A Glance at Psychophysics Software Programs

Ali Yoonessi [1,2], Ahmad Yoonessi [3]

1. School of Advanced Medical Technologies, Tehran University of Medical Sciences, Tehran, Iran.
2. Iranian National Center for Addiction Studies, Tehran University of Medical Sciences, Tehran, Iran.
2. McGill Vision Research, McGill University, Canada

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ABSTRACT

Visual stimulation with precise control of stimulus has transformed the field of psychophysics since the introduction of personal computers. Luminance and chromatic features of stimulus, timing, and position of the stimulus are the main features that could be defined using programs written specifically for psychophysical experiments. In this manuscript, software used for the psychophysical experiments have been reviewed and evaluated for ease of use, license, popularity, and expandability.

1. Introduction

Since the foundation of psychophysics by Ibn-Haytham in the 4th century (Solar Hijri, S.H.), scientists have been puzzled by the complexity of visual experience1. His method of controlled experiment made him the pioneer of scientific methods 2. With development of personal computers in 1970s, vision scientists realized the opportunity for a precise control over the experiments. With the usage of computer, it was possible to control how long a visual stimulus is shown with precision of milliseconds, how much light is reached to the eyes with precision of millilux, and where the stimuli is shown in relation to the fovea of the retina. A vast range of Color could be generated with combining the three guns of monitors, which necessitated the definition of new methods for identifying colors such CIE1976 or CIELab color spaces.

Several programs have been developed to allow the vision scientists to easily define their stimulus and record the response of the subjects. Among them, two popular freely available programs include Psychtoolbox3 and Psychopy4. Psychtoolbox is a toolbox written for Matlab, a commercially available software for signal processing. Psychopy is an open-source platform-independent program written under Python, a very popular programming tool. Visionegg is another open-source software for generating stimuli. Other programs include Presentation, e-Prime, and Psykinematix. These programs are commercial products and the prices vary up to more than 1000$. Some of them have been reported in the scientific literature, and the rest rely on advertisement for keeping the scientists informed. We will evaluate each program briefly and rate several aspects including source code availability, platform independence and community size in the following text.

2. PsychToolbox

Precise control of features of visual stimuli is required for psychophysical experiments. Such precision can be obtained using low-level programming languages such as C or Assembly. However, most psychophysicists are not familiar enough with these tools to write programs that they need. In addition, it will be time consuming even if they can. On the other hand, most high level

**** Corresponding Author:***
Ali Yoonessi, MD, PhD
School of Advanced Medical Technologies and Iranian National Center for Addiction Studies Tehran University of Medical Sciences.
Email:a-yoonessi@tums.ac.ir

programs do not contain customized code for creating and controlling visual stimuli. In 1995 and through a National Science Foundation grant, Brainard released first version of a toolbox for Matlab, a popular high level programming language5. Psychtoolbox Is a set of Matlab extensions consisting of compiled C plugins and Matlab M files customized for high-level psychophysical tasks such as data collection, response logging, and monitor calibration. It is available for MacOs/X, Microsoft Windows, and Linux distributions and is released under General Public License (GPL-2).

The toolbox can create visual stimuli for stereo vision on multiple monitors; can set an accurate timing for the stimuli presentation using techniques such as double buffering; and can generate fast 2 dimensional stimuli using batch drawing, texture mapping, and video playback. Psychtoolbox also supports OpenGL for fast and high precision three-dimensional output. In addition to visual stimuli, Psychtoolbox can generate low-latency, high precision 3-D sounds.

Several other toolboxes for Matlab are based on Psychtoolbox. Eyelink toolbox (used for eye-tracking)6, and Masked Priming Toolbox7 are among those toolboxes. Psychtoolbox has the largest community size among all the psychophysics software. Most accessories available for vision scientists support Psychtoolbox integration.

3. Psychopy

Released in 2009, Psychopy is an open source software package written in Python programming language8. Python is a platform-independent programming language and Psychopy uses Python to generate visual and auditory stimuli for neuroscientists. It is also available for all three major operating systems (MacOs/X, Ms-Windows, and Linux), released under GPL, and is freely available. Psychopy also support OpenGL. Since Psychopy and Vision Egg use Python as the platform, their time precision is more accurate than the other rivals.

The advantage of Psychopy over Psychtoolbox goes back to its platform (Python) which is freely available, compared to Psychtoolbox platform (Matlab), which is a commercial and relatively expensive package. While installing Python and Psychopy are more difficult than installing Matlab and Psychtooolbox, Psychopy can generate stimuli faster and can be used to generate stimuli on the fly. Psychopy also enjoys an automated tool for calibration of displays.

Psychopy community size is relatively small compared to Psychtoolbox, while its popularity has gained increase in recent years.

4. Vision Egg

Vision Egg is a free, open-source library written in Python with some extensions in C released in 20019. Its main focus is on using the OpenGL capabilities embedded in new graphic cards. At that time, most of the graphic cards did not support OpenGL capabilities and therefore, it did not gain much popularity. OpenGL is an open-source cross-platform, cross-language API for generating 2D and 3D computer graphics and its use in popular software such as CAD, Virtual Reality, video games and flight simulation has made it a widely accepted standard for computer graphic generation. OpenGL mainly uses the Graphic processing Unit

Table 1. this table compares the features of the above mentioned open-source software programs.

	Psych Toolbox	Psychopy	Vision Egg
Free	✓ (Matlab is required)	✓✓	✓✓
Open Source	✓ (Matlab is required)	✓✓	✓✓
Platform Independence	✓	✓	✓
Usability	✓✓	✓✓	✓
Automated Calibration	✓	✓✓	✓
Real-time Stimuli	✓	✓	✓✓
Hardware Interfaces	✓	✓	✓✓
Community Size	✓	✓	✓✓

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(GPU) embedded on the graphic cards rather than the Central Processing Unit (CPU) on the motherboards. This feature allows the stimuli to be generated much faster and independent of the workload of CPU (i.e. the running programs on the computer do not slow up the stimuli generation).

Vision Egg is object-oriented, and therefore it will take time for novice users to fully understand the concept of this type of programming. One of interesting capabilities of Vision Egg is the ability to remotely control the application via a TCP/IP standard protocol, which makes it a suitable candidate for remote collaborations. Storage of the stimulus library as a form of a database is another advantage of Vision Egg. Each stimuli record in the database consist of the stimuli itself with its timing, its luminance, frame rate and other features such as the sequence of the stimuli. Overall, Vision Egg is a suitable candidate for flexibility and well controlled experiment, while setting up an experiment is not as easy as other open-source psychophysical software.

5. Other Software

Presentation is a commercial software written by Neurobehavioural System Inc. for Windows operating System. E-Prime is another software tool for Windows offered by Psychology Software Tools Inc., the same company that offers fMRI software Brain Voyager. Psykinematix from KyberVision is available only for MacOs/X with a complete GUI for designing experiments. Psykinematix has an iPhone version for running experiments on iPhone/iPad devices.

6. Comparison of Software Programs

Several software programs are developed for Psychophysical experiments and are being upgraded rapidly. This is a rapidly changing field and currently, the most popular software is PsychToolbox. Table 1 (adopted from Pierce 2007) compares the features of the above mentioned open-source software programs.

7. Discussion

Currently, PsychToolbox is the most popular software program for psychophysical experiments. Its setup and installation is also easy. It relies on installing Matlab, a commercial software. Vision Egg and Psychopy are two full open-source software programs. Vision Egg relies heavily on OpenGL standard, which its various capabilities can bring more exciting ways of exploration of the visual system. Psychopy is easier to install than Vision Egg and have gained an increasing popularity in the last two years.

For the novice users, PsychToolbox possibly is the best choice. Many sample source codes are available online, it is easy to setup and it gives the full functionality a vision scientists might need. On the other hand, Psychopy would be a good choice for more advanced users who do not wish to buy Matlab. Vision Egg is suitable for very advanced users who want to fully utilize the 3D capabilities of the new graphic cards as well as remote control of their application.

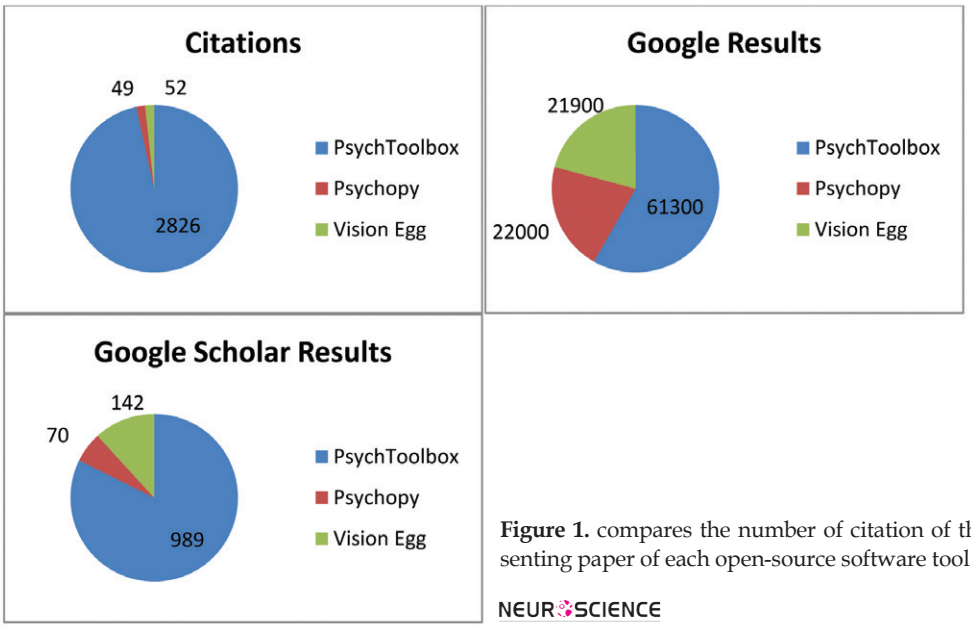

Figure 1. compares the number of citation of the presenting paper of each open-source software tool.

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