2021 Joint CORM / CNC / USNC CIE
Annual Meeting Nov. 15-16, 2021

2021 NIST Vision Experiment on Hunt Effect at High Illuminance Levels using Covid-19 Safety Procedures

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Vision experiment with human subjects during the pandemic time

NIST Laboratories general requirements for Covid-19 Safety (March 2021)

- Only one person can work in a lab space.
- 72 hours separation before a different person can use the lab
- Surfaces touched by the lab user must be sanitized after the use.

Hazard Review required for each new experiment.

Institutional Review Board (IRB) approval required for all human subjects experiments

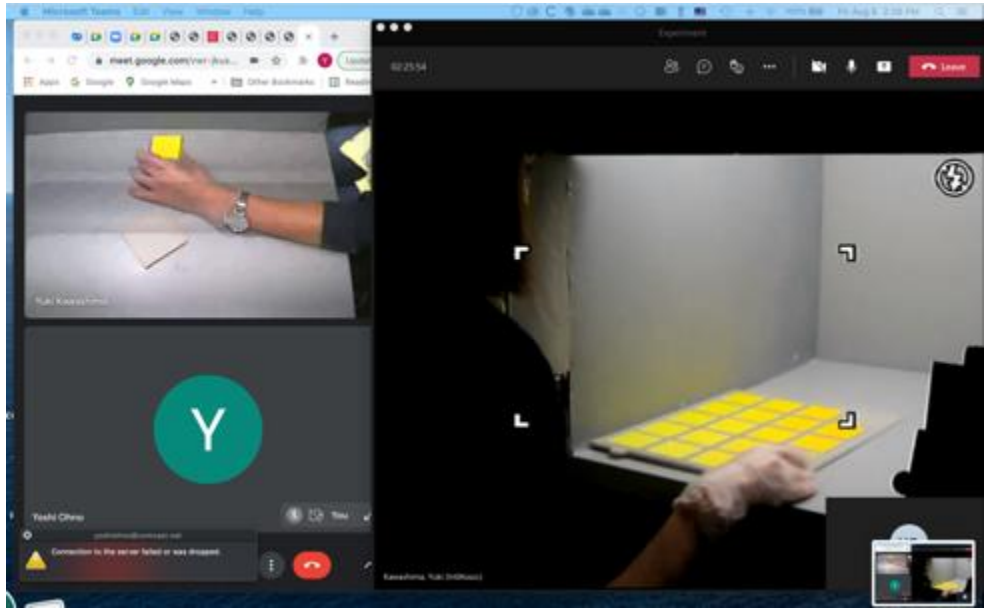
- Safety for pandemic was also considered.

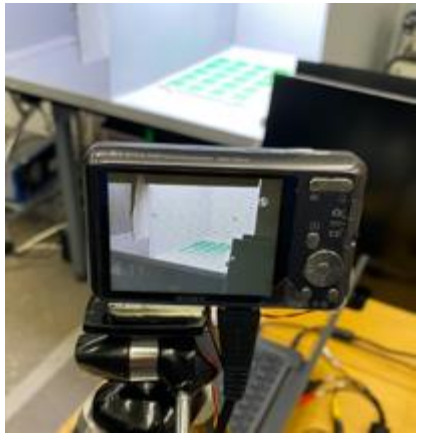
Special experimental methods and procedures developed for Hunt Effect experiment, ensuring Covid-19 safety (approved by NIST Hazard Review, IRB)

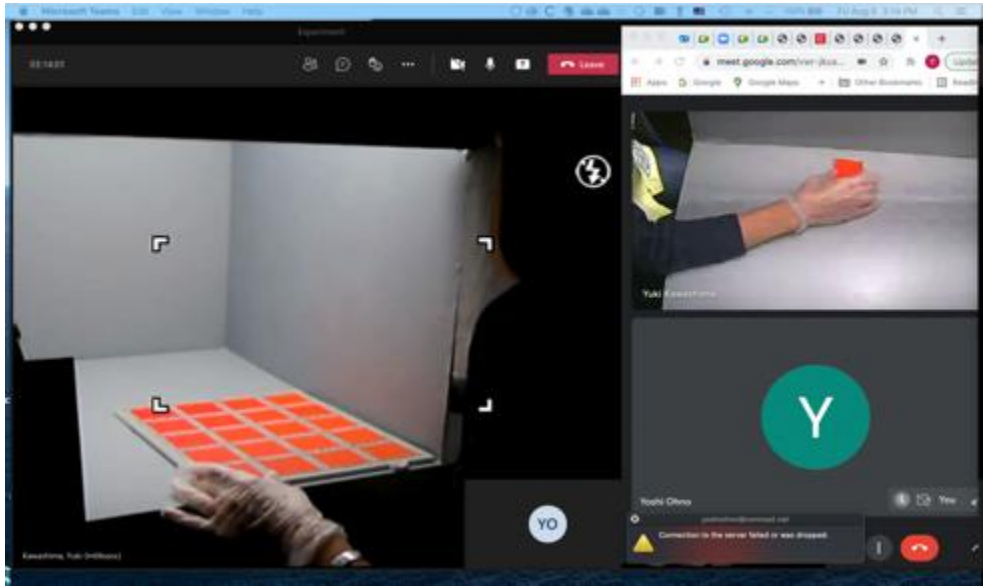
- **Remote experiment** (the subject is alone in the lab, no contact with anyone)
- **Special procedures**

Remote Experiment using Cameras and On-line meeting Tools

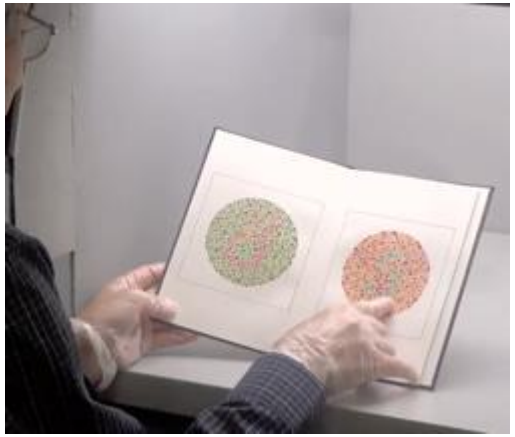
Operator's computer screen

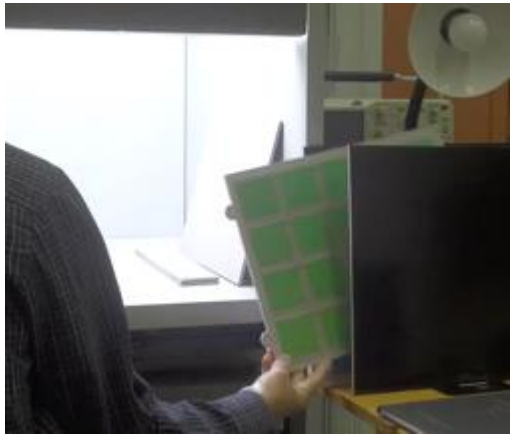




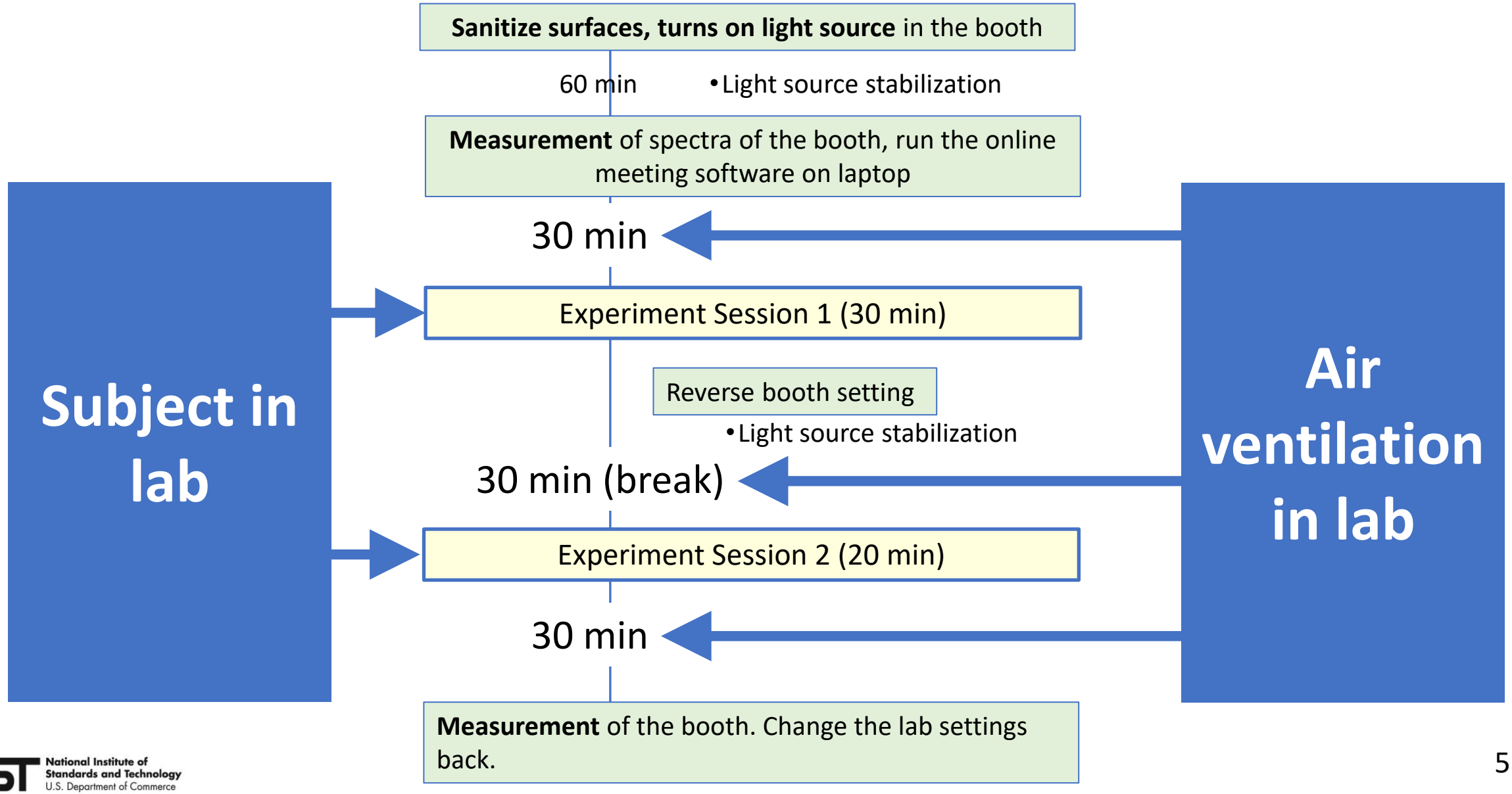


Covid-19 Safety Procedures - Instruction video





Covid-19 Safety Procedures - Ventilation



Procedures during experiments

- Subjects wore a face mask.
- Subjects wore lab gloves
- Covid-19 check list for subjects and operators
- Operators wore full PPE (N95 mask, gloves)

COVID-19 Screening

All campus entrants must meet these requirements

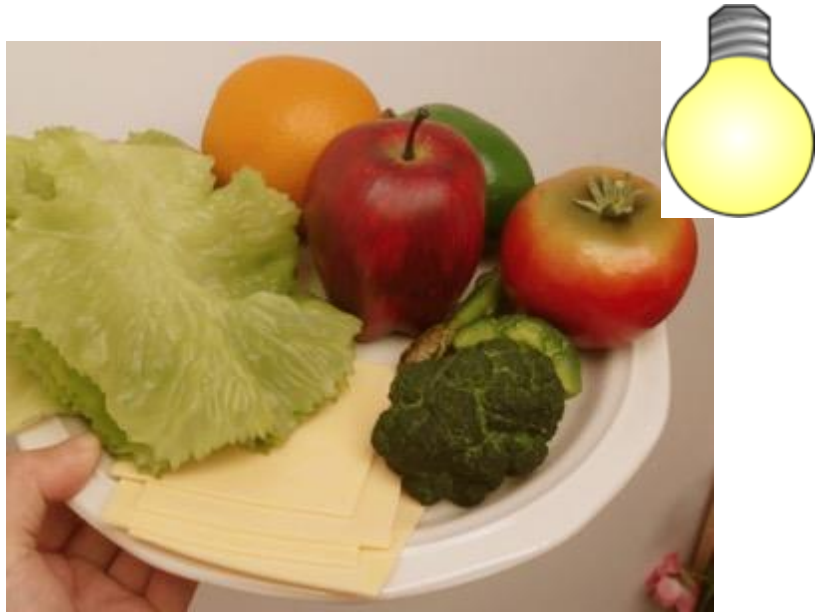
NOTE: Masks use is required for all staff and visitors, regardless of vaccination status, during periods of high and substantial COVID transmission; this currently applies to both the NIST Boulder and Gaithersburg campuses. Click here to see the campus status and basic COVID-19 protocol requirements including those for mask use.

Symptom Checklist: Today, are you experiencing any of the following symptoms not caused by another known condition?	Yes	No
Fever over 100.4 °F (38 °C) or Chills	☐	☐
Cough	☐	☐
Shortness of breath or difficulty breathing (unrelated to physical activities)	☐	☐
Muscle pain/body aches or fatigue (unrelated to physical activities)	☐	☐
Headache (bad or severe)	☐	☐
New loss of taste or smell	☐	☐
Sore throat, congestion or runny nose	☐	☐
Vomiting/nausea or diarrhea	☐	☐
If you are recovering from COVID-19, are all of the following true:	**Yes**	**No**
You have not had a fever (>100.4F) for more than 24 h and you are not taking fever-reducing medications; it has been more than 10 days since onset of symptoms; and your symptoms have improved	☐	☐
In the last 10 days have you tested positive for COVID-19?	☐	☐
Exposure Checklist: In the last 14 days have you:	**Yes**	**No**
Spent more than 15 min over a 24 h period, within 6 feet (or 2 meters) of someone with known or suspected to have COVID-19?	☐	☐
Spent any time in your home with someone with confirmed or suspected COVID-19 or who currently has COVID-like symptoms not caused by another known condition?	☐	☐
Travel Restrictions for Oct 4-11, Is your entry restricted?	**Yes**	**No**
Entry is prohibited to those not fully vaccinated who traveled during the last 14 d to any of the following:	☐	☐

- The sponge piece for view divider replaced by new one for each subject

Introduction – Hunt effect

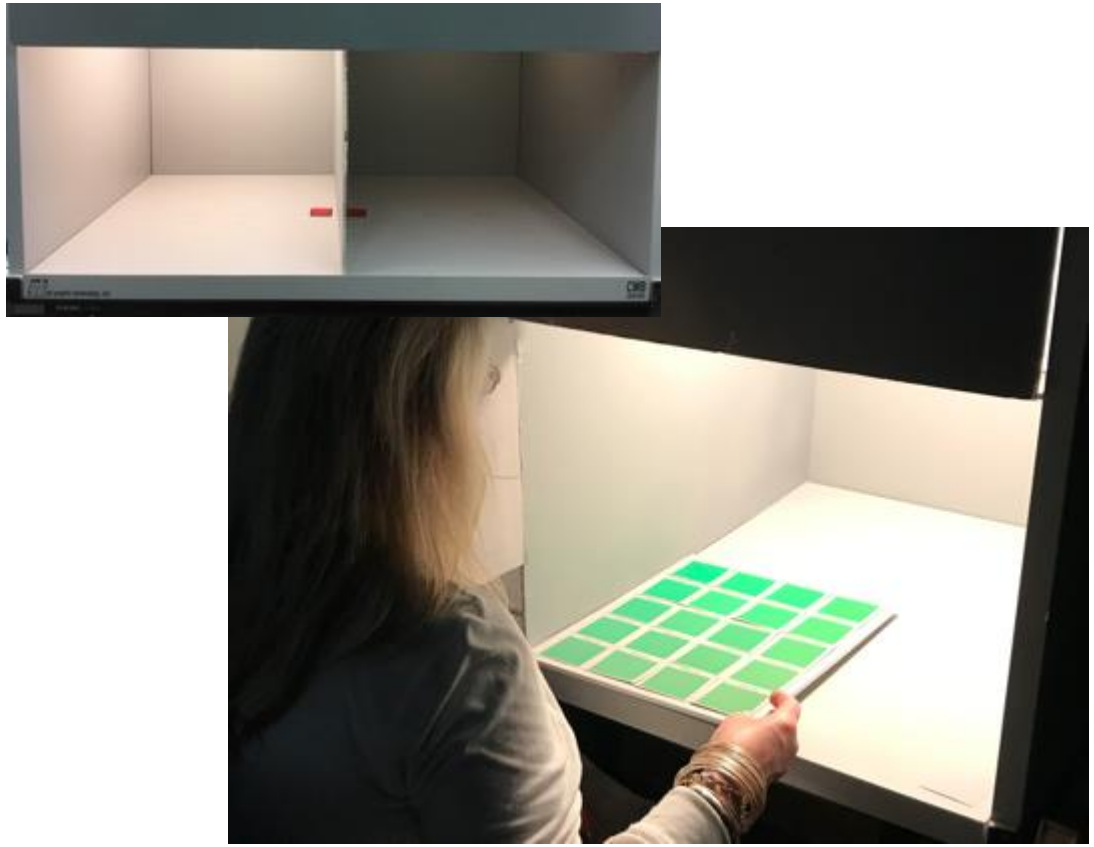
The illuminance level of the lighting can affect the perceived chroma (**Hunt Effect**)

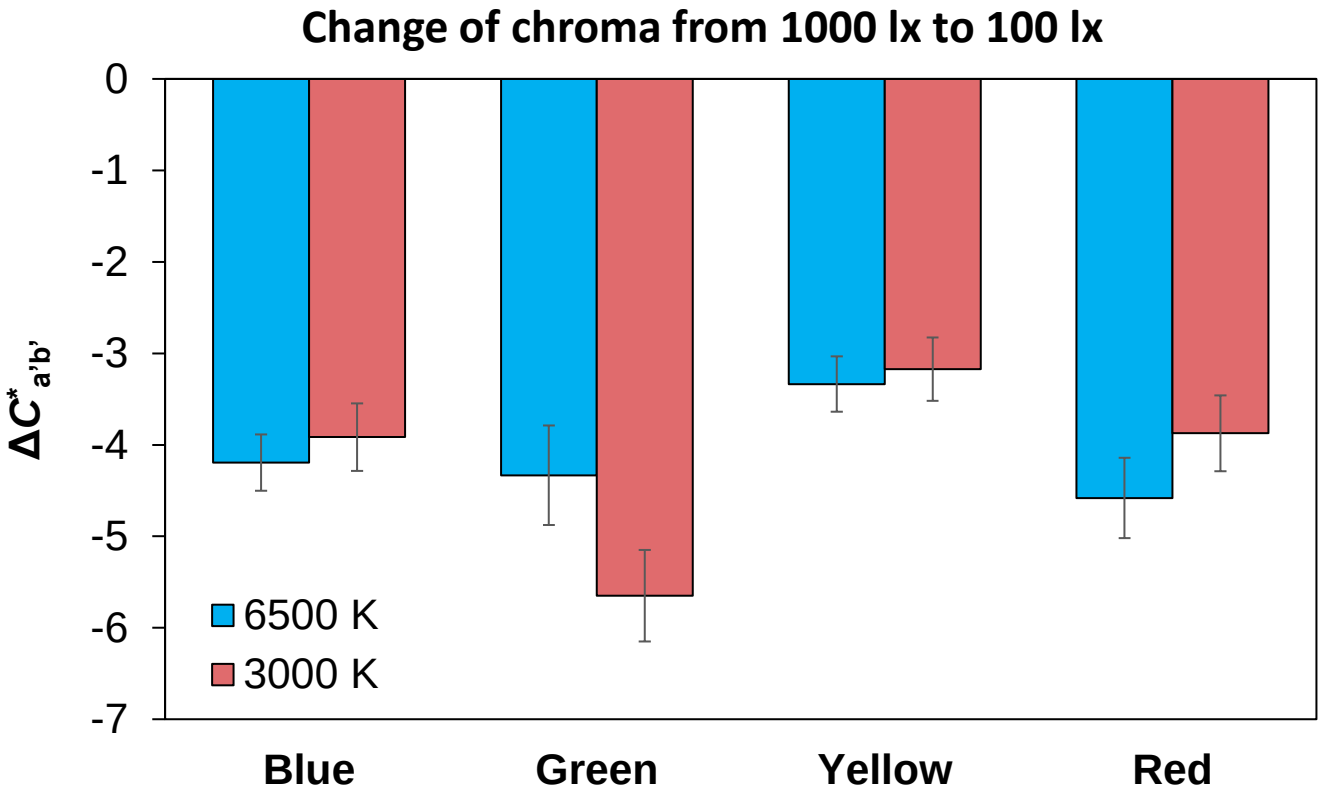


If the object colors at the outdoor daylight are considered as the reference for color appearance of objects, the decrease of the perceived chroma at indoor lighting level would be a matter of color fidelity

Introduction – Previous study (2019)

Our previous study experimentally quantified the changes chroma and hue between 100 lx and 1000 lx for four different colors





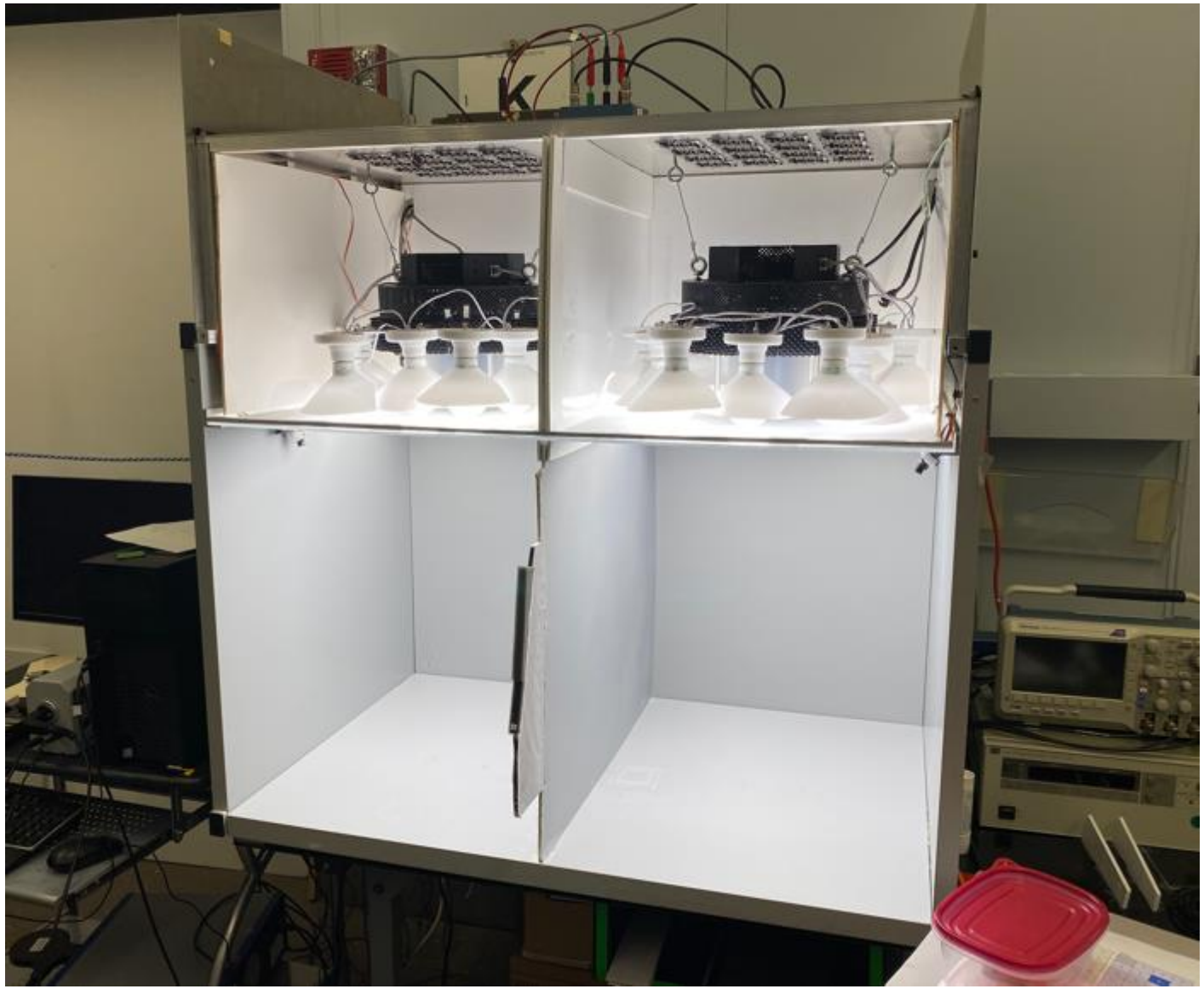
Y. Kawashima & Y. Ohno, Change of Perceived Chroma and Hue of Object Colours at Different Lighting Levels Due to Hunt Effect, CIE x047:2020 "Collection of papers accepted for the 5th CIE Symposium on Color and Visual Appearance."

However, there has been no fundamental data on the degree of the Hunt effect between 1000 lx and the outdoor daylight illuminance level.

Introduction – Purpose

To quantify the Hunt Effect in a range from indoor lighting levels to outdoor daylight levels

Method – Apparatus



Method – Light source

Illuminance

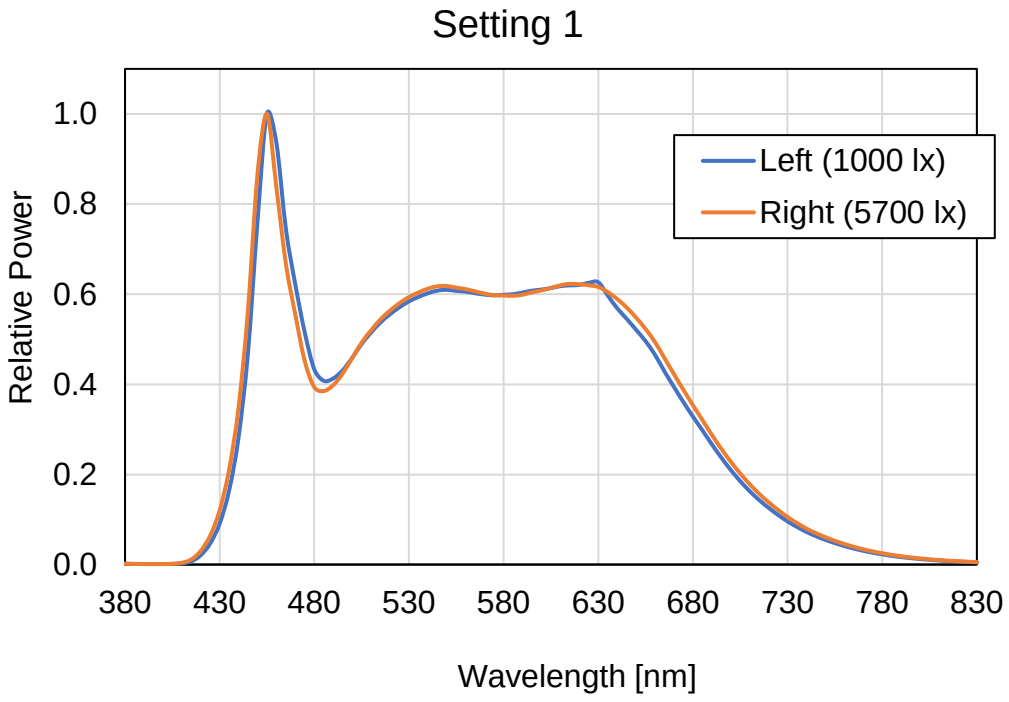
Maximum setting ≈5700 lx

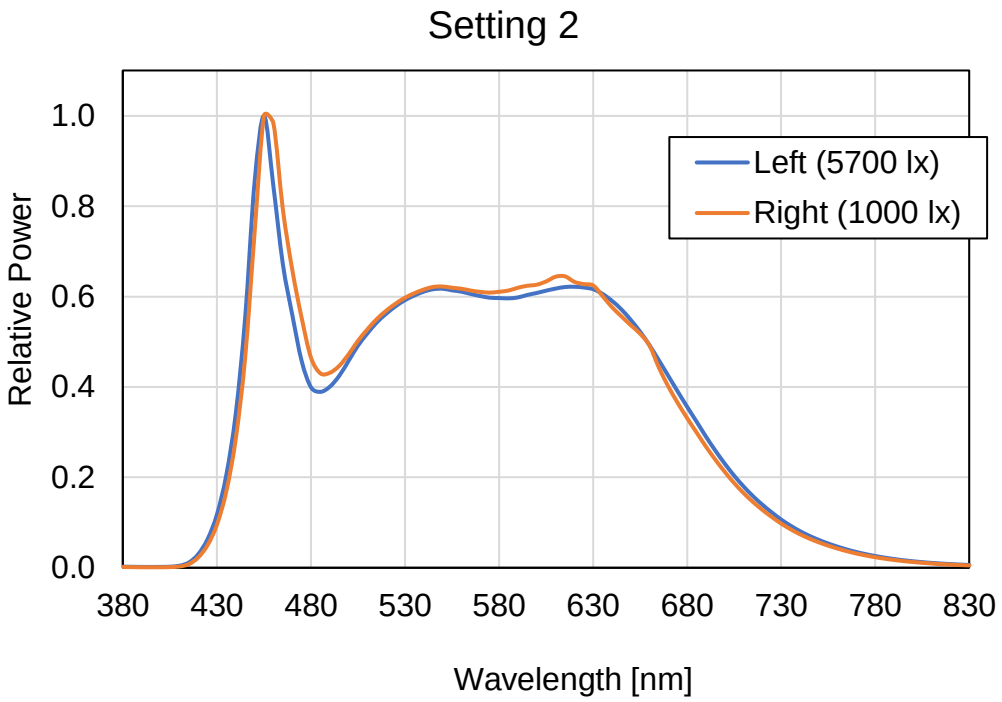
Dimmed setting ≈1000 lx

CCT ≈ 4860 K

Duv ≈ -0.0002

CRI Ra ≈ 95





Method – Subjects

16 subjects (NIST employees +1 other)

9 males

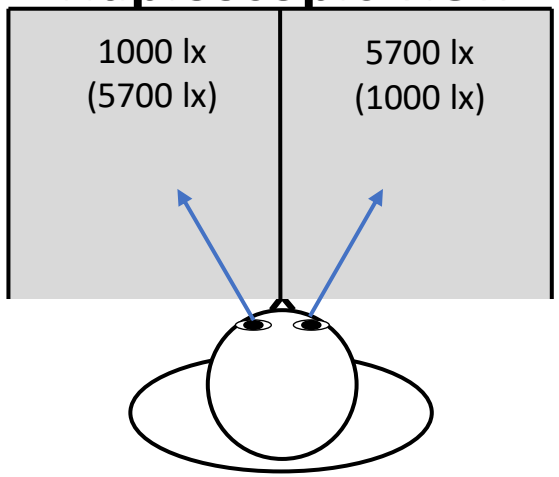
7 females

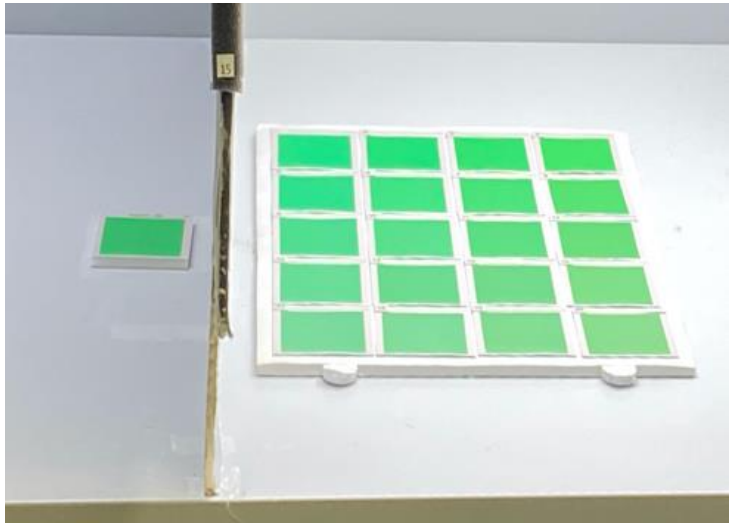
Age: 33 to 64 years old

(average: 48 years old) … No summer students this year.

Method

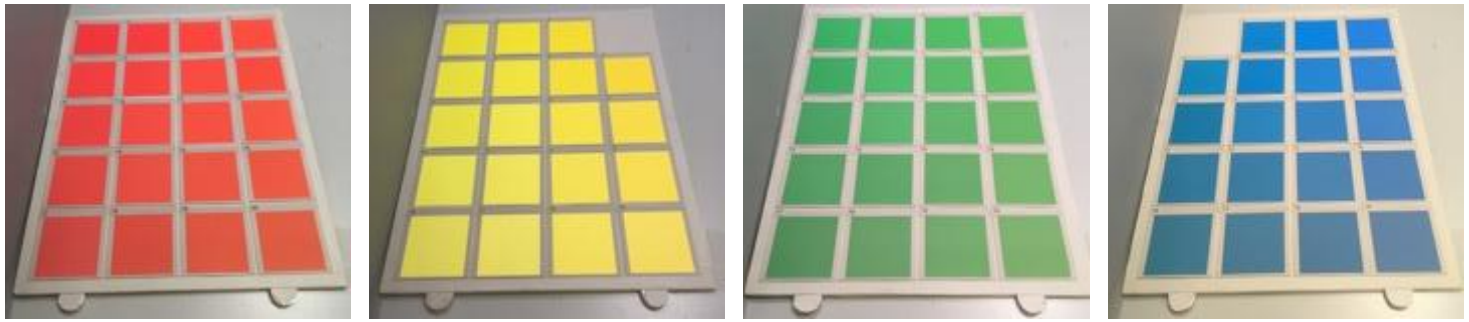
Haploscopic view





Test color patches (5700 lx side)

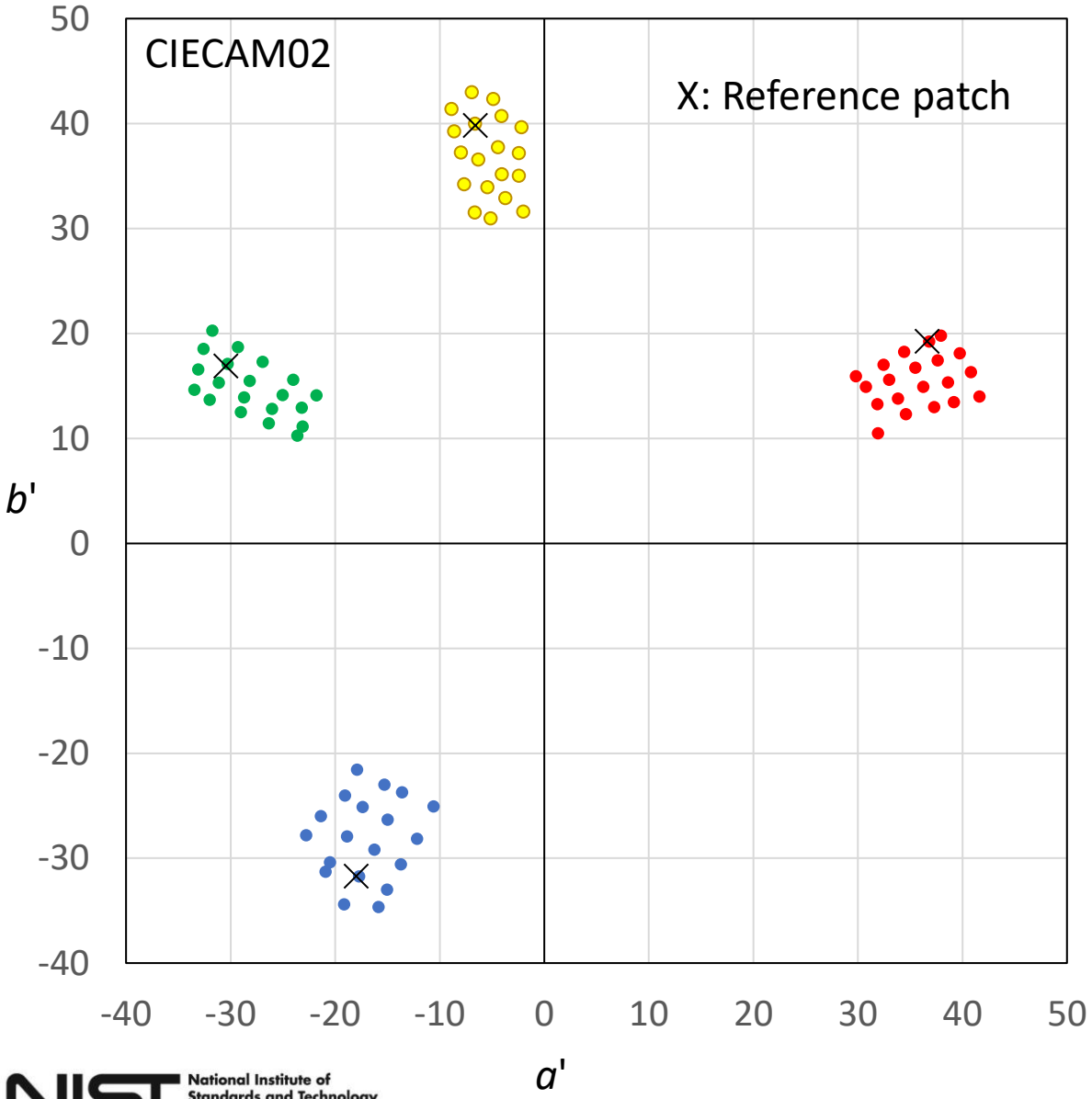
19 or 20 color patches with gradual shifts of chroma and hue for each color

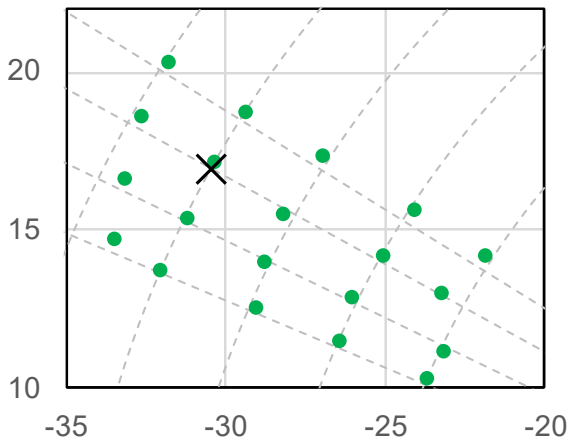


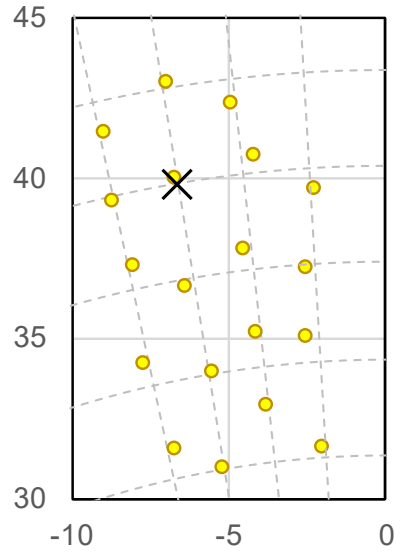
Reference color patches (1000 lx side)

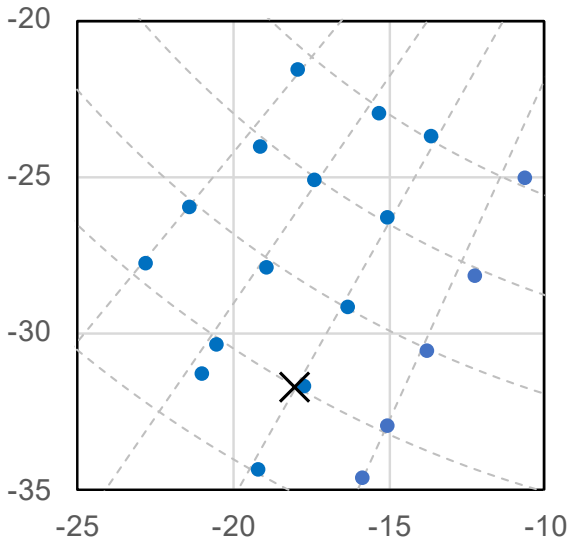
The same color as one of the test colour patches (second from maximum chroma level)

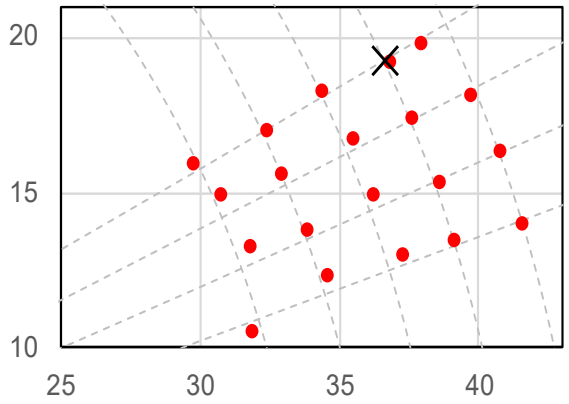
Method – Color coordinates of the color patches



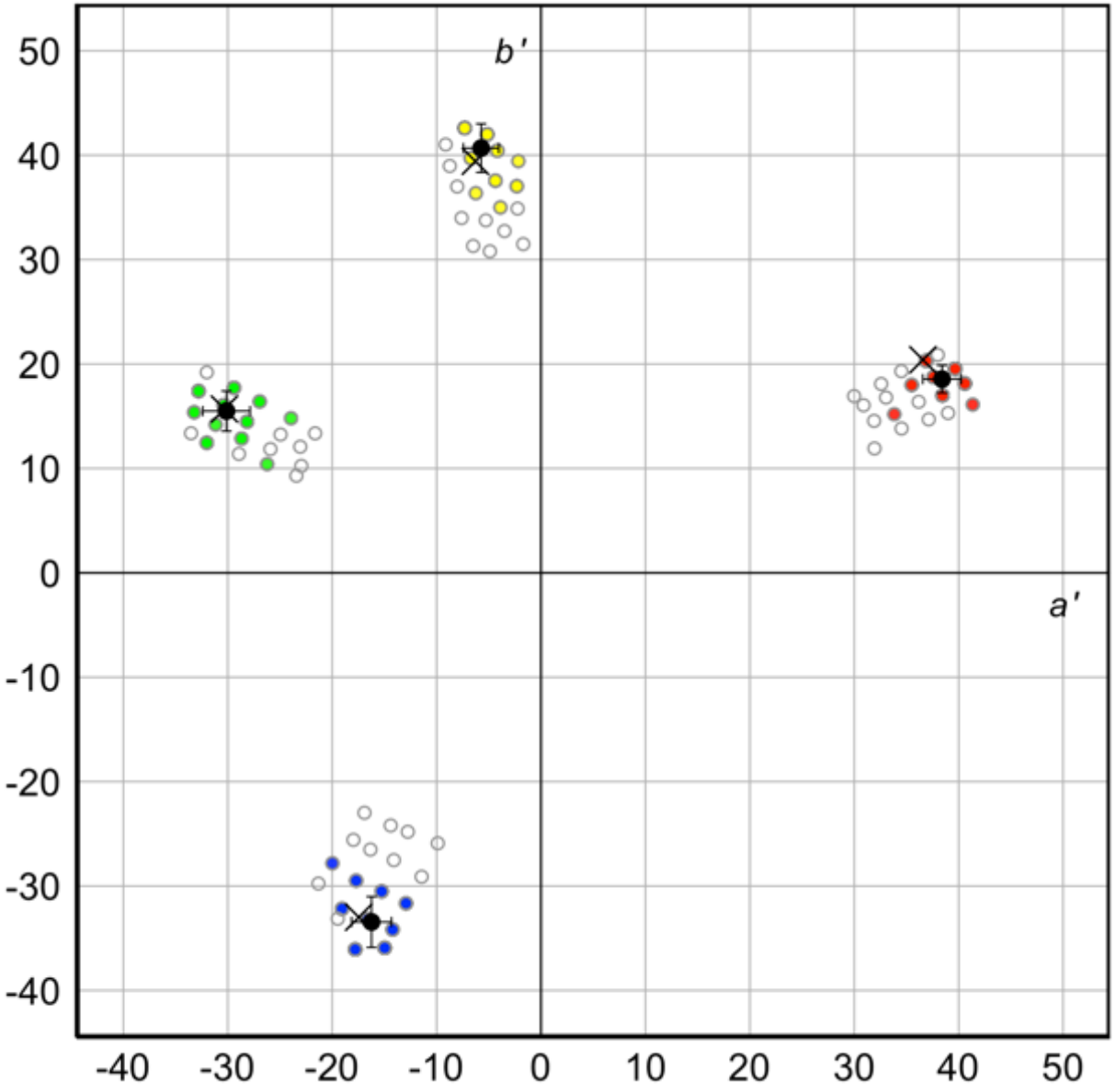


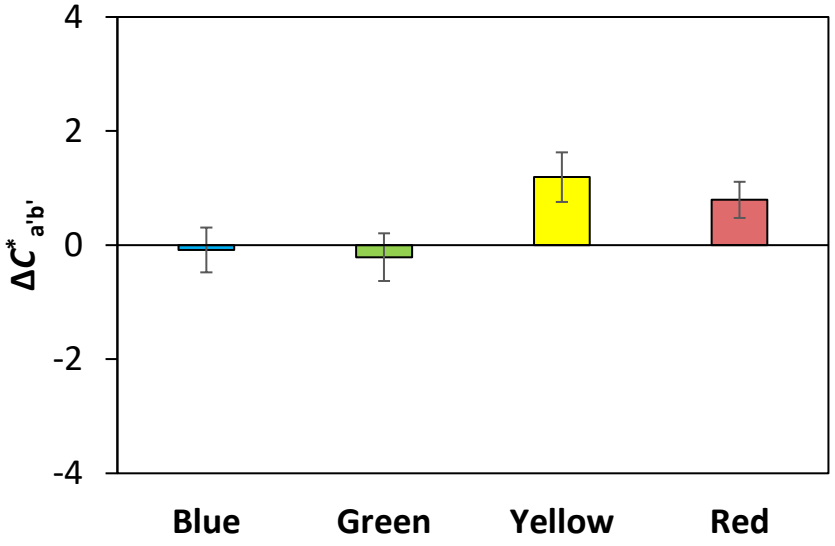


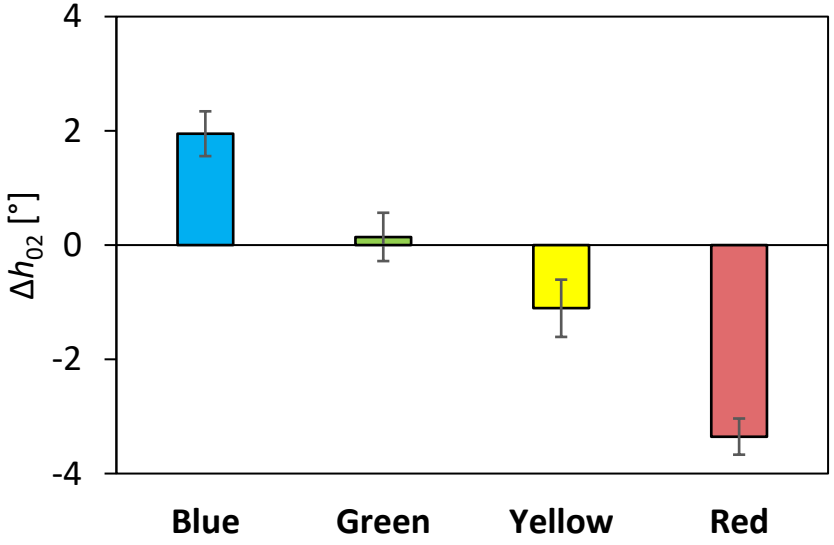




Result – Before correction

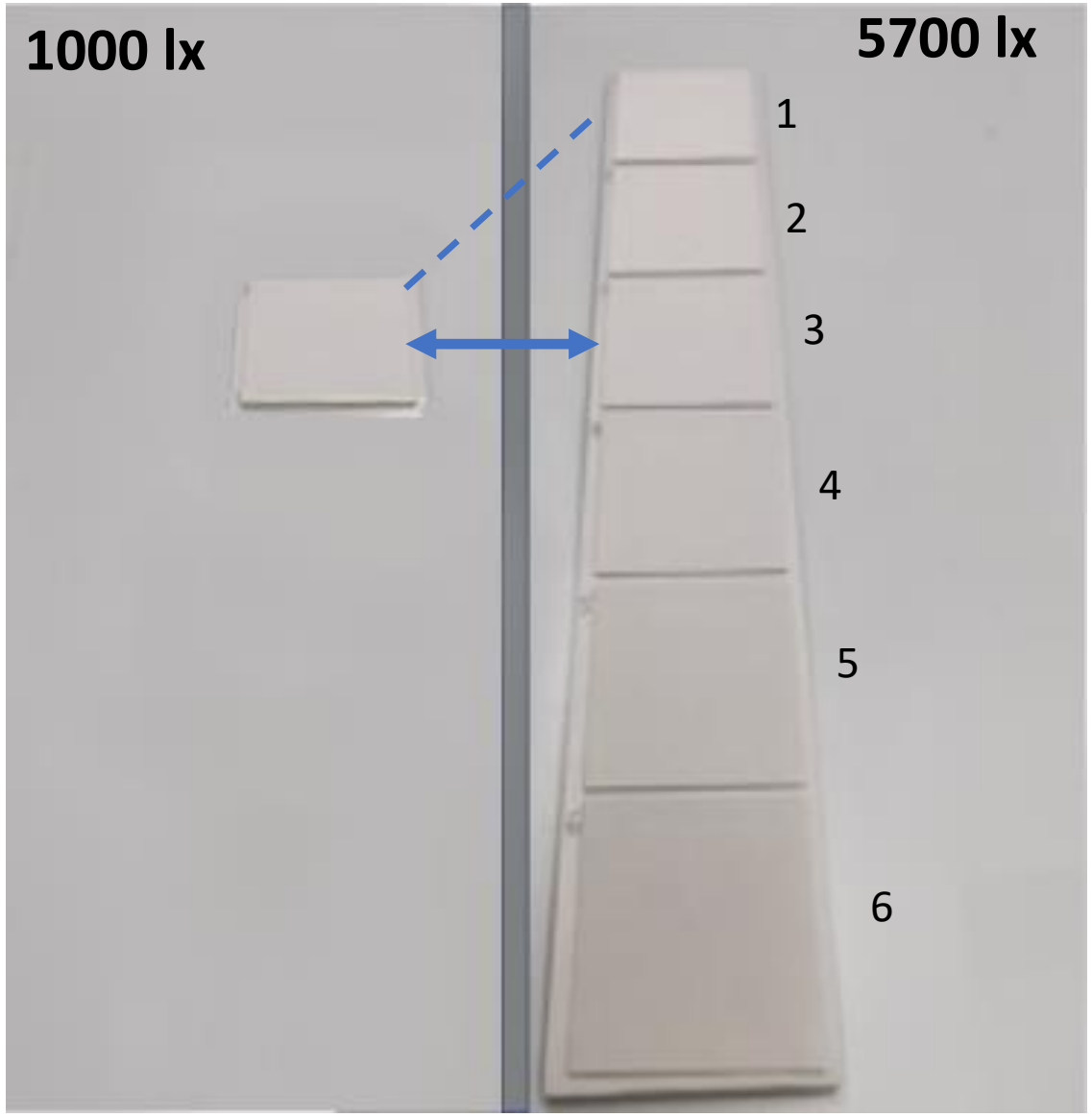


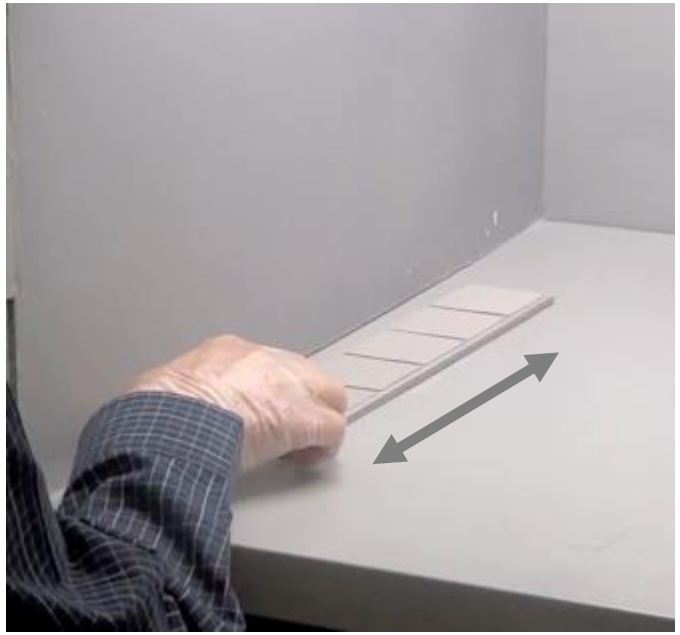




N = 16

Testing haploscopic adaptation (lightness matching)

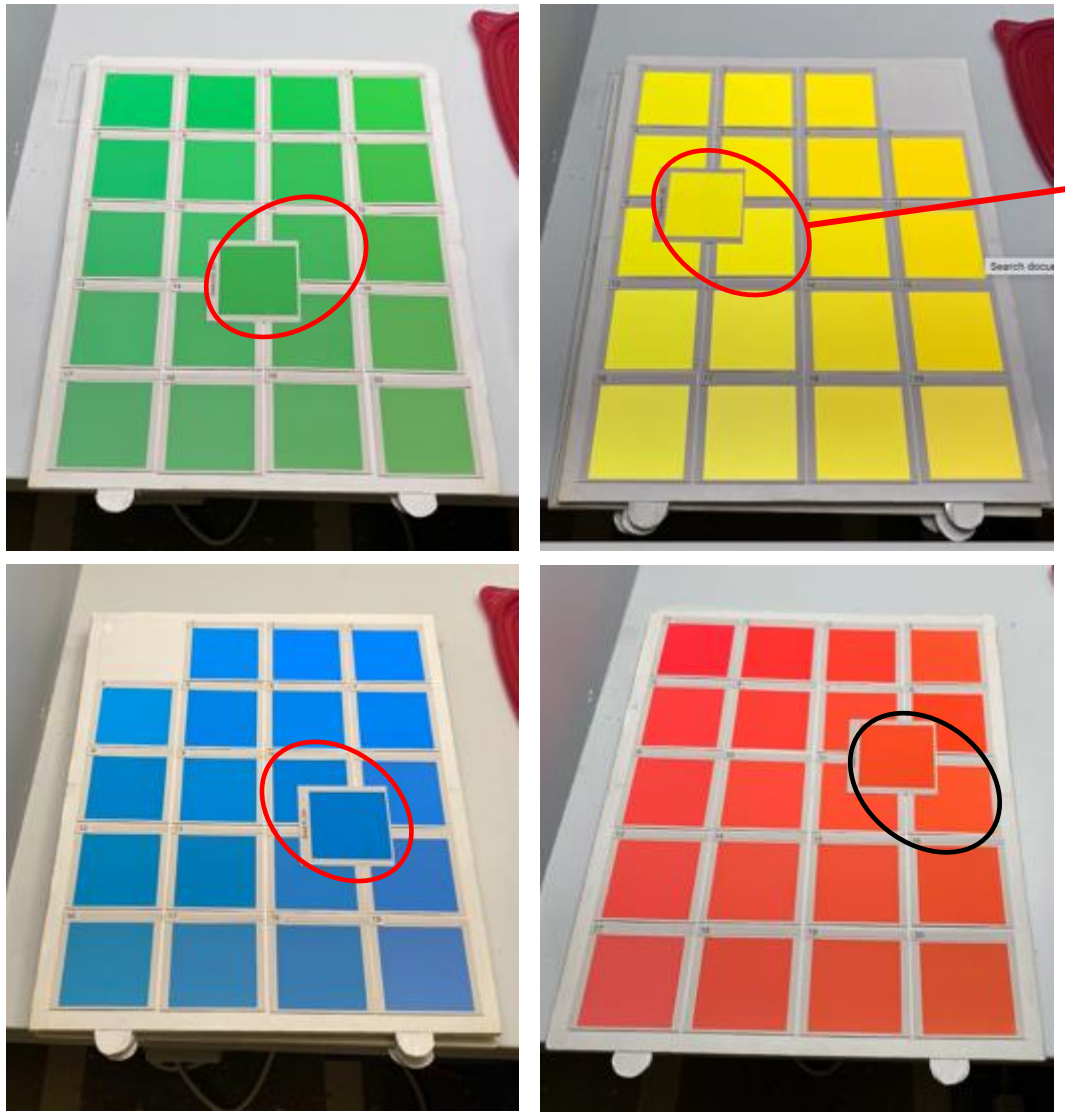




- The grey patches No. 2 to No. 4 were typically chosen

The reference patches in the 1000 lx side appeared slightly darker due to imperfect adaptation

Experiment to determine lightness correction factors



- New (darker) reference patches

  The hue and chroma are the same, only lightness of the reference is lower (darker by two gray steps)

- 11 subjects compared the new patches with the five patches in a column of same hue angle

Results

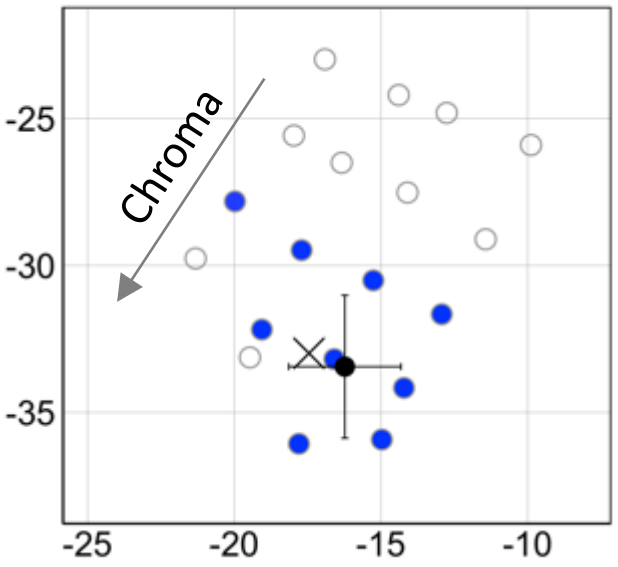
New references appear slightly higher chroma

	$\Delta C^*_{a'b'}$	Correction Factors
Green	≈0.14	0.07
Yellow	≈1.50	0.75
Blue	≈0.41	0.20
Red	≈0.50	0.25

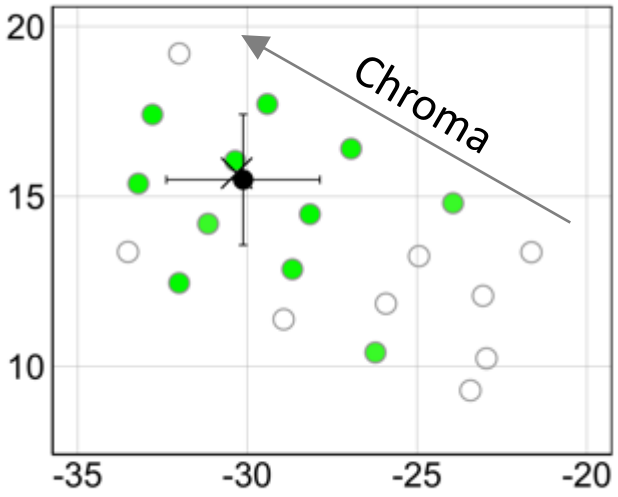
unit: $\Delta C^*_{a'b'}$/gray step

Result – before adaptation correction

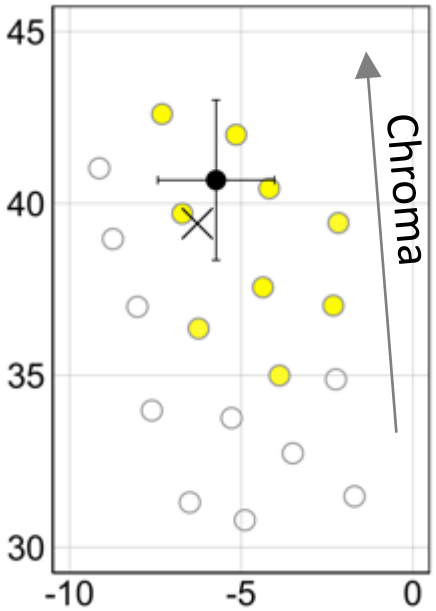
Blue



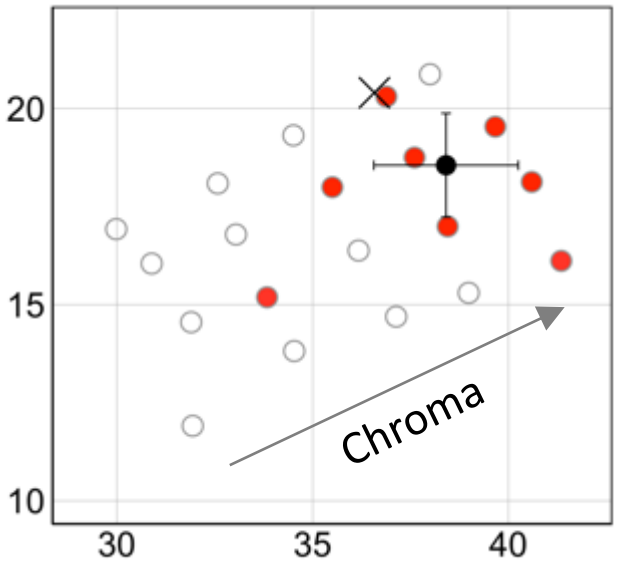
Green



Yellow

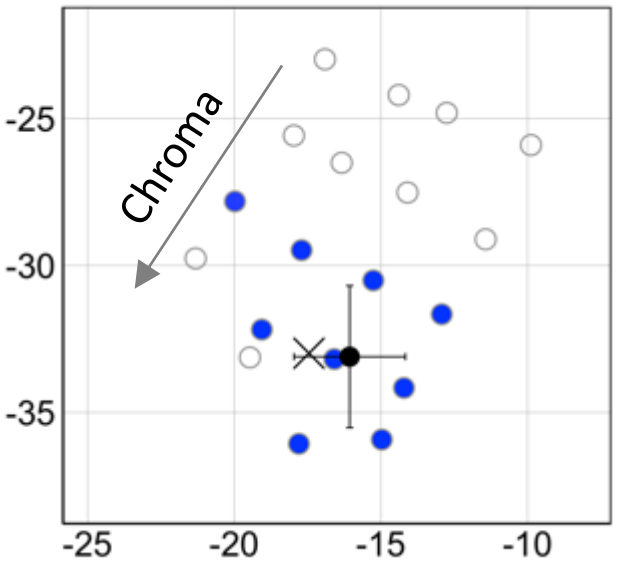


Red

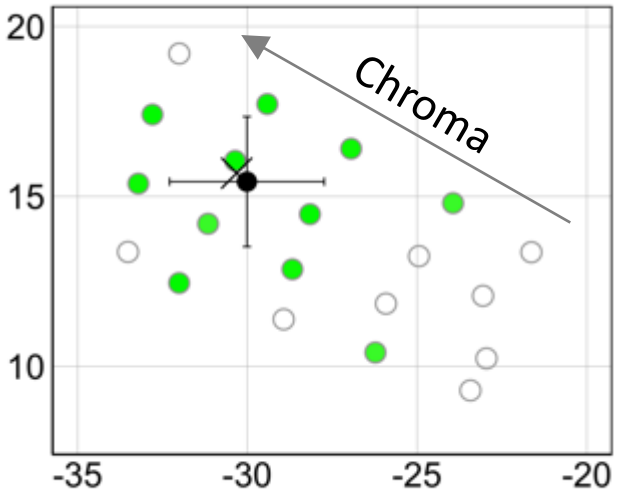


Results – after adaptation correction

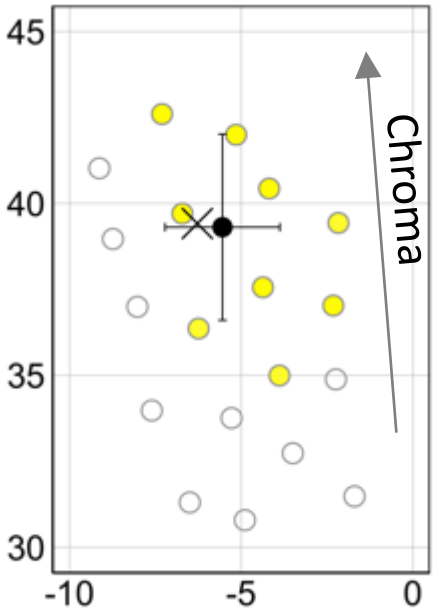
Blue



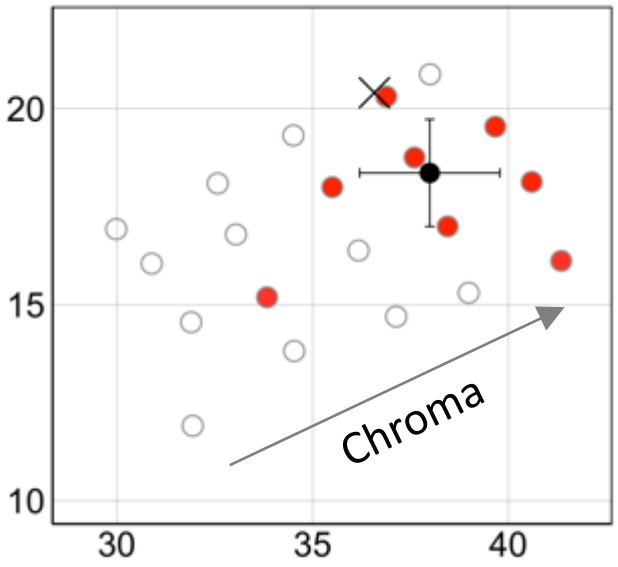
Green



Yellow

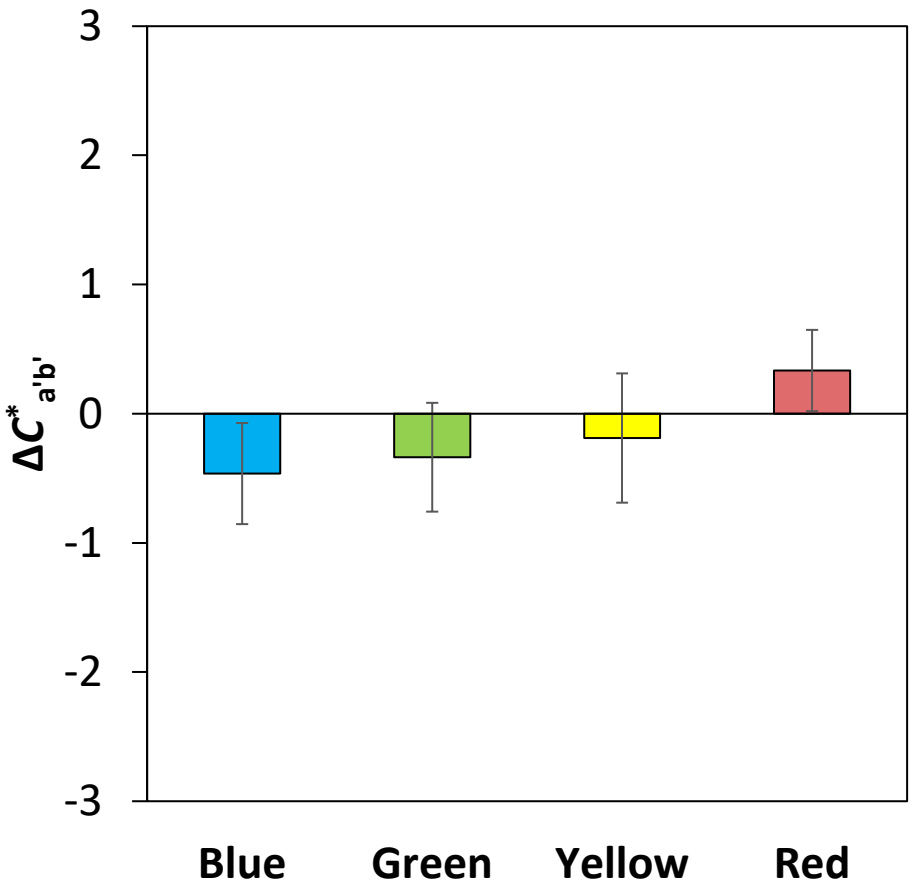


Red

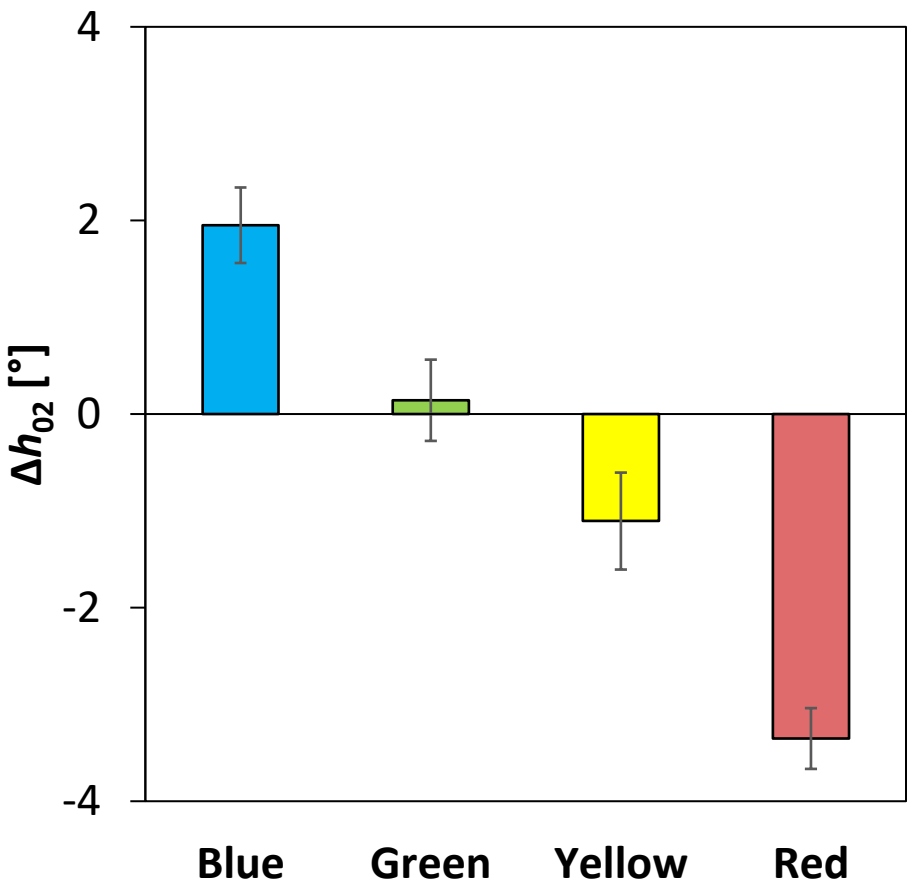


Results – after adaptation correction

Change of chroma from 5700 lx to 1000 lx

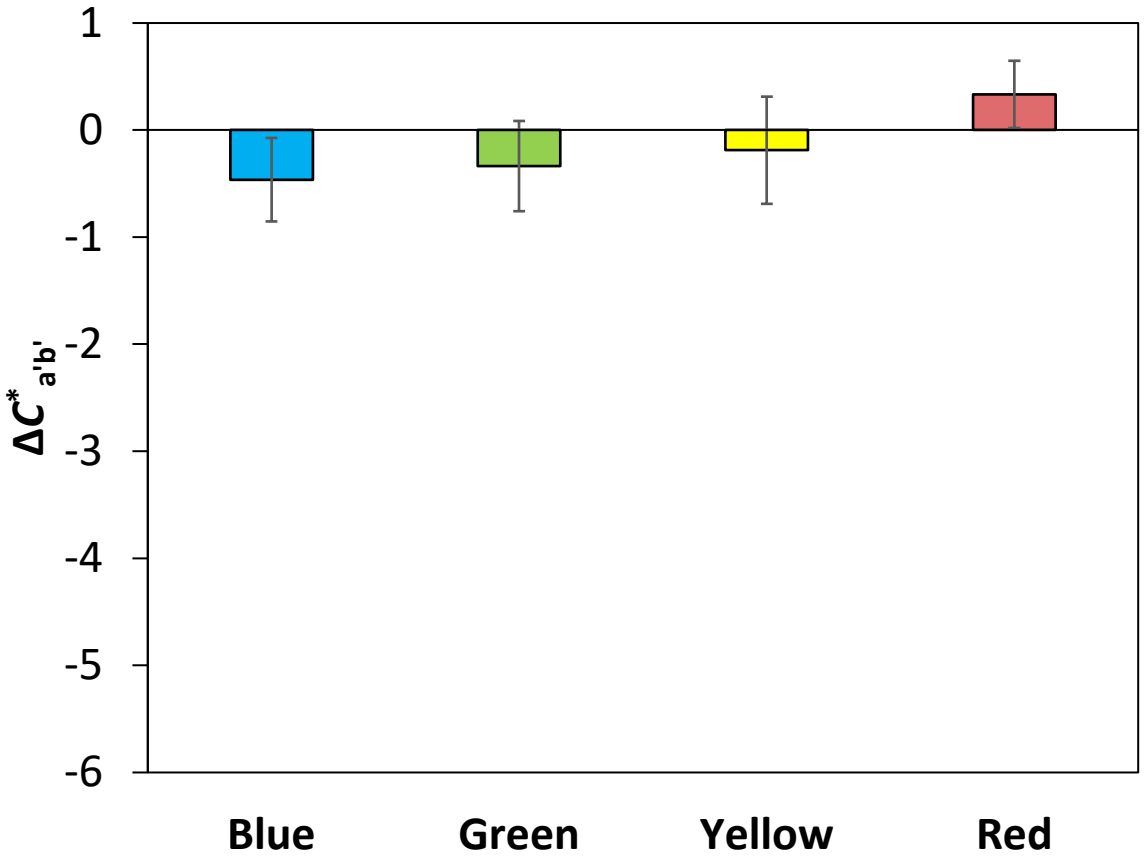


Change of hue from 5700 lx to 1000 lx

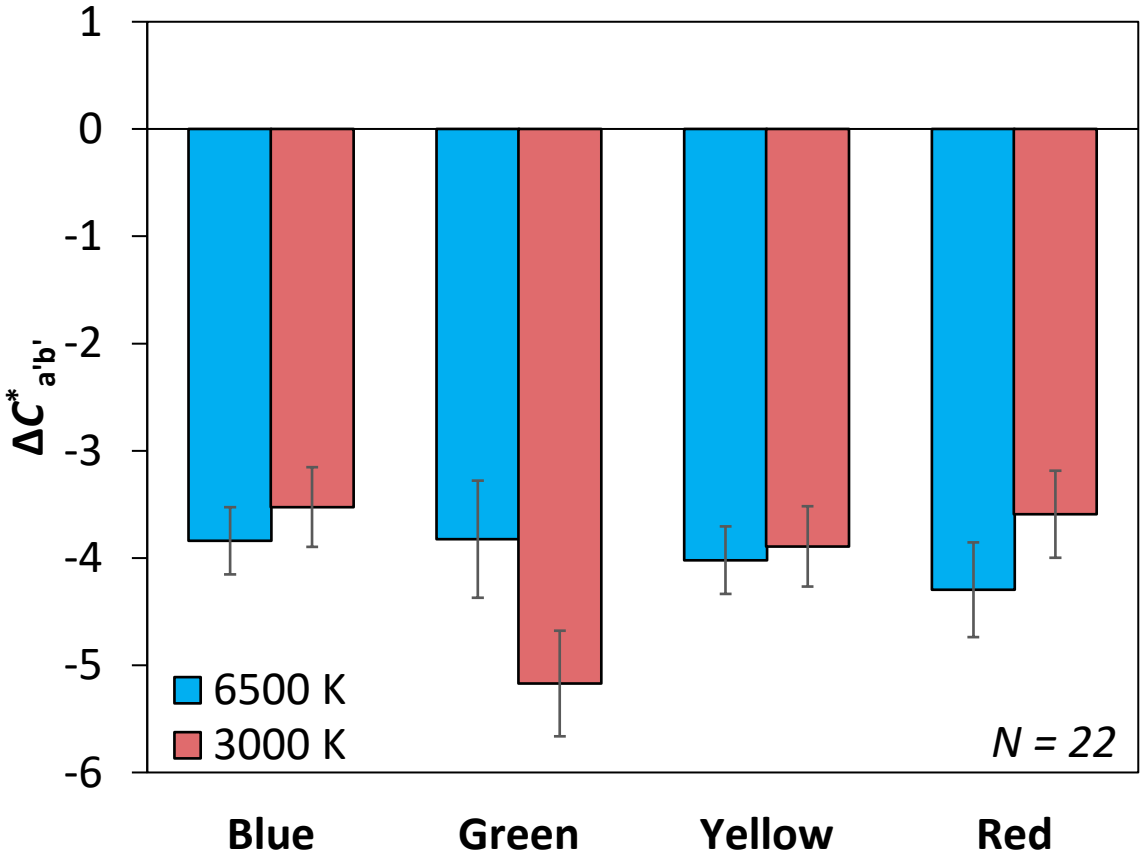


Chroma changes results compared to 2019

2021: 5700 lx to 1000 lx

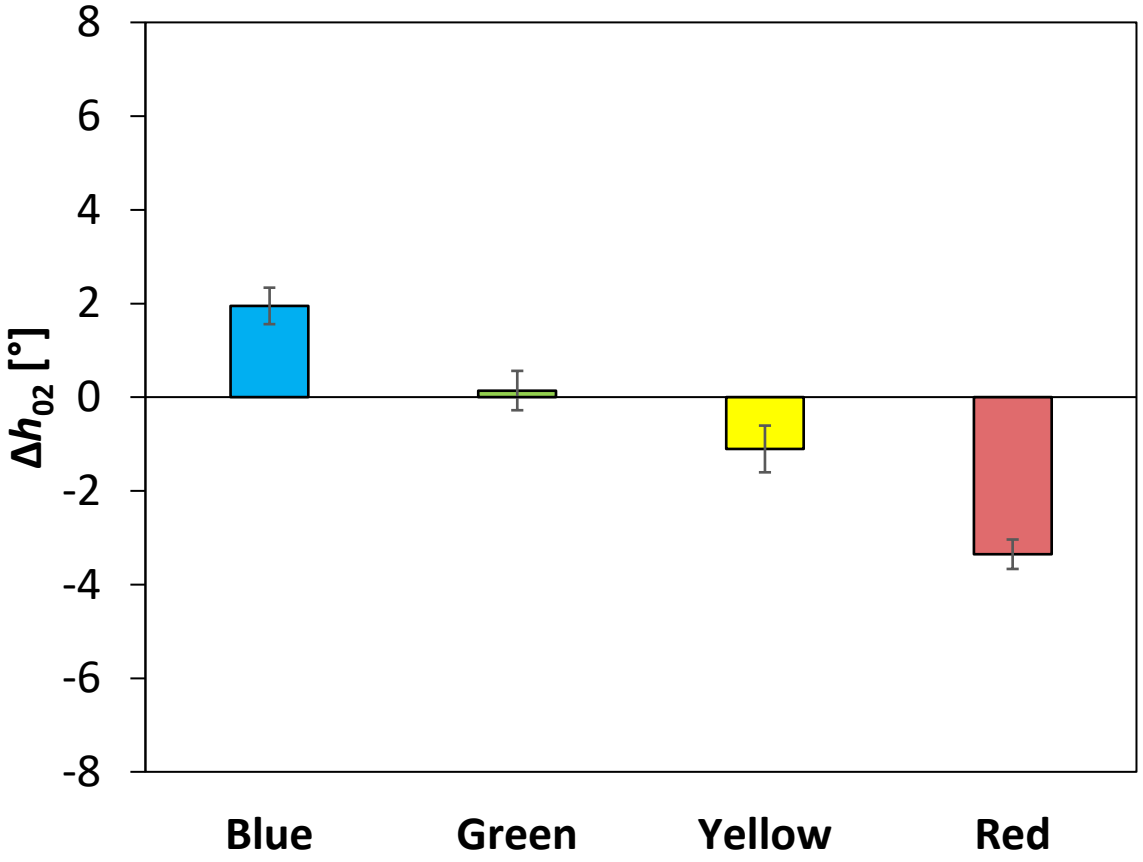


2019: 1000 lx to 100 lx

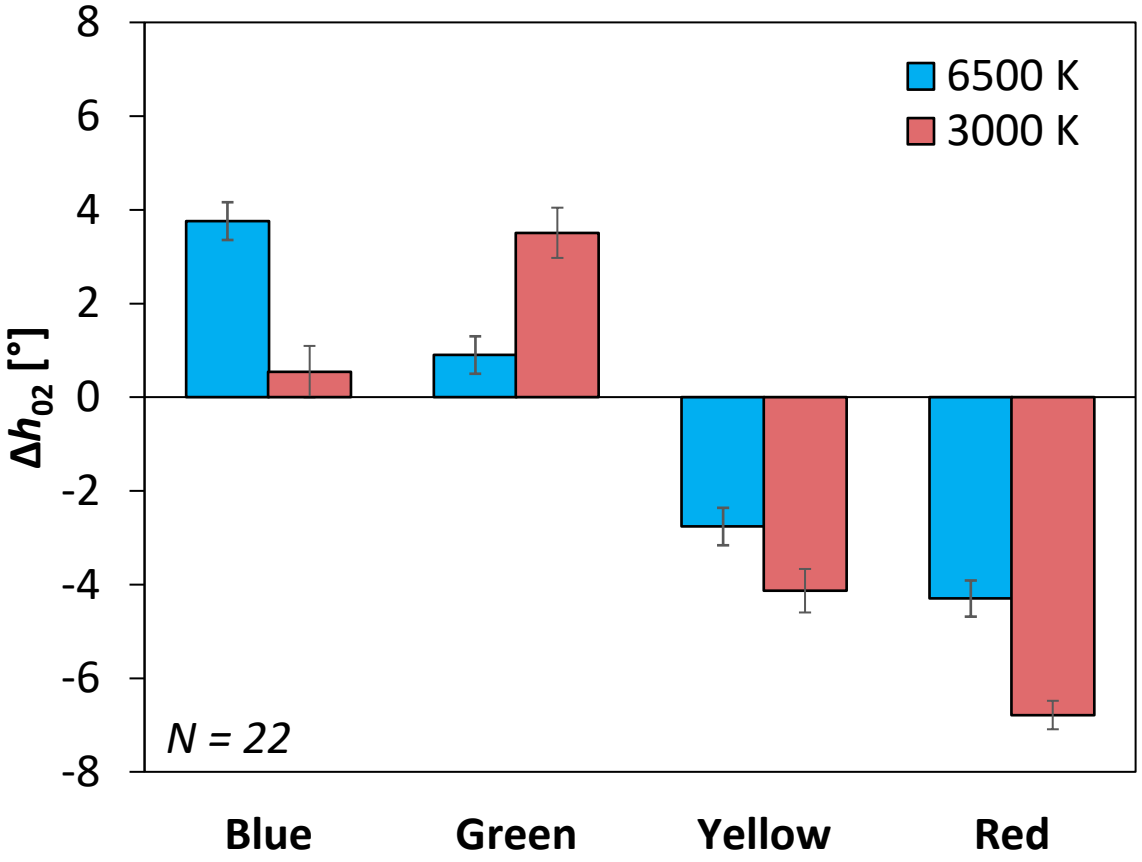


Hue changes results compared to 2019

2021: 5700 lx to 1000 lx



2019: 1000 lx to 100 lx



Conclusions

- The perceived chroma changes between 1000 lx and 5700 lx are much smaller (average $\Delta C^*_{a'b'}$ less than 0.5) and insignificant compared to the results between 100 lx and 1000 lx found in our previous study (average $\Delta C^*_{a'b'} \approx 3.5$)
- Small hue angle changes were also observed
- These data will be useful for developing a color fidelity model based on the Hunt Effect using the outdoor daylight condition as the reference, which may lead to an improved tool or a metric for evaluating color rendition of light sources

CIE 2021 Proceedings paper (open access) "Perceived Chroma and Hue Changes of Colours at High Illuminance Levels Due to Hunt Effect" will be published.

Acknowledgement

We thank all the NIST colleagues who participated in this experiment as subjects.

THANK YOU !