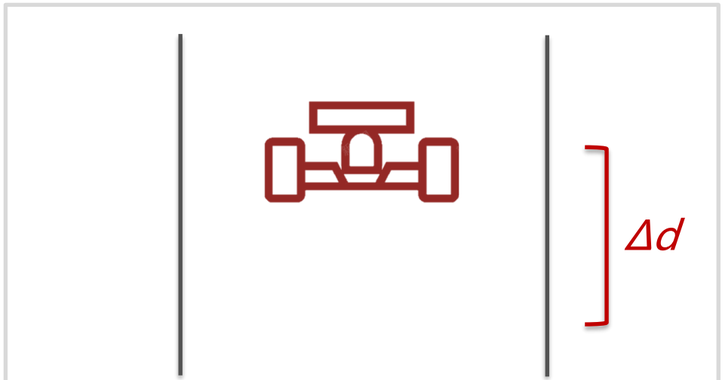
0G



+1G

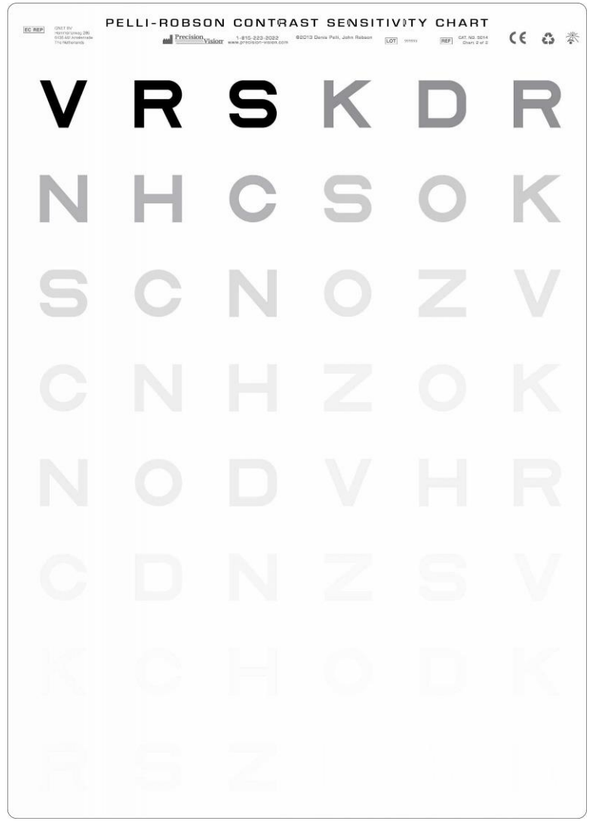






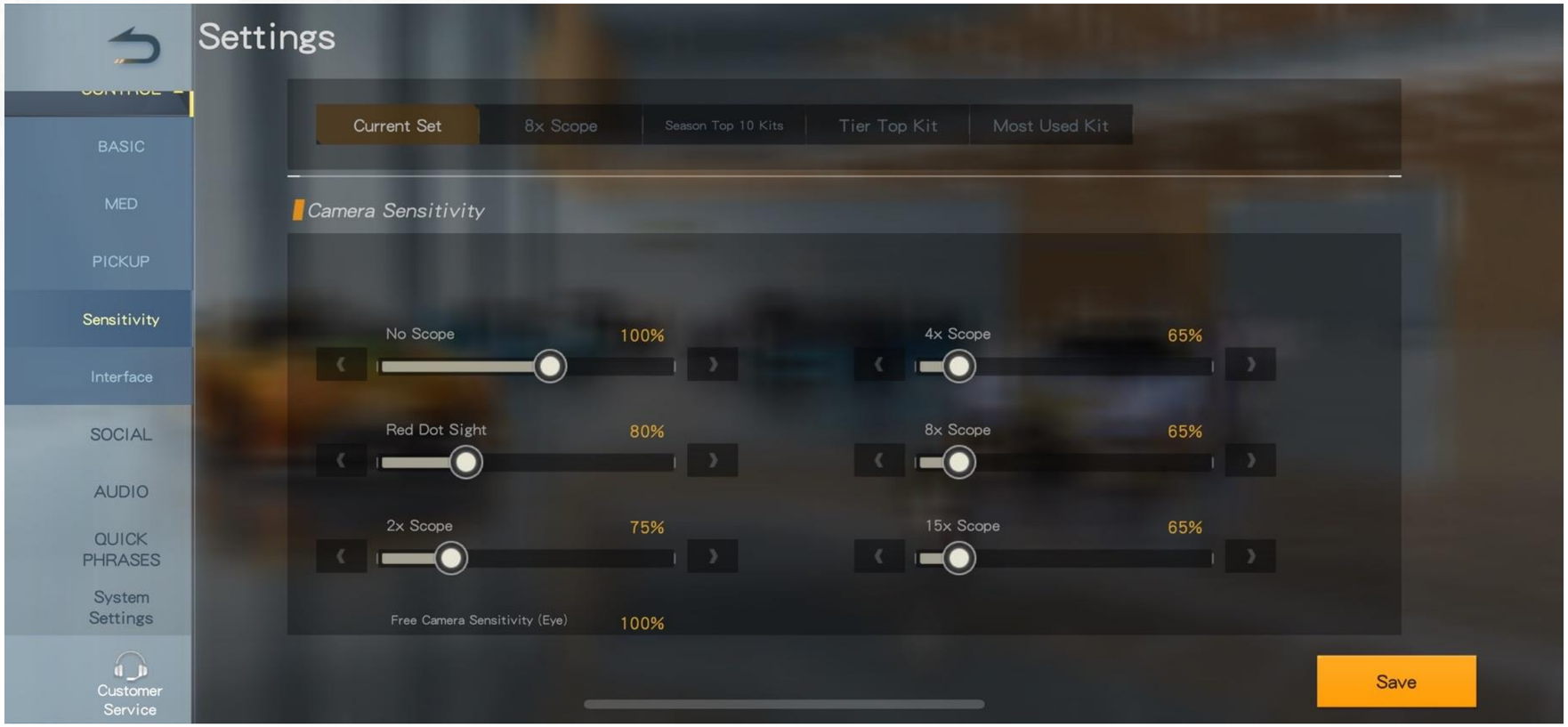
Suggestions

- **Use A/B test to find out risk factors**



Suggestions

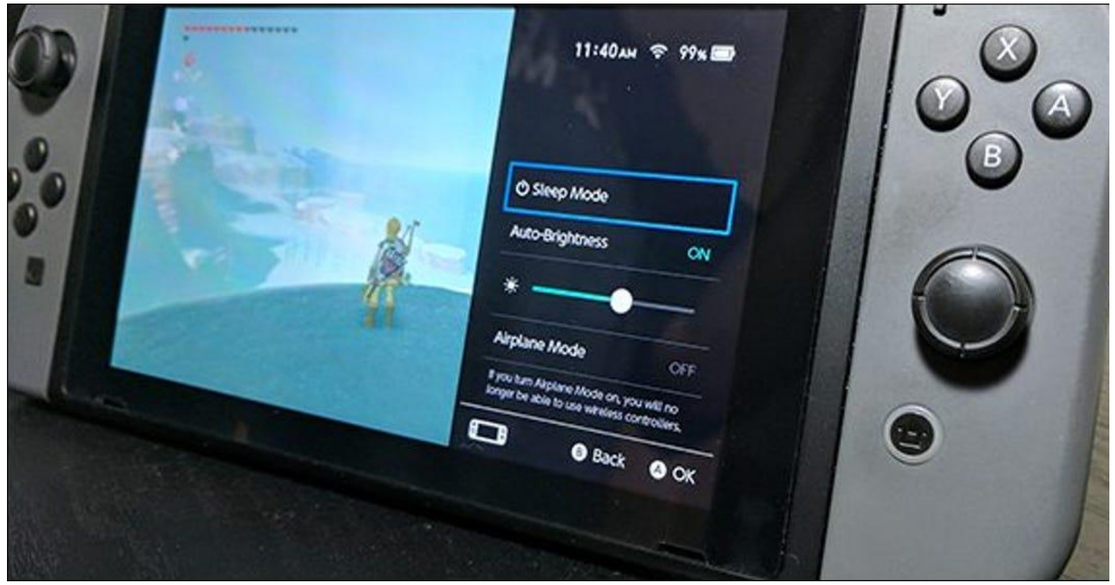
- **Provide customization when possible**



*Snapshot from **Knives Out**, published by NetEase Games*

Suggestions

- **Reminders and adjustment of game settings**



Summary

- **CFF** and **contrast sensitivity** are effective psychophysiological indicators of visual fatigue
- Using these indexes in **A/B test** can help us **identify risk factors** of visual fatigue
- **Brightness** and **contrast** are common causes of visual fatigue
- **Unmatched FOV** and **shaky camera** leads to visual fatigue in moving scenes
- **In-game settings** such as reminding, automatic brightness, can relief eye strain

Credits

Jade Wang

User experience researcher of NetEase Games

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