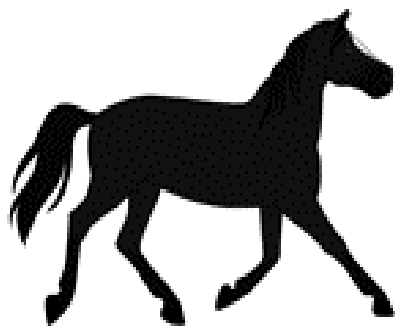




馬國杰
馬哥語系
老馬後進
天馬行空

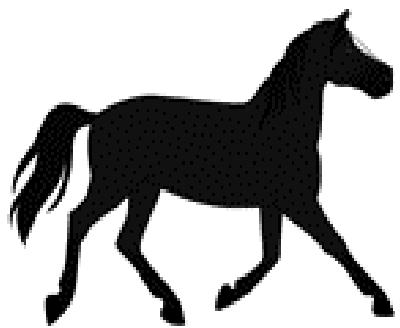


眼动仪（硬件与软件）

主讲：马国杰
陕西师范大学 心理学院
QQ群：513581118
微信公众号：眼动之家

目录

- 眼动仪大观园
- 发展简史
- 硬件构成
- 软件构成

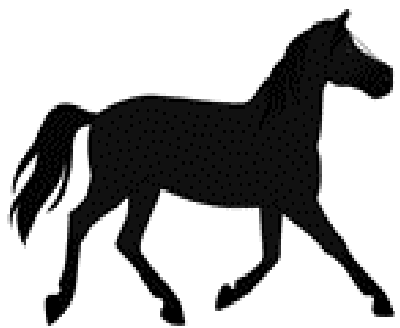


天馬行空
驚馬十駕
馬哥語系
老馬識途
走馬觀花



眼动仪大观园

- 头戴式
- 眼镜式
- 桌面式—遥测
- 塔式



天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



眼动仪大观园

▼ 头戴式

ASL



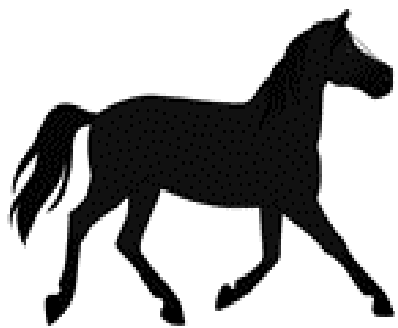
单目H6 光学系统



双目H6 光学系统

单目眼动系统（H6）50/60Hz，单目高速眼动系统以及双目高速眼动系统可以达到 120Hz，240Hz，360Hz。（该公司有整合虚拟现实头盔的眼动仪）

See: <http://www.asleyetracking.com/Site/>



天馬行空
驚馬十駕
馬哥語系
老馬識途
走馬觀花



眼动仪大观园

▼ 头戴式

Arrington



NOVIS



Oculus



SENSICS



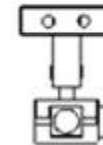
CYBERMIND



VIRTUAL FEATURES

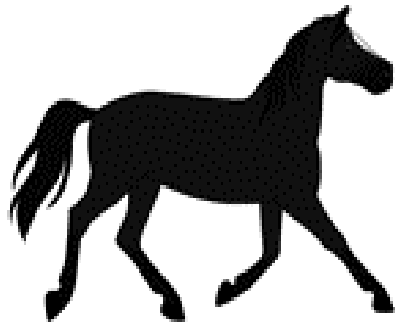


custom modules



整合定做头戴式眼动仪

See: <http://www.arringtonresearch.com/headmountframe.html>



驚馬十駕

天馬行空

馬哥語系

老馬識途

走馬觀花



眼动仪大观园

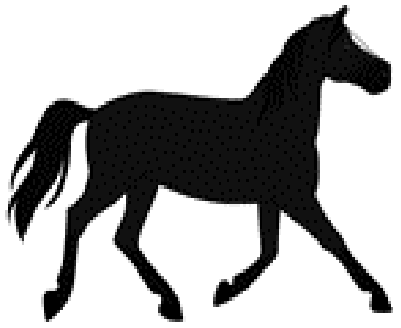
▼ 头戴式

SMI



整合头盔：头盔上装有红外光源、半反半透镜和两个摄像头。采样率50/200Hz
See: <http://www.smivision.com/en/gaze-and-eye-tracking-systems/products/eye-tracking-hmd-upgrade.html>

备注：SMI公司2017年被苹果收购，不再从事科研方向的眼动开发



馬哥語系
老馬識途
驚馬十駕
天馬行空



眼动仪大观园

▼ 头戴式

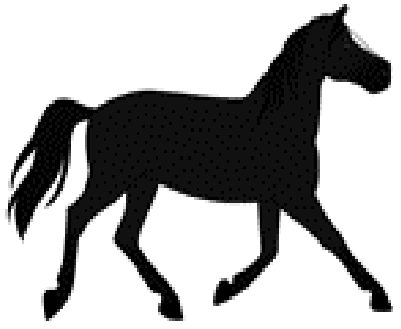
EyeLink II



Key Features

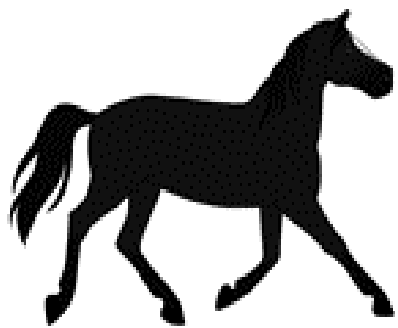
- 500 Hz binocular eye monitoring
- 0.5° average accuracy
- Access eye position data with 3.0 msec delay
- 0.01° RMS resolution
- High quality computer based or scene camera eye tracking
- Fast and simple participant setup, calibration, and validation

See: <http://www.eyelinkinfo.com/eyelinkII.html>



天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花





驚馬十駕 天馬行空

馬哥語眾

老馬識途

走馬觀花



眼动仪大观园

眼镜式

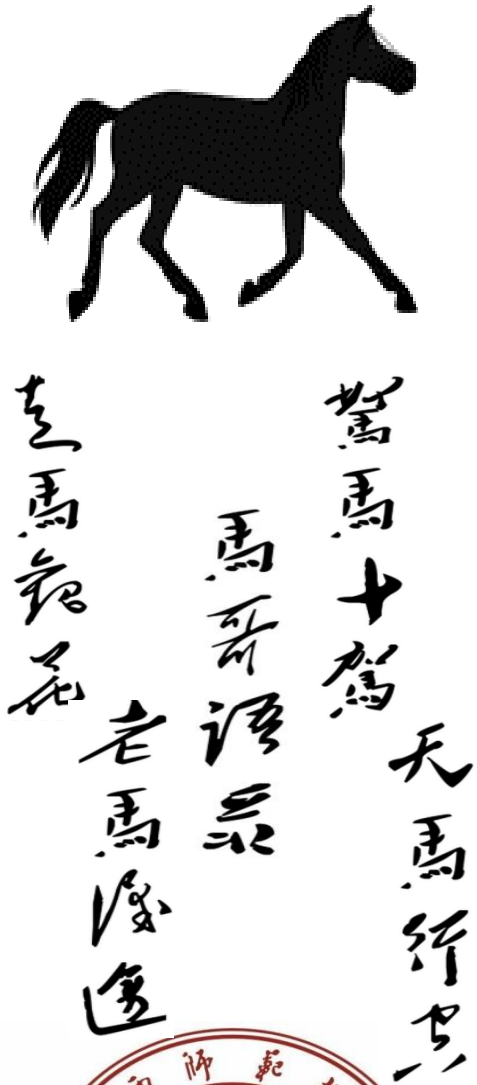
ASL eye-5



世界上最轻的重量，头箍+摄像头76g，电池工作130分钟，录像带长75分钟
采样率：25/30Hz

See:

<http://www.asleyetracking.com/Site/Products/MobileEye5Glasses/tabid/330/Default.aspx>



眼动仪大观园

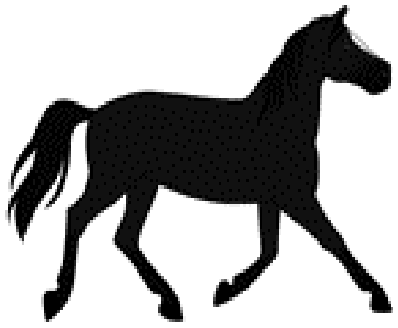
▼ 眼镜式

SMI



采样率：120Hz

See: <http://www.asleyetracking.com/Site/Products/MobileEye5Glasses/tabid/330/Default.aspx>



老馬識途
馬哥語眾
驚馬十駕
天馬行空



眼动仪大观园

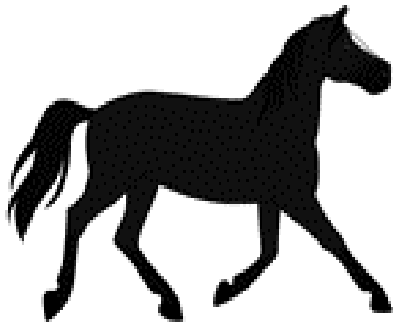
▼ 眼镜式

Tobii



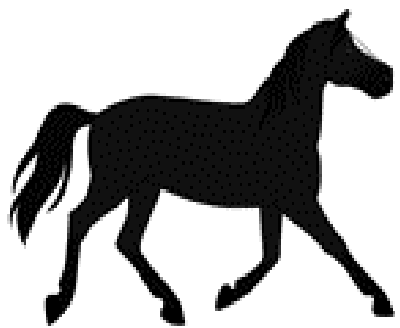
采样率：50/100Hz

See: <http://www.tobii.com/product-listing/tobii-pro-glasses-2/>



天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花





驚馬十駕 天馬行空

馬哥語眾

老馬識途

走馬觀花



眼动仪大观园

▼ 桌面式

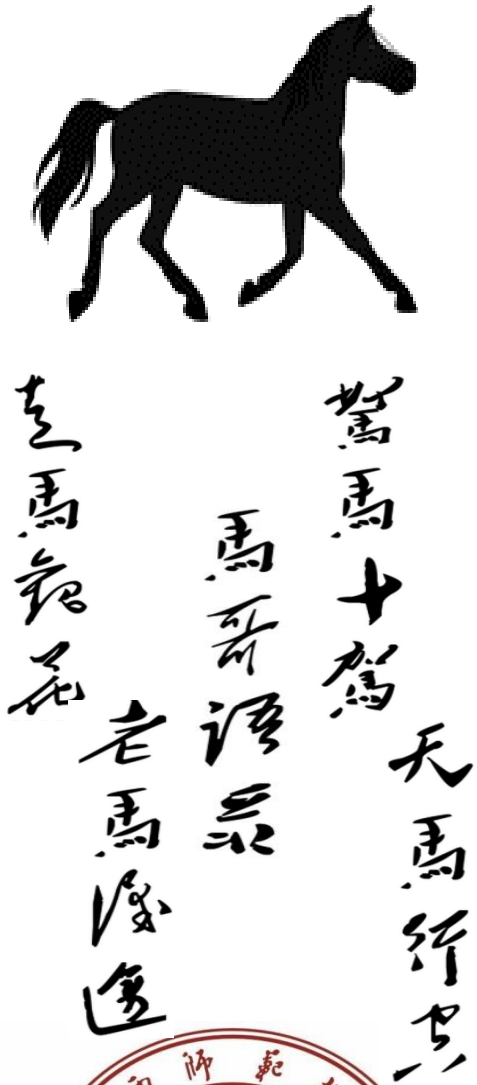
ASL Eye-track 7



采样率：120/240Hz

See:

<http://www.asleyetracking.com/Site/Products/EYETRAC7Series/RemoteDesktop/HighSpeed/tabid/67/Default.aspx>

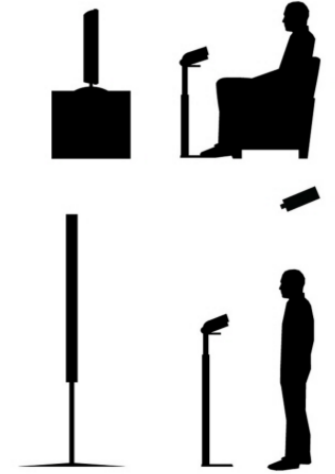


眼动仪大观园



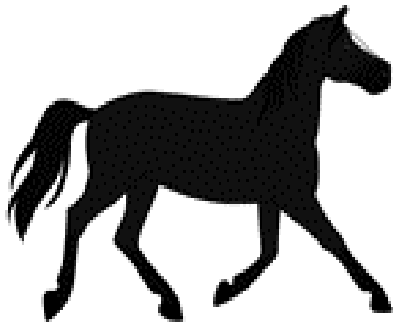
桌面式

Tobii TX300



采样率：300Hz

See: <http://www.tobiipro.com/product-listing/tobii-pro-tx300/>



天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



眼动仪大观园



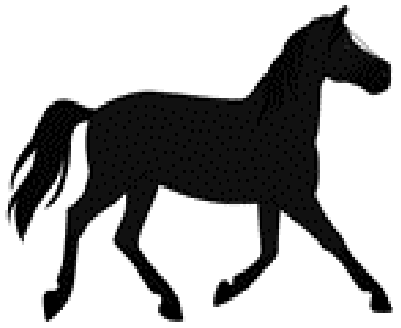
桌面式

Tobii Pro Spectrum



采样率：1200Hz

See: <https://www.tobii.com/product-listing/tobii-pro-spectrum/#Features>



驚馬十駕
馬哥語系
老馬識途
天馬行空
走馬觀花



眼动仪大观园



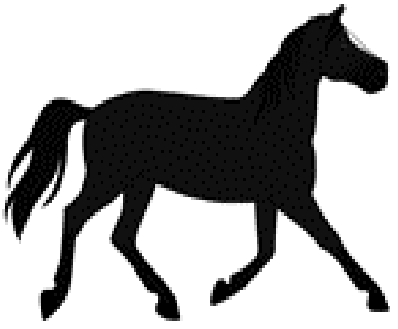
桌面式

SMI iview X red500



采样率：500Hz

See: <http://www.smivision.com/en/gaze-and-eye-tracking-systems/products/red250-red-500.html>



驚馬十駕 天馬行空

馬哥語系

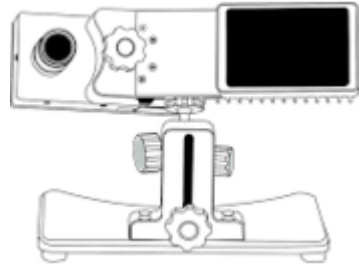
老馬識途

走馬觀花



眼动仪大观园

▼ 桌面式

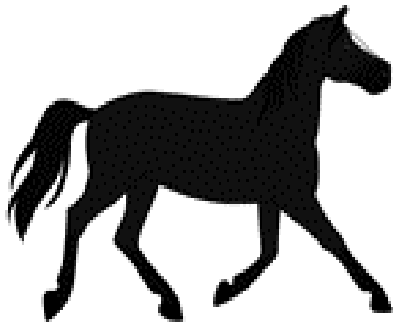


Eyelink 1000 plus



采样率：500Hz，遥测模块等

See: http://www.eyelinkinfo.com/camup_remote_1000plus.html



馬十駕 天馬行空
馬哥語系 老馬識途
走馬觀花

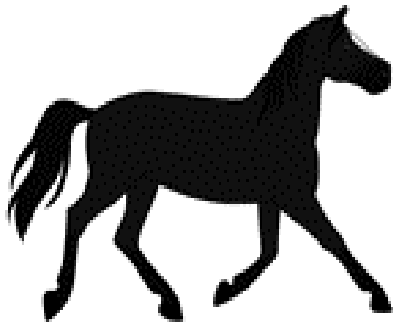


眼动仪大观园



桌面式

- EyeLink Portable Duo
 - 500Hz-2000Hz
 - 15-17寸 screen



馬十駕
馬哥語系
老馬後進
天馬行空
走馬觀花



00000858 ms

念奴娇·赤壁怀古

大江东去，浪淘尽，千古风流人物。故垒西边，人道是，三国周郎赤壁。乱石穿空，惊涛拍岸，卷起千堆雪。江山如画，一时多少豪杰。

遥想公瑾当年，小乔初嫁了，雄姿英发。羽扇纶巾，谈笑间，檣櫓灰飞烟灭。故国神游，多情应笑我，早生华发。人生如梦，一尊还酹江月。

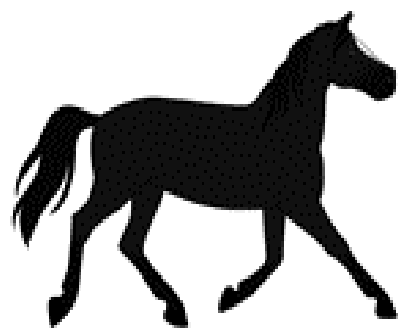
汉字位置编码研究

据根中科国学院心理所研表究明，汉字的序顺并不定一能影阅响读，比如当你看完这句话后，才发这现里的字全是都乱的。

重叠歧义词研究

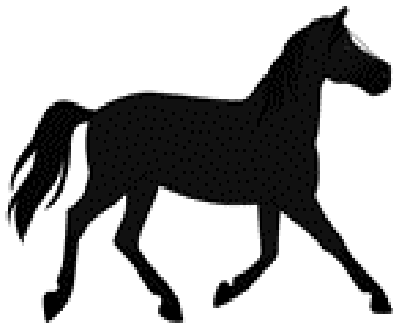
这位文学家从小吃了很多苦才有今天的成就

这位文学家从小吃谈起了北京的传统文化



老馬識途
馬哥語系
驚馬十駕
天馬行空





馬十駕 天馬行空
馬哥語眾 老馬識途
走馬觀花



Cambridge Research Systems



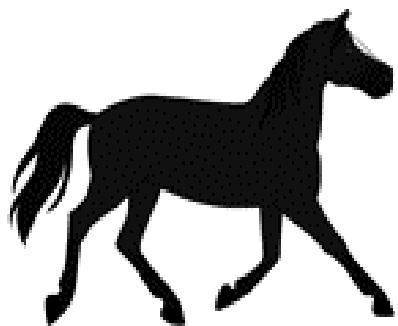
眼动仪大观园

▼
塔式

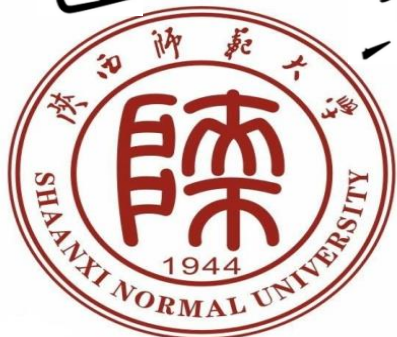
Ideal for oculomotor research
Low noise, drift free measurements
Better than 0.25° at 250Hz
Stereo option: contact CRS for details
First paper featuring HS-VET presented at
International Strabismological Association,
February 2006, Brazil.

Guide Price: £12750

 [Add to MyCRS](#)



老馬識途
馬哥語眾
驚馬十駕
天馬行空



眼动仪大观园

Arrington

HeadLock™ Ultra Precision Head Positioner™



Rigid



Stable



Comfortable

Remote / Desk Mounted



塔式

Prices

90 Hz systems

Item MHU903	Monocular	90 Hz	\$7,998
Item BHU903	Binocular	90 Hz	\$10,998

220 Hz systems

Item MHU03	Monocular	220 Hz	\$9,998
Item BHU03	Binocular	220 Hz	\$14,498

400 Hz systems

Item MHU400	Monocular	400 Hz	\$12,498
Item BHU400	Binocular	400Hz	\$17,998

Prices

90 Hz systems

Item MCU902	Monocular	90 Hz	\$5998
Item BCU902	Binocular	90 Hz	\$8998

220 Hz systems

Item MCU02	Monocular	220 Hz	\$7998
Item BCU02	Binocular	220 Hz	\$12,498

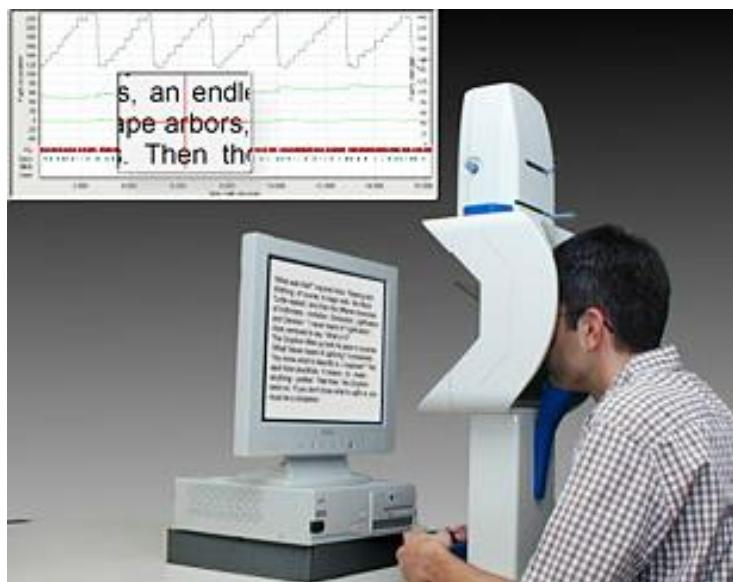
400 Hz systems

Item MCU400	Monocular	400Hz	\$9,998
Item BCU400	Binocular	400Hz	\$15,498

Wide variety of camera-to-eye distances available. From approximately 20 cm to 140 cm. Please specify approximate distance required when ordering.

眼动仪大观园

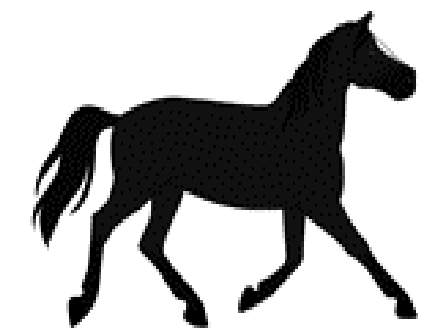
▼
塔式



SMI iView X Hi-Speed1250

性能：

- 采样率 1250 Hz / 500 Hz（单眼）， 500 Hz（双眼）；
- 追踪分辨率 $< 0.01^{\circ}$ （typ.）；
- 凝视精度 $0.25^{\circ} - 0.5^{\circ}$ （typ.）；
- 处理延迟 < 0.5 毫秒；
- 视角 水平($\pm 30^{\circ}$), 垂直 $+30^{\circ}$ （上） -45° （下）。



老馬識途
馬哥語系
驚馬十駕
天馬行空



眼动仪大观园

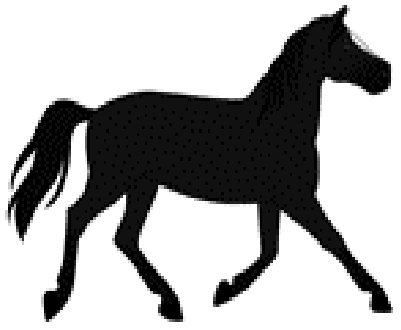
▼
塔式



EyeLink 1000 plus



采样率：1000Hz, 有2000Hz的升级模块



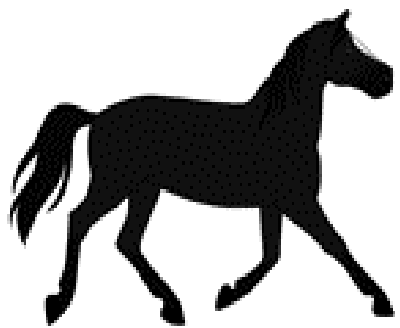
天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



眼动仪大观园

▼ 其它

- 整合
 - VR-眼动整合
 - 投影仪电视研究平台
 - 平板支架整合平台
 - 动物研究整合平台
- 国内眼动设备研发
 - 七鑫易维的VR整合
 - 青研的眼控应用
 - 等

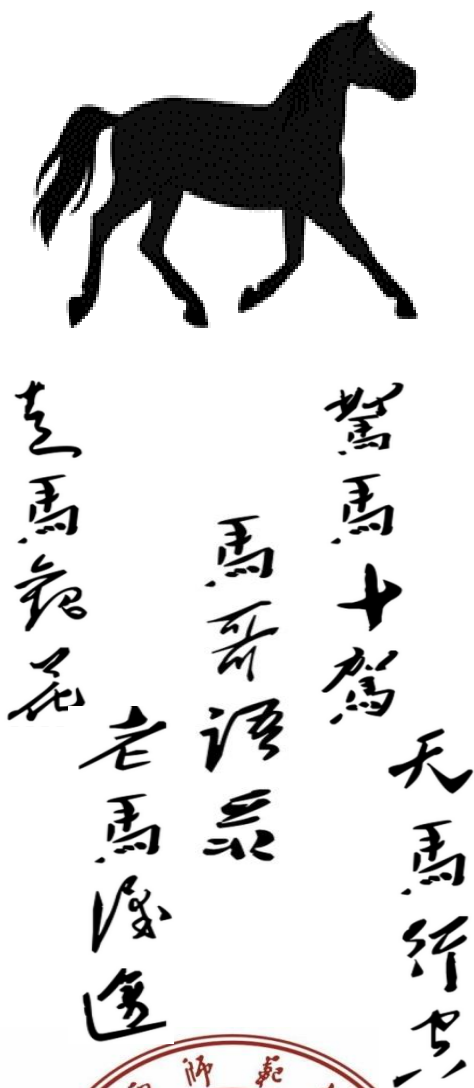


馬十駕
馬哥語系
老馬識途
天馬行空
走馬觀花



小结

- 如何选择眼动仪？
 - 实验需求
 - 经济成本
 - 可得性



眼动仪发展简史



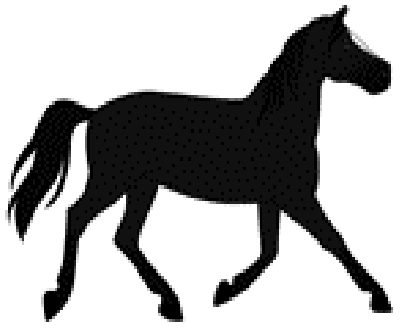
阅读材料

Yarbus, A. L. (1967). *Eye Movements and Vision*. New York: Plenum Press.

Young, L., & Sheena, D. (1975). Survey of eye movement recording methods. *Behavior Research Methods & Instrumentation*, 7(5), 397–429.

Rayner, K. (1998). Eye movements in reading and information processing: 20 years of research. *Psychological Bulletin*, 124(3), 372–422.

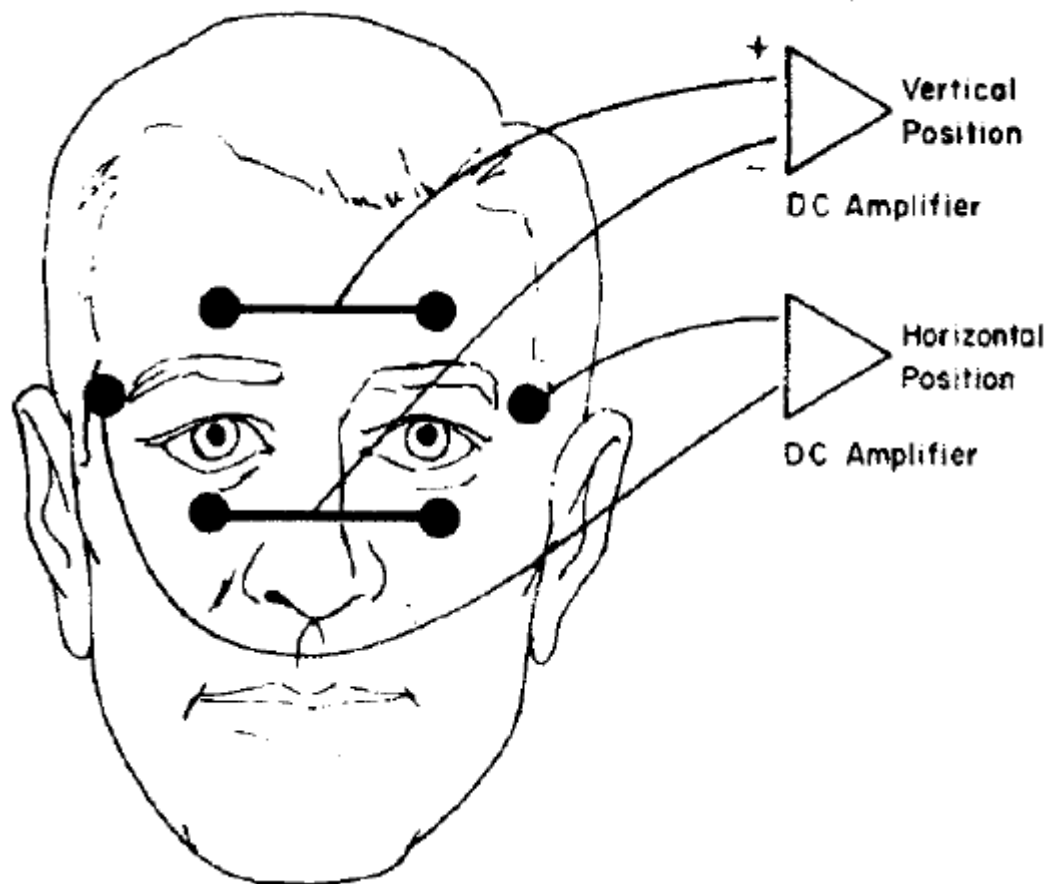
Duchowski. (2007). *Eye tracking methodology: Theory and practice*



馬十駕
馬哥語
老馬識途
天馬行空

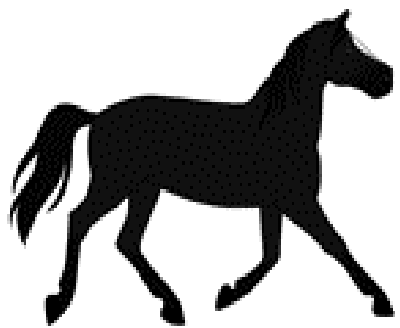


眼动仪发展简史



眼电记录法

"There is no appreciable lag between what is fixated and what is processed" (Just & Carpenter, 1980).

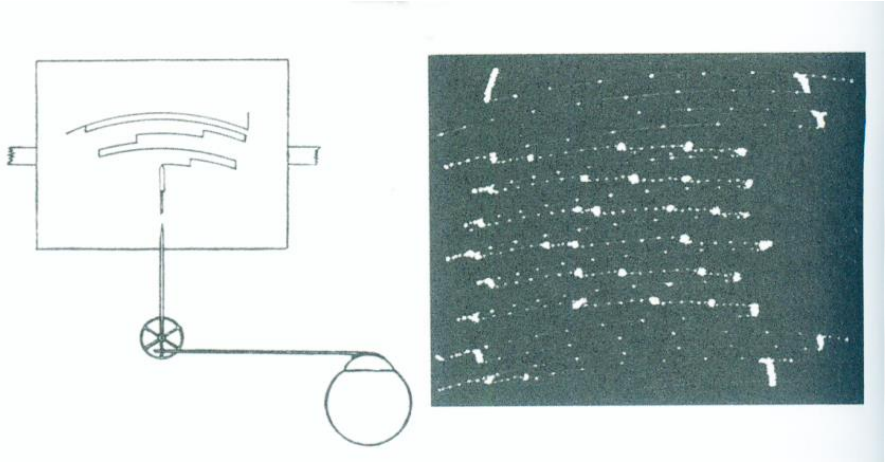


驚馬十駕
馬哥語系
老馬識途
天馬行空
走馬觀花



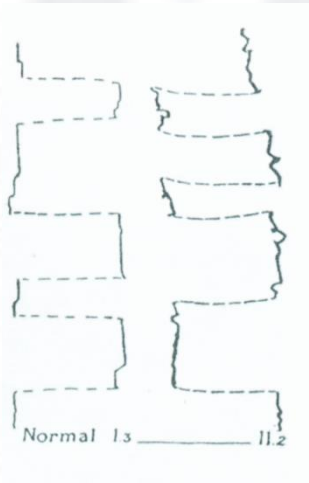
眼动仪发展简史

天馬行空
驚馬十駕
馬哥語系
老馬識途
走馬觀花



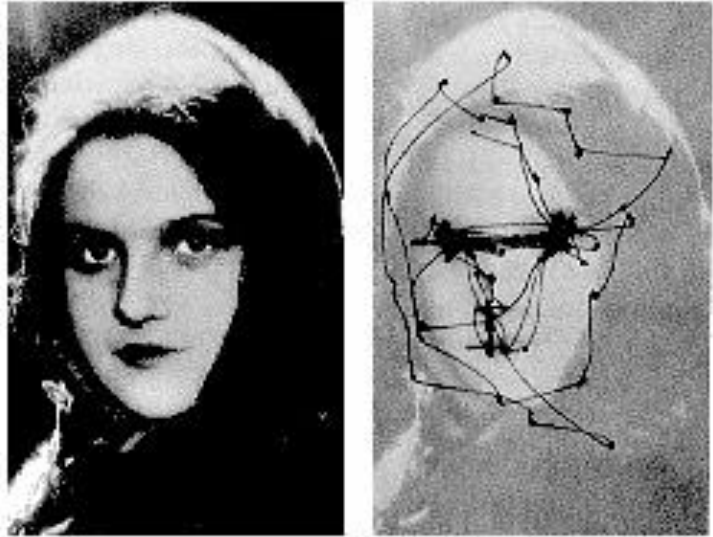
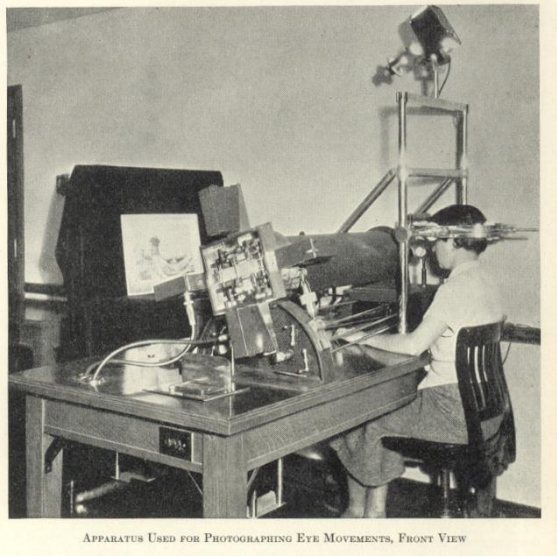
Huey, 1898

巩膜接触镜/搜索
线圈法

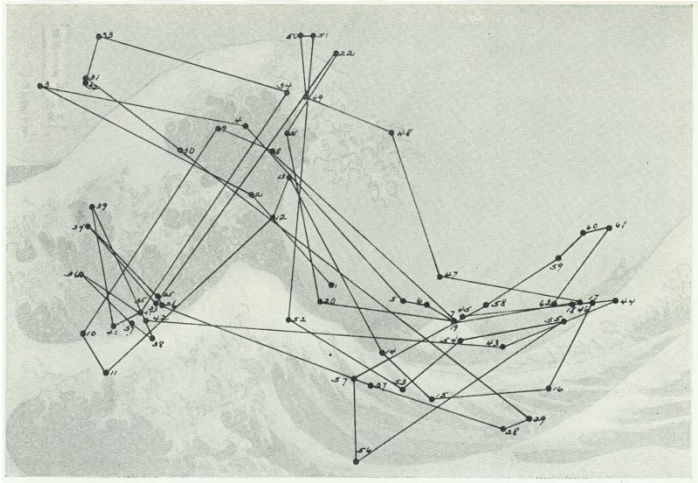
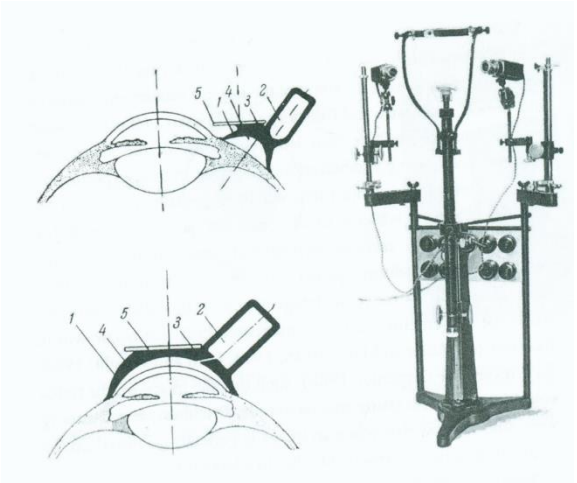


Diefendorf & Dodge, 1908

眼动仪发展简史

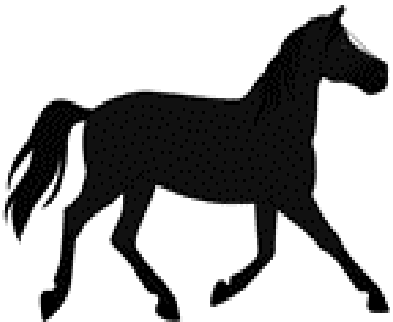


Buswell, 1935



眼图录像法

Yarbus, 1967



驚馬十駕 天馬行空

馬哥語系

老馬識途

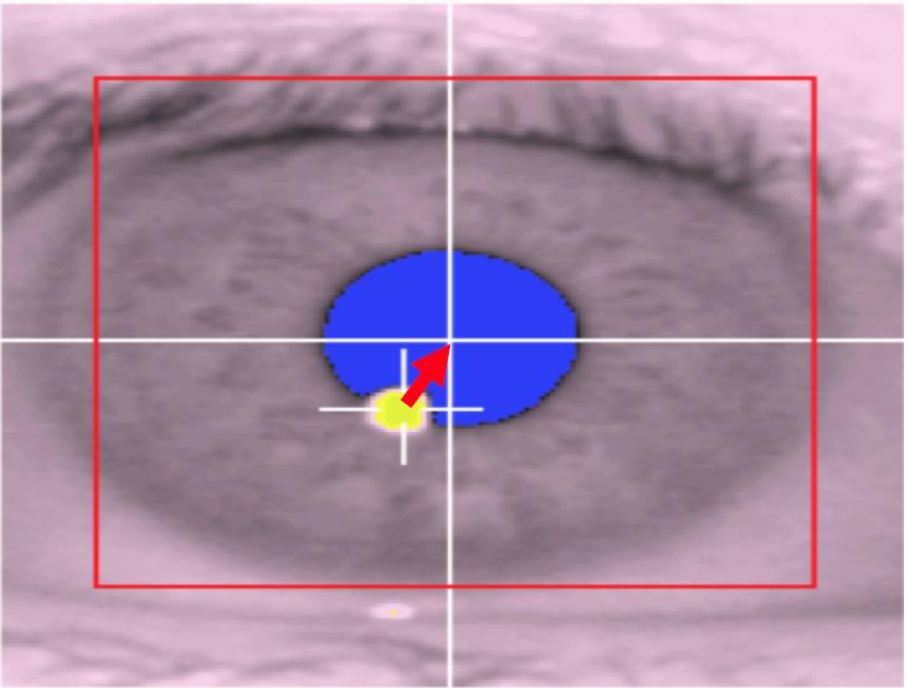
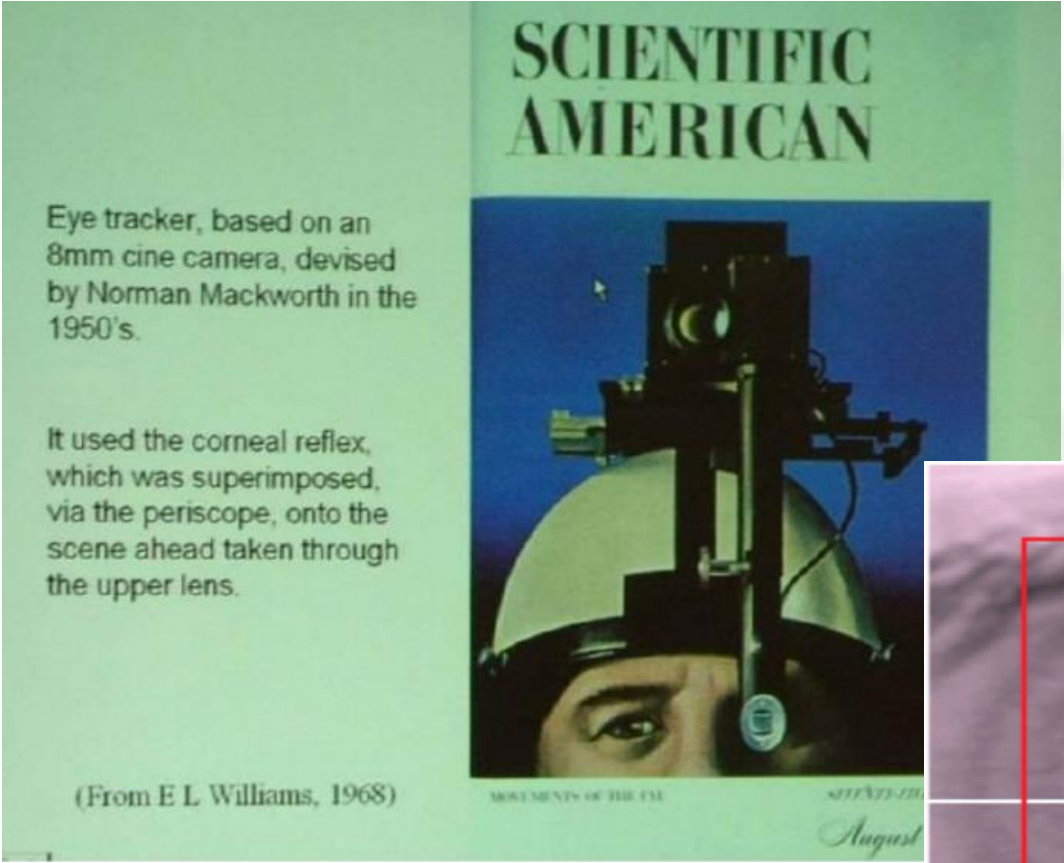
走馬觀花



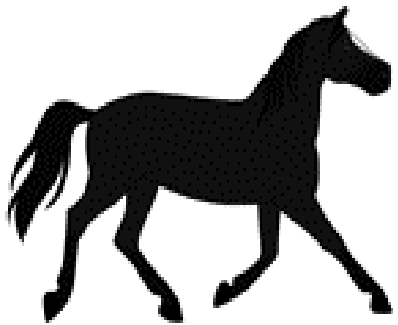
眼动仪发展简史

▼ 新一代眼动仪

基于视频的瞳孔角膜反射法



Pupil-CR tracking



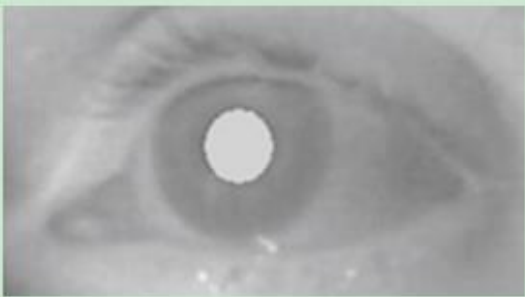
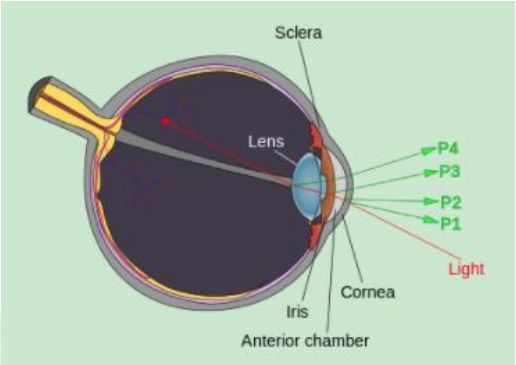
天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



眼动仪发展简史

▼ 新一代眼动仪

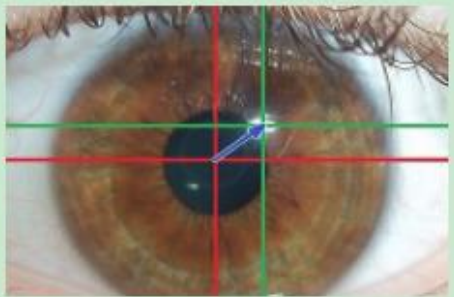
Purkinje images are [reflections](#) of objects from the structure of the [eye](#). They are also known as Purkinje reflexes and as Purkinje-Sanson images. At least four Purkinje images are usually visible. The first Purkinje image (P1) is the reflection from the outer surface of the [cornea](#). The second Purkinje image (P2) is the reflection from the inner surface of the cornea. The third Purkinje image (P3) is the reflection from the outer (anterior) surface of the [lens](#). The fourth Purkinje image (P4) is the reflection from the inner (posterior) surface of the lens. Unlike the others, P4 is an inverted image.



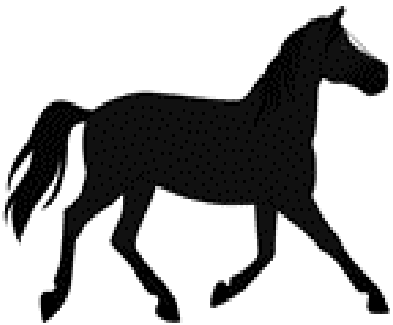
Infrared / near-infrared:
bright pupil.



Infrared / near-infrared:
dark pupil and corneal
reflection.



Visible light: center of
iris (red), corneal
reflection (green), and
output vector (blue).



天馬行空

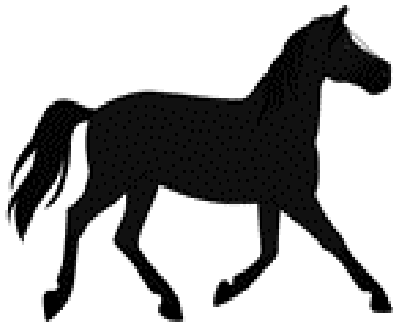
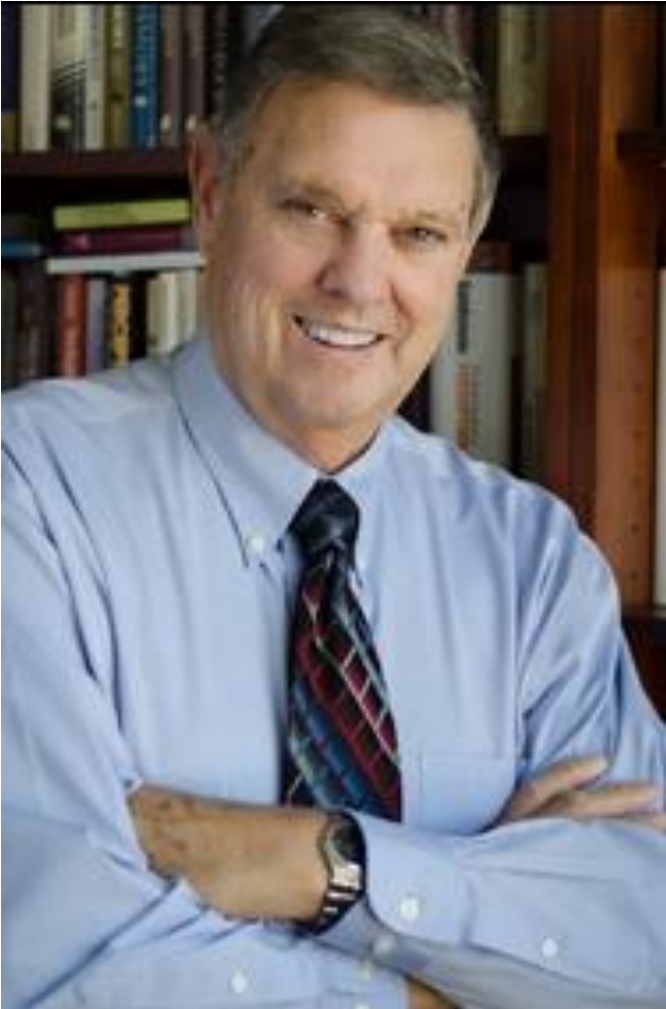
馬哥語系
老馬識途



眼动仪发展简史

▼ 阅读中的眼动发展

Keith Rayner



驚馬十駕 天馬行空

馬哥語系

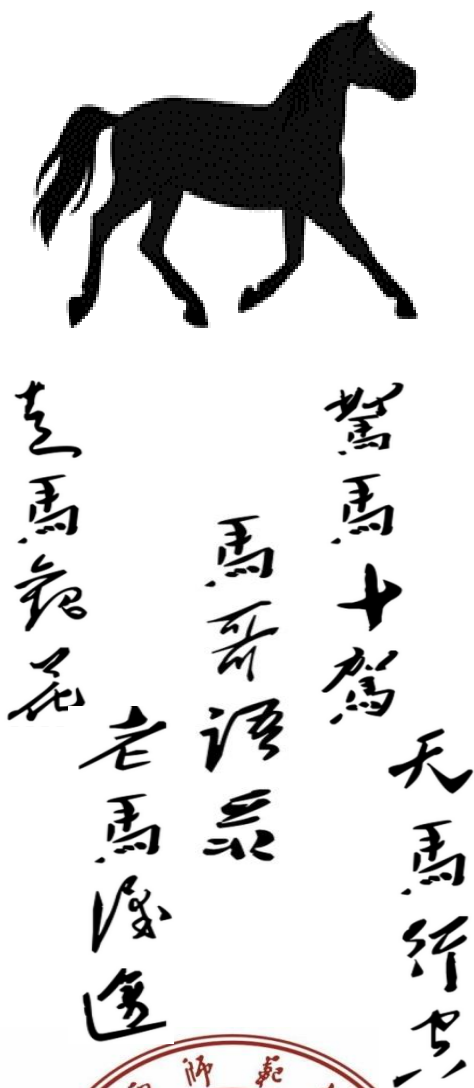
老馬識途

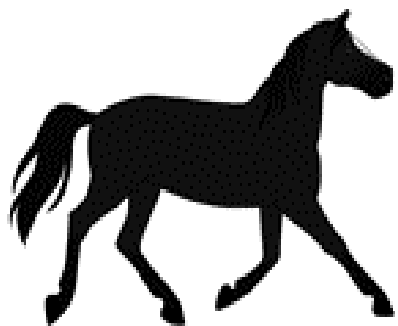
走馬觀花



小结

- 国际上从1970年飞速发展，国内从80年代开始发展，整整落后一代人
- 长江后浪推前浪，一代更比一代强
- 眼动是心理学学生应该优先掌握的科研工具





天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



硬件构成

▼ 以Eyelink为例

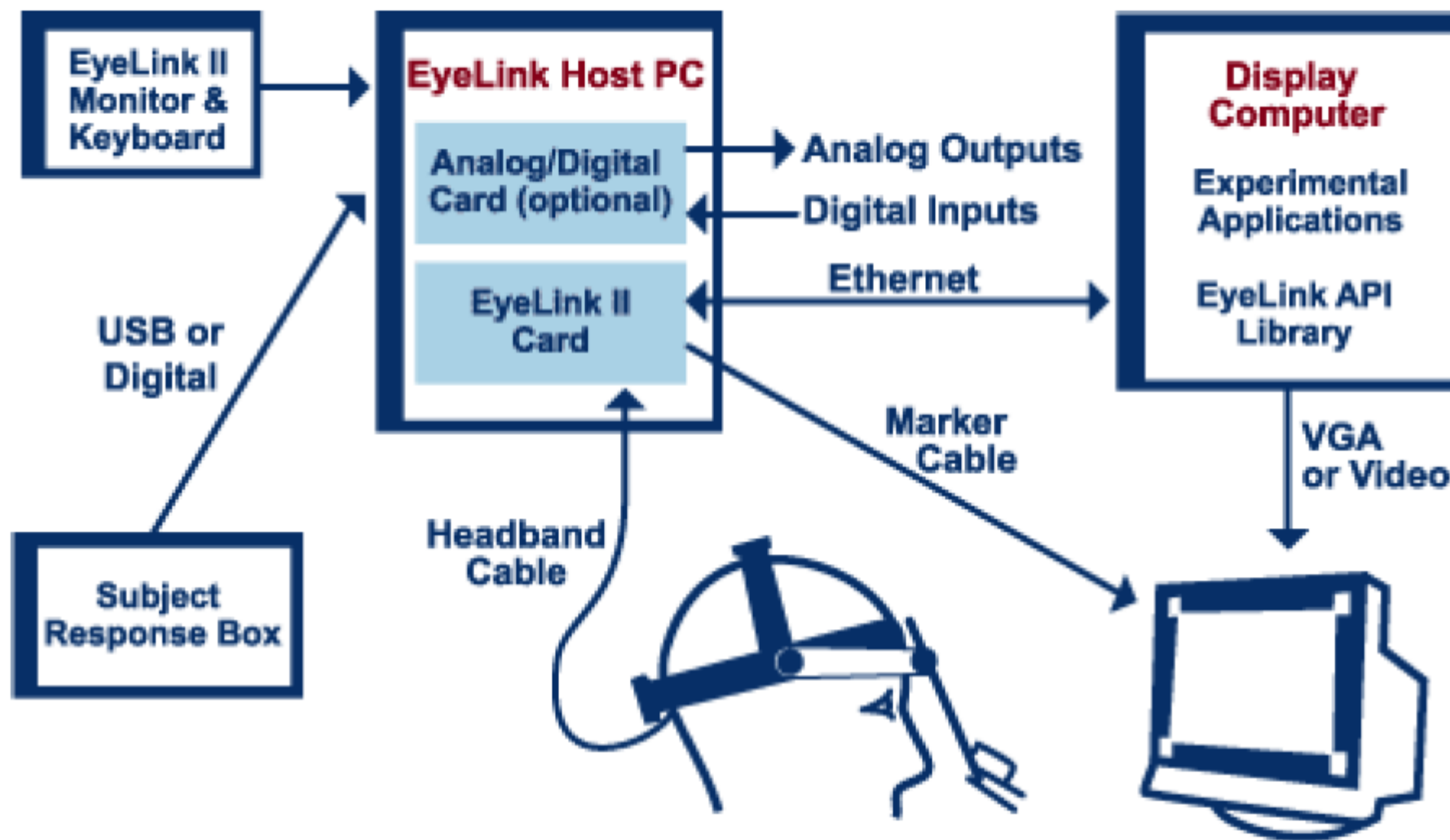
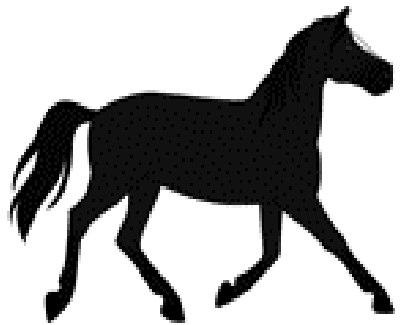


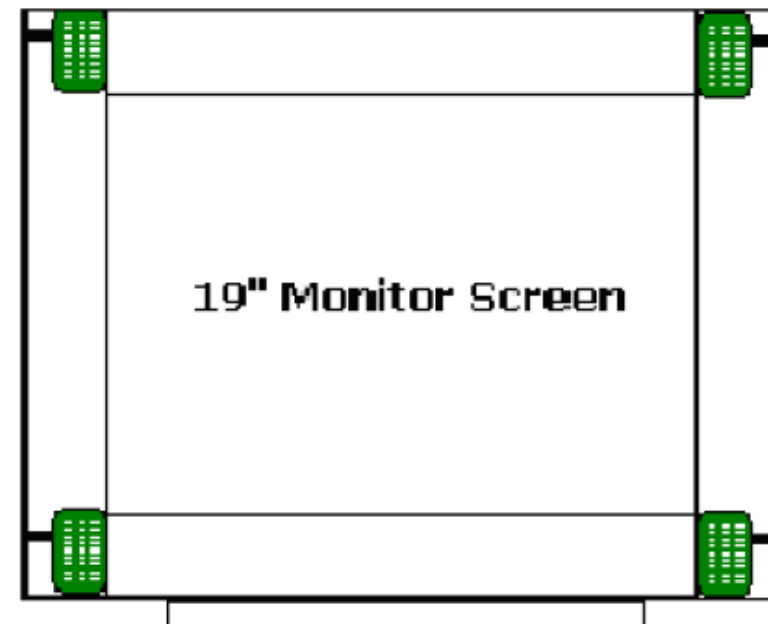
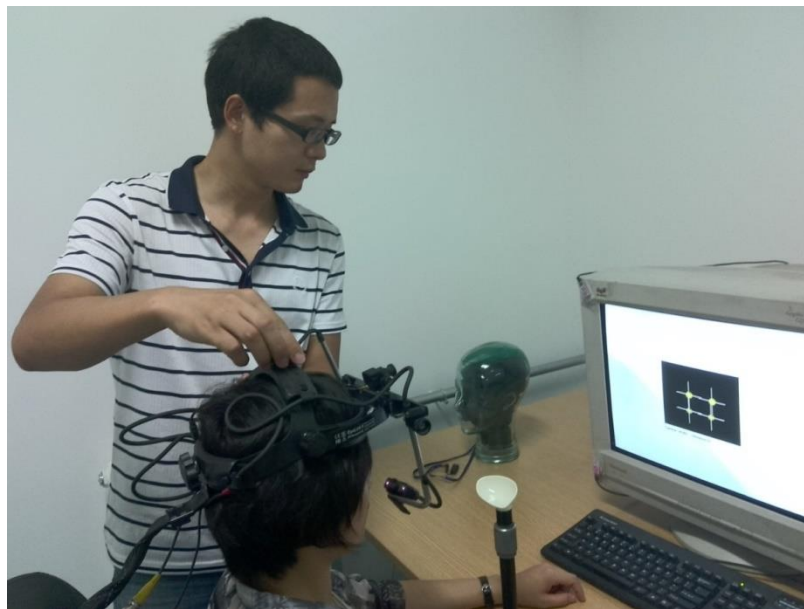
Figure 1-1: Typical EyeLink II System Configuration



天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



硬件构成



Markers aligned top and bottom



Figure 1-2 EyeLink II PCI Card Connectors

硬件构成

EyeLink II 头盔

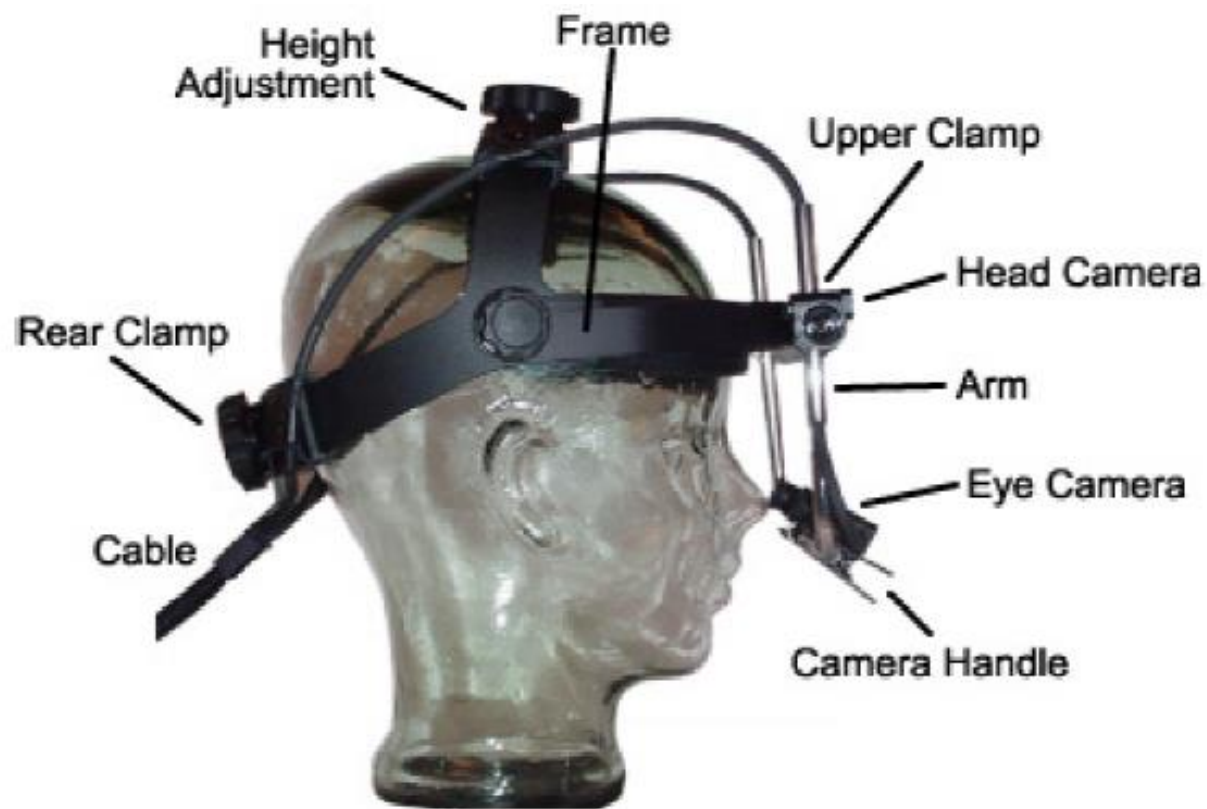
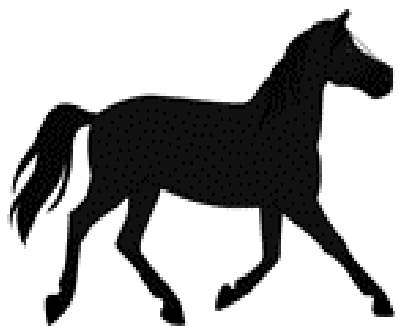


Figure 3-2: Parts of the EyeLink Headband



天馬行空
驚馬十駕
馬哥語系
老馬識途
走馬觀花



硬件构成

▼ 安装布局

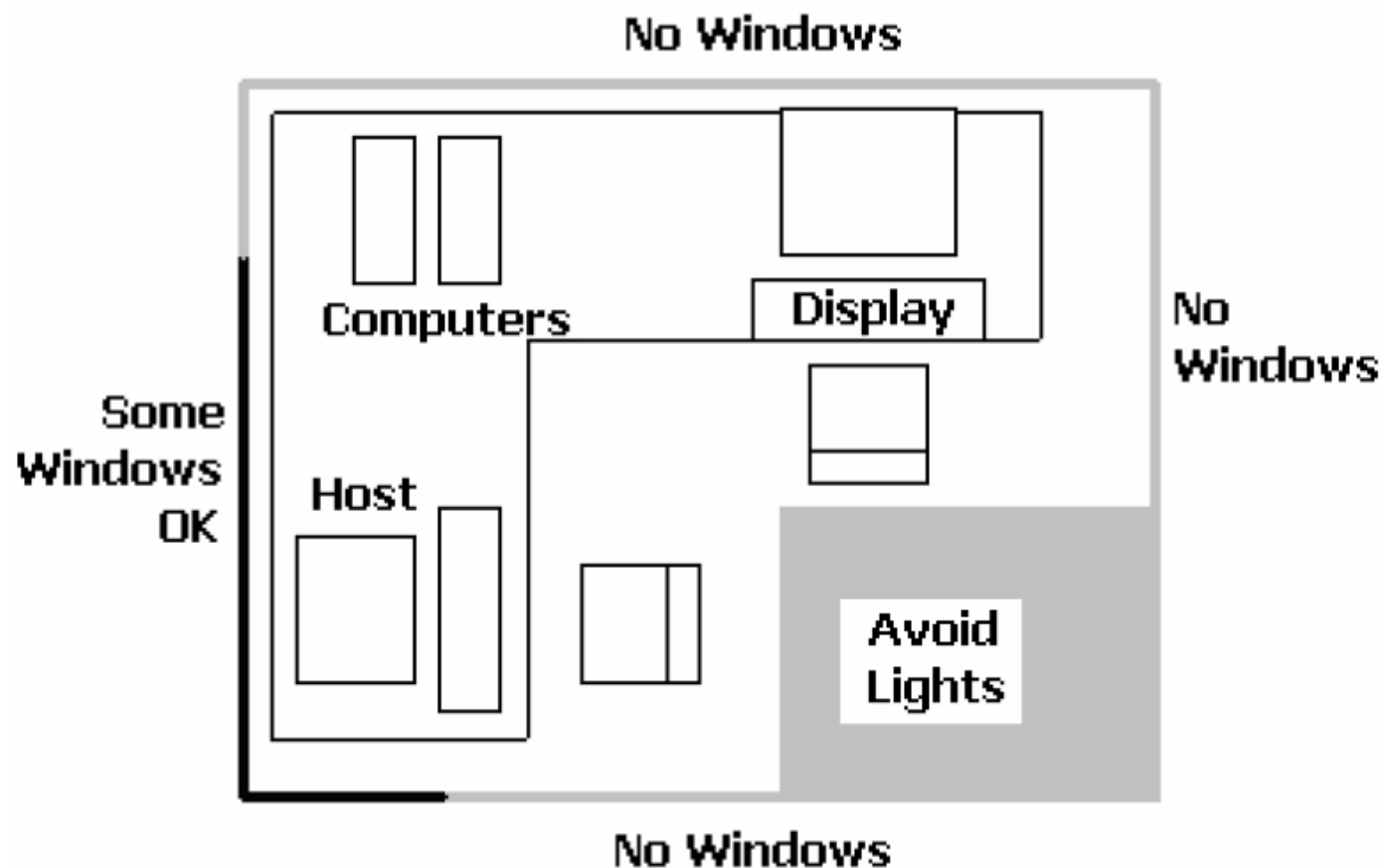
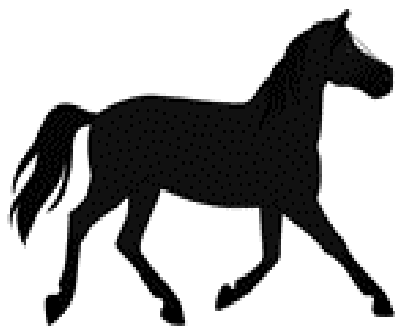


Figure 1-1: Suggested EyeLink II System Layout



天馬行空
驚馬十駕
馬哥語眾
老馬識途
走馬觀花



硬件构成

EyeTribe 为例



HELLO WORLD

Affordable eye tracking is finally here

Making eye tracking available for everyone is the driving force behind everything we do. We believe that the true potential can only be reached once this technology has become widely available.

Our small device represents a major breakthrough in eye tracking. It is the world's smallest eye tracker, the first to use USB 3.0 and the only alternative below the magical price point of \$100.

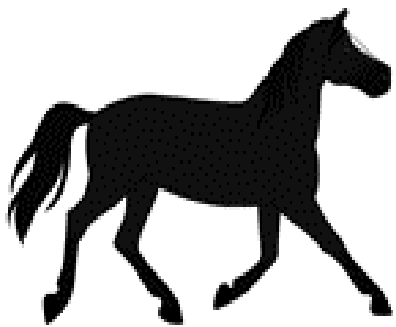
The first batch ships in time for the Holiday Season 2013. Limited quantities. Pre-order today!



真的只要99美元



备注：被Facebook旗下的OculusVR2016年收购



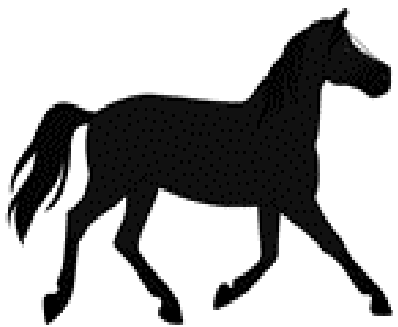
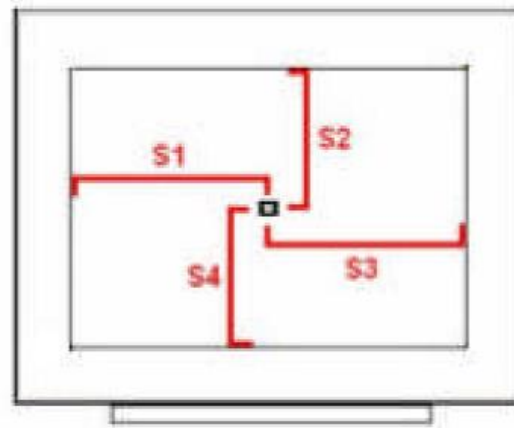
老馬識途
馬哥語眾
驚馬十駕
天馬行空



硬件构成

物理设置与连接

- Physical.ini
 - specifies the physical distance of the four edges of the presentation surface to the center of the
 - screenscreen_phys_coords = -188.0, 146.0, 188.0, -146.0
 - specifies the distance to the top and bottom of the display surface from the participant's eye, respectively.
 - screen_distance = 600 660

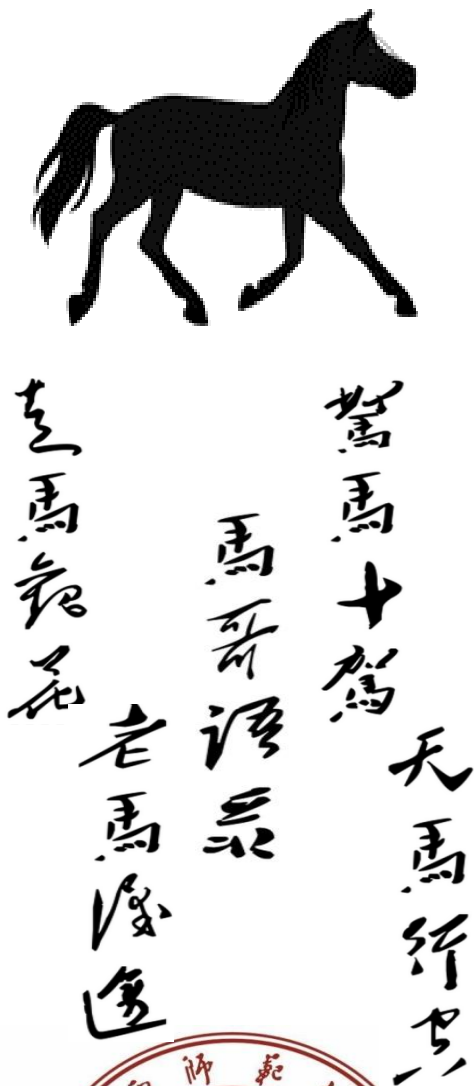


老馬識途
馬哥語眾
驚馬十駕
天馬行空



小结

- 举一反三，大多眼动仪都包含以下硬件：
 - 相机（记录场景或记录瞳孔）
 - 红外光源（一般植入在相机上）
 - 连接线
 - 主机和/或被试机



软件构成

- 主流眼动仪所用的配套软件:

- Eyelink

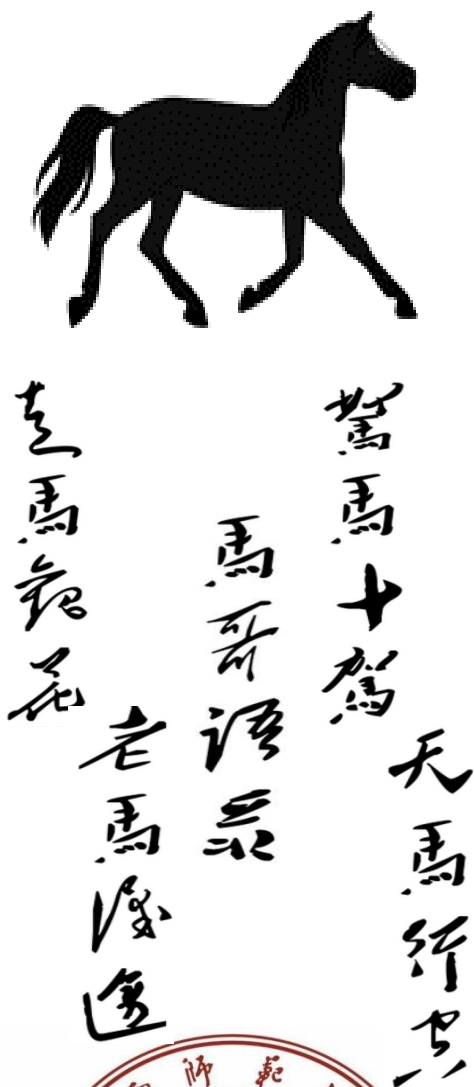
- EB, DV

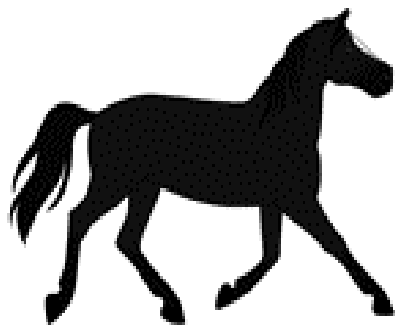
- Tobii

- Tobii pro studio(二合一)

- SMI

- Experiment center, Begaze



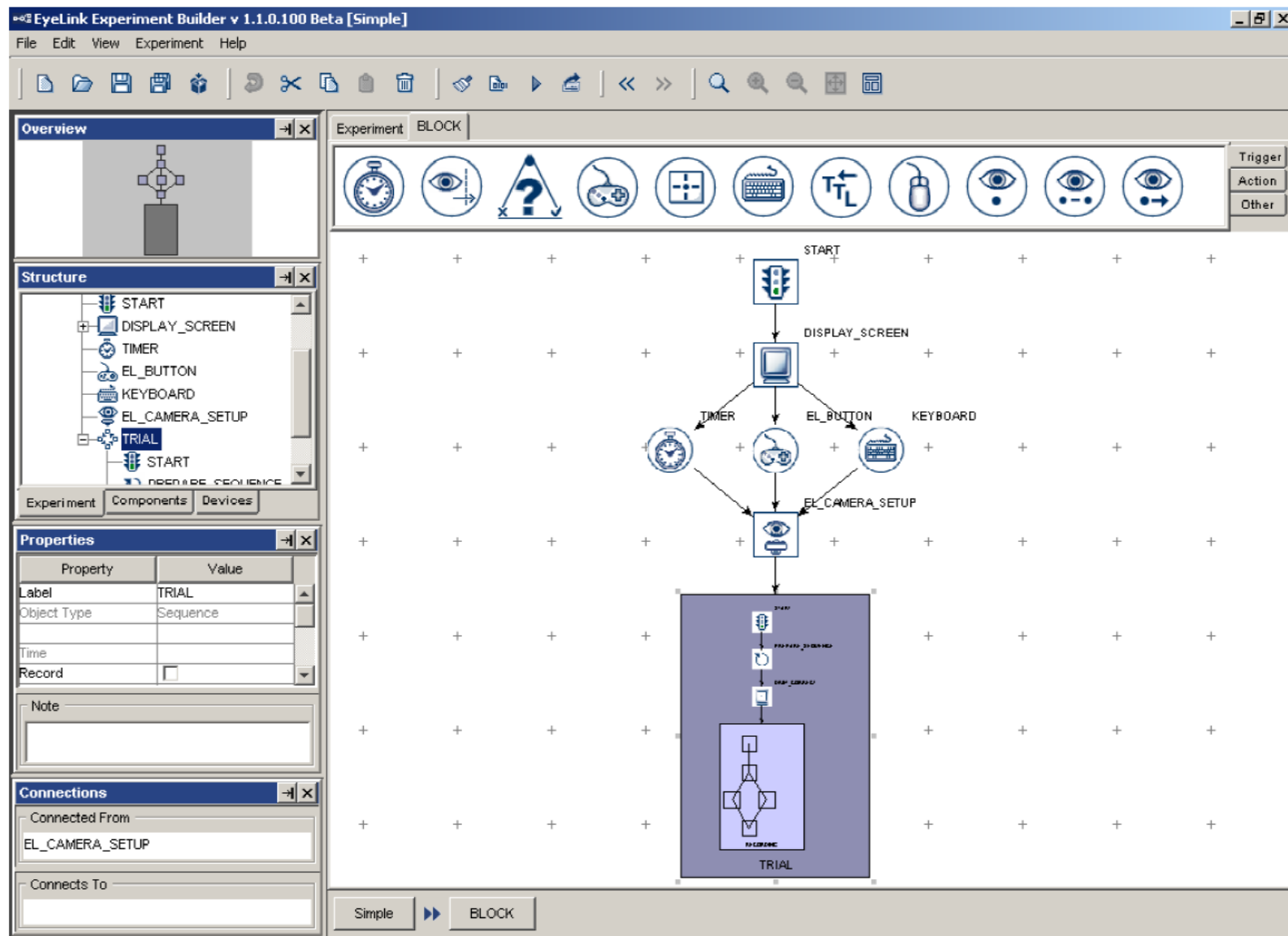


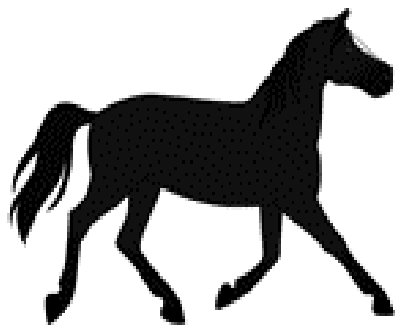
老馬識途 天馬行空
馬哥語眾 驚馬十駕



软件构成

➤ EB



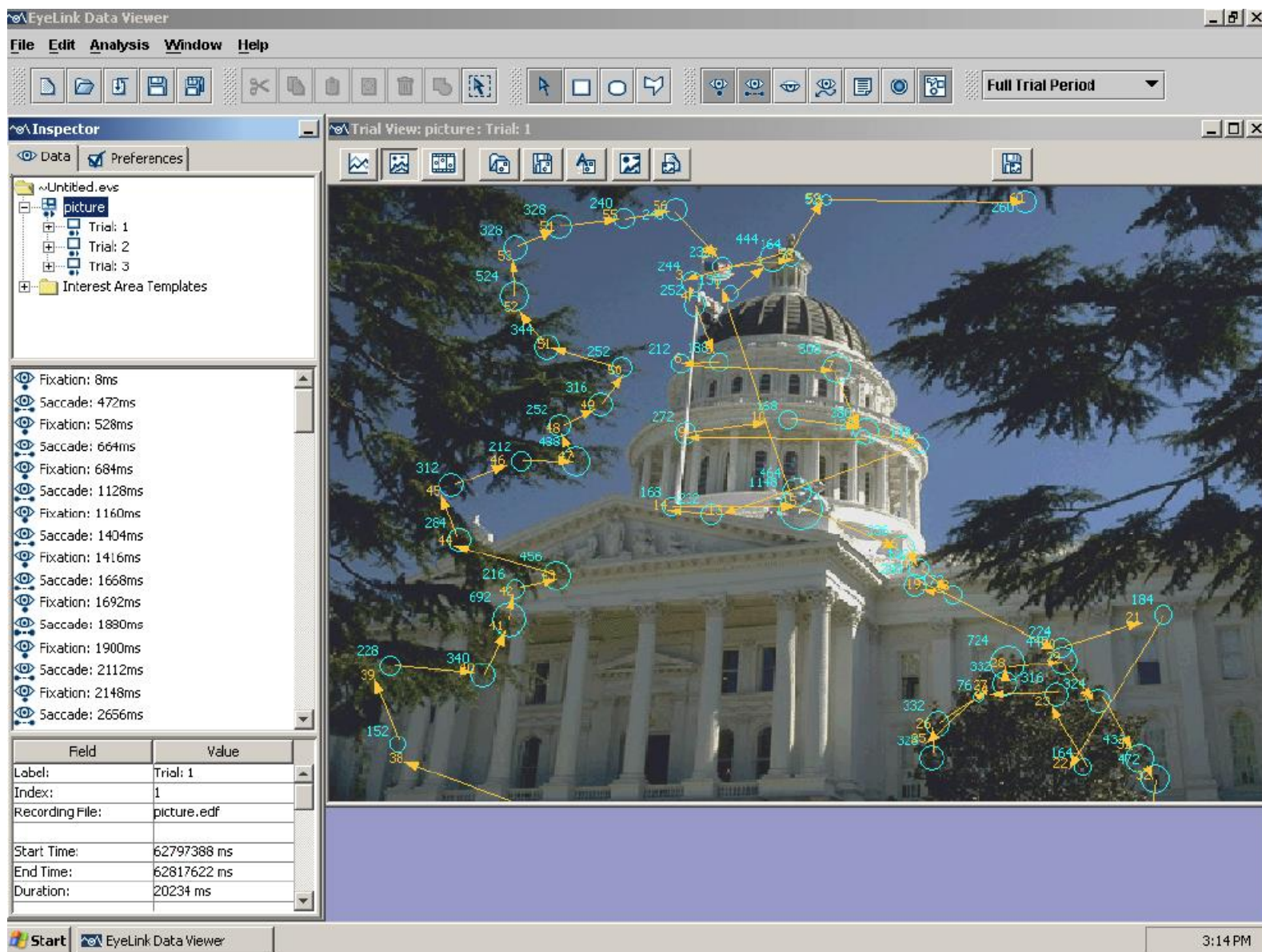


驚馬十駕
 天馬行空
 馬哥語眾
 老馬識途
 走馬觀花



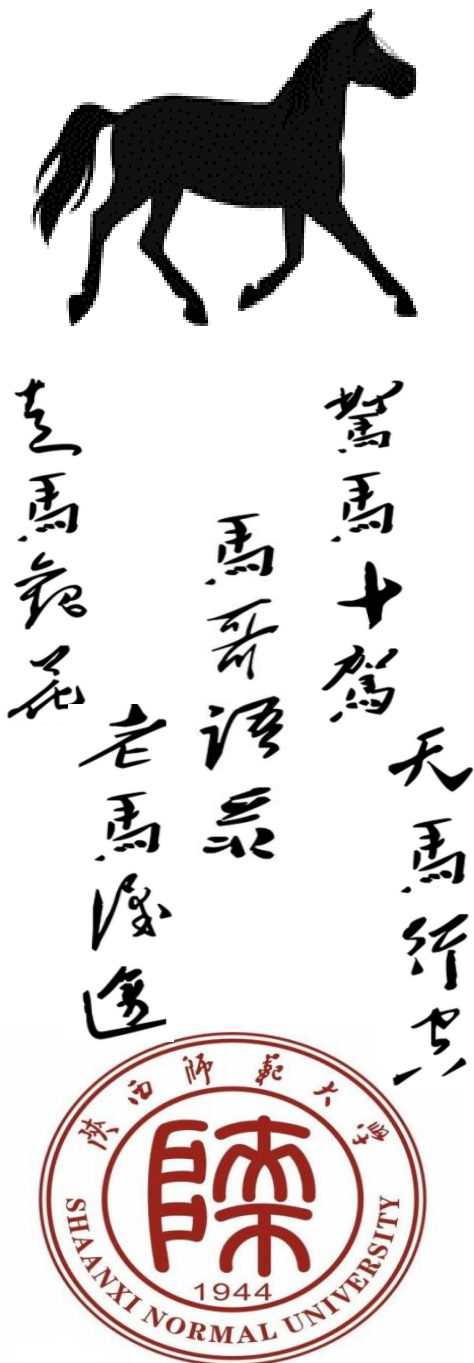
软件构成

DV
 3



软件构成

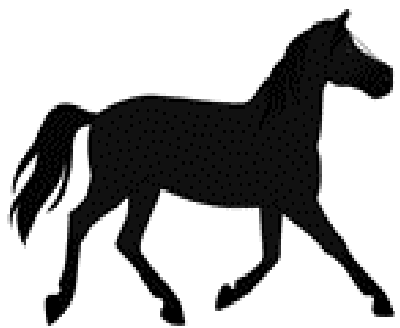
- 软件共同缺点：收费



软件构成

▼ 开源软件

- 考虑其它软件
 - UMASS eye tracker (阅读)
 - EyeMap(阅读)
 - Python (Pygaze; Pylink; PsychoPy等)
 - Matlab/E-prime
 - Presentation
 - Ogama
 - Opensesame



老馬識途
馬哥語眾
驚馬十駕
天馬行空



小结

- 应该学习哪些软件？
 - **EB, DV**, Tobii pro, EC, Eye tracker, Matlab, E-prime, Pygaze, Gazealyze, Ogama, OpenSesame, EMDAT et al.
 - 认真学一种，做到触类旁通
- 课堂教学：EB, DV（针对Eyelink产品）

