MANUSCRIPT UNDER REVIEW - JUNE 2021 ##.

SHINE_color: controlling low-level properties of colorful images

Rodrigo Dal Ben
Concordia University
0000-0003-2185-8762 (orcid)

Summary

Pupil dilation responses can be used to investigate an array of cognitive abilities across the lifespan [@Hepach2016; @Sirois2014; @Zhang2019; @Zhao2019a]. Whereas it is a versatile measure of high-level abilities, pupil dilation can be greatly affected by low-level properties of stimuli and experimental setting such as luminance of visual stimuli and experimental room [e.g., @Hepach2016; @Tsukahara2020].

One powerful way to control low-level properties of experimental stimuli is to use the SHINE toolbox for MATLAB [@Willenbockel2010]. This toolbox contains a set of functions that allows users to precisely specify luminance and contrast, histogram, and Fourier amplitude spectra of visual stimuli. These parametric manipulations minimize potential low-level confounds when investigating higher-level processes (e.g., cognitive effort, recognition). However, SHINE only works with greyscale images. Whereas this serves well to many research purposes [e.g., @Lawson2017; @Rodger2015], other research goals might benefit from colorful images [e.g., @Cheng2019; @Hepach2016; @Zhang2019]. Here, we describe the SHINE_color, an adaptation of SHINE that allow users to perform all operations from SHINE toolbox to colorful images.

Implementation

The SHINE_color toolbox works in an intuitive way (\autoref{fig:Figure 1}). Once called in the command window of MATLAB, by typing SHINE_color, the script guides the user through a series of questions that specify the input files characteristics (either a set of images or a video) and the operations to be performed (luminance, histogram, Fourier amplitude spectra specification; \autoref{fig:Figure 1}). Following, the input RBG images are transformed to HSV images. If a video is provided, its' frames are first extracted, then they are transformed to HSV color space. The HSV color space separates Hue, Saturation, and Value (luminance) channels. Once transformed, Hue and Saturation are hold in memory and are not manipulated, but the Value channel (originally ranging from 0 to 1) is rescaled to match greyscale range (from 0 to 255). Then, all operations from SHINE (Table 1) can be performed in the scaled Value channel. Following, the Value channel is rescaled to its' original range (0-1) and is combined with its' original Hue and Saturation channels. These HSV images are transformed back to RBG images. For videos, the frames are recombined back into a video. In addition, to quantify the changes, the mean and standard deviation of each image's Value channel is automatically calculated before and after manipulations.

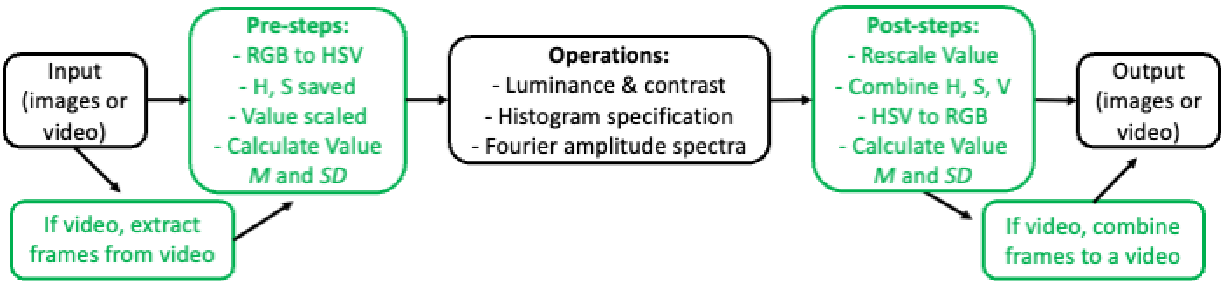

Table 1. Overview of the functions from SHINE_color. Most functions come from the SHINE toolbox, and their descriptions are also available on REF. Single stars (*) denotes functions that has been adapted from SHINE, double stars (**) indicates new functions from SHINE_color. Functions are listed in alphabetical order.

Function	Description
avgHist	computes average histogram
frames2mpeg**	creates a mpeg (.mp4) video from a sequence of frames
getAllFilesInFolder**	read all frames from a folder
getRMSE	computes root mean square error
hist2list	transforms histogram into a sorted (darker-to-brigther) list
histMatch	exact histogram matching across images
imstats	computes image statistics
lum_calc**	computes the luminance average and standard deviation
lumMatch	scales mean luminance and contrast
match	histogram specification
readImages*	read input images and apply the v2scale function (see below)
rescale	luminance rescaling
scale2v**	scales the Value channel from greyscale range to HSV range
separate	foreground-background segregation
sfMatch	equates the rotational average of the amplitude spectra
sfPlot	plots the energy at each spatial frequency
SHINE_color*	main function for loading, equating, and saving greyscale and colorful images
specMatch	matches amplitude spectrum
spectrumPlot	plots amplitude spectrum
ssim_index	computes Structural Similarity index
ssim_sens	computes SSIM gradient
tarhist	computes a target histogram
v2scale**	converts RGB to HSV color spaces, extracts the Value channel, and scale it to greyscale range
video2frames**	extracts all frames from a video

The SHINE_color toolbox is openly available at OSF and GitHub. Plans for future development include a MATLAB guided user interface and an adaptation to Python language, for integration with experimental packages such as PsychoPy [@Peirce2019]. The control of low-level properties of visual stimuli is an essential step for minimizing confounds that might affect pupil dilation responses [@Hepach2016; @Sirois2014; @Tsukahara2020]. SHINE_color allow users to take full advantage of the powerful functions from the SHINE toolbox [@Willenbockel2010] for controlling low-level properties of colorful images and videos.

Acknowledgments

I am thankful for my former supervisors, Jessica Hay, Ph.D., and Debora de Hollanda Souza, Ph.D., for their support. This work was partially funded by grants from FAPESP (#2015/26389-7, #2018/04226-7) and CAPES (#001). The funders had no role in study design, data collection, analysis and interpretation of the data, decision to publish, or preparation of the manuscript.

References

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inputs. Infants have also been shown to make predictions with simple stimuli and recent work has suggested top-down processing is available early in infancy. However, it is unknown whether this indicates that top-down prediction is an ability that is continuous across the lifespan or whether an infant's ability to predict is different from an adult's, qualitatively or quantitatively. We employed pupillometry to provide a direct comparison of prediction abilities across these disparate age groups. Pupil dilation response (PDR) was measured in 6-month olds and adults as they completed an identical implicit learning task designed to help learn associations between sounds and pictures. We found significantly larger PDR for visual omission trials (i.e. trials that violated participants' predictions without the presentation of new stimuli to control for bottom-up signals) compared to visual present trials (i.e. trials that confirmed participants' predictions) in both age groups. Furthermore, a computational learning model that is closely linked to prediction error (Rescorla-Wagner model) demonstrated similar learning trajectories suggesting a continuity of predictive capacity and learning across the two age groups.},
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