Eye-Tracking Workshop

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Eyes = The Window to the Mind

The gaze of man is free to move around
From place to place where'ere the eye does will.
It flicks about to give the mind its fill
And make the image whole within the head.
It seeks with lightning speed the source of sound
And follows smoothly anywhere it's led.

From deep within the brain the signals come
To stablize the world of visual space
Against all violent motion of the face:
And does it all with simple rules of thumb.

John W. Senders

Outline

Part 1

- History of Eye Movement Research
- Types of Eye-tracking Systems
- Topics of Research/Applications
- Data Analysis Issues
- Conclusions

Part 2

- An example research program

Four Era's of Research

1. Early era: rather crude apparatus, discovered many basic facts about eye movements
2. Dark ages: behaviorist era in psychology, overt properties – eye-blinks
3. Cognitive influences and rapid technological advances
4. Sophisticated computer models

First Era

- Dodge, Dearborn, Huey
- Very crude apparatus
- Important basic discoveries regarding eye movements that have stood the test of time:
- Average fixation times
- Saccade lengths and durations
- Saccadic suppression
- Some theory

Second Era

- Buswell, Tinker, Yarbus
- Largely confirmatory work
- Often dealt with surface aspects of eye movements
- Not much theory
- Tinker's final review (1958): all that has been learned about reading via eye movements has been learned

Third Era

- Coincides with the Cognitive revolution in Psychology
- Better description of language
- Techological advances
- Eye-contingent display change techniques (McConkie & Rayner, 1975; Rayner, 1975; Rayner & Bertera, 1979)
- Initial development of theories (Just & Carpenter)

Fourth Era

- Development of sophisticated models (computer simulations) to predict where people will fixate and how long they will fixate (E-Z Reader – Reichle, Pollatsek, Fisher, & Rayner, 1998; Reichle, Rayner, & Pollatsek, 2003)
- Wide variety of applications
- Further development of eye-tracking systems

Types of Eye-Tracking Systems

- Coil system
- Dual Purkinje System (infrared)
- Corneal reflection and pupil boundary (infrared)
- Video based systems
- EOG systems

What System is the Best?

- Depends on your needs
- Typically there is a trade-off between spatial/temporal accuracy versus ease of use/cost

Examples of Trade-offs

- Coil: very accurate (min of arc), hard to use, comfort of subject, often used with monkeys
- Purkinje tracker: very accurate (10 min of arc, millisecond by millisecond sampling), best for eye-contingent display changes, requires a fixed head, takes time to learn to use, fairly expensive ($70,000), need to develop software

Trade-offs (continued)

- Corneal reflection/pupil boundary: Spatial resolution only average (1-2 degrees), better resolution with fixed head, generally not as expensive, usually simple to use, relatively easy to learn to use, often software comes with the system, variability in price
- Video based: Spatial resolution average (1-2 degrees), better resolution with fixed head, easy to use, often comes with software, variability in price (best systems = $25,000-$40,000)

Trade-offs (continued)

- Video-based systems: Recent technological advances – head mounted eye-tracking (monitor head position), 2 ms sampling rate (500 hz)
- EOG: good for measuring latency (when the eyes move), but not for location, typically cheap

Applications

Standard Areas:

- Reading
- Visual Search
- Scene Perception

Applications

Newer Applications:

- Mental rotation
- Use of graphical material
- Memory processes
- Driving behavior (pilot behavior)
- Action sequences: making tea/sandwiches
- Music performance
- Speech perception/production
- Sport (basketball, golf, baseball, etc)
- Ads, webpages

Future/Current Applications

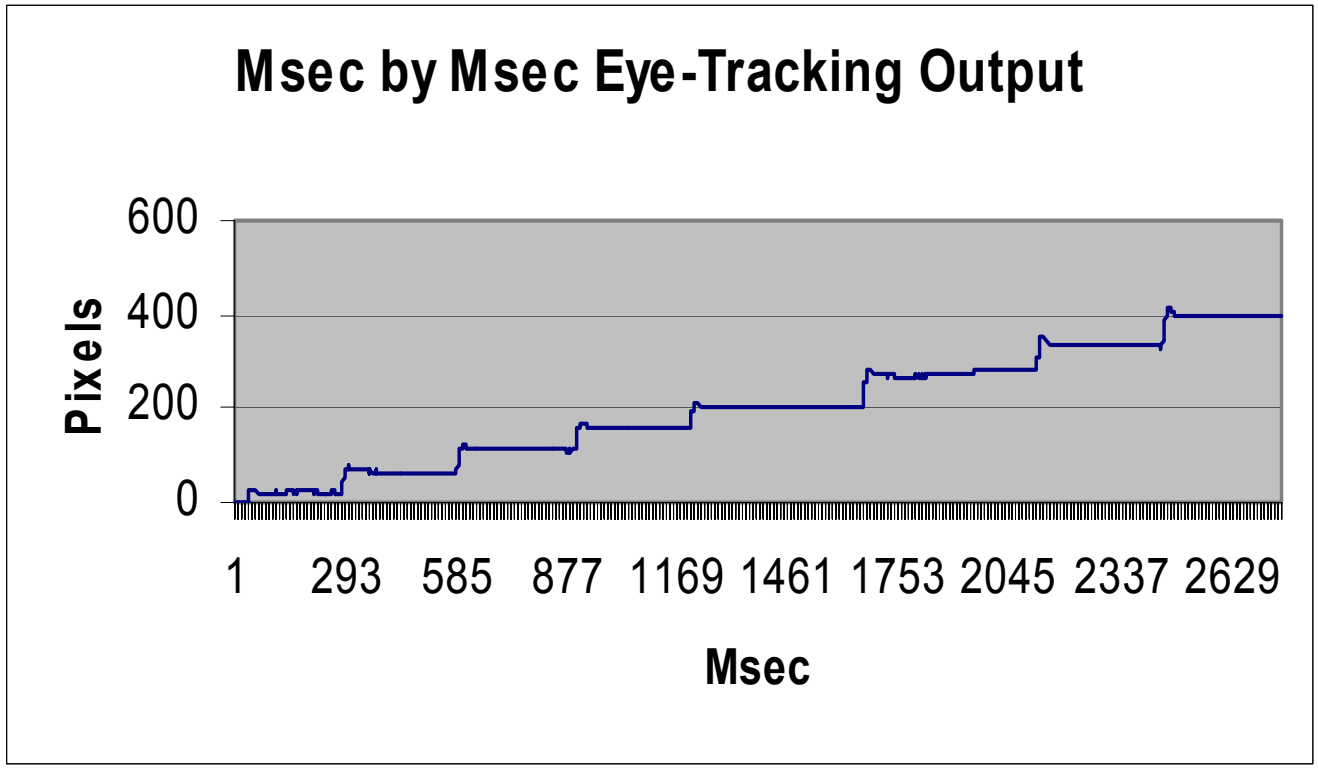
- Eye movements and ERP
- Eye movements and Brain Imaging
- More studies with children

Learning to Use Eye-tracking Systems

- Advice 1: Never accept what sales people and manufacturers tell you. They want to sell their product. Talk to people who have the system and see what they think.
- Advice 2: Spend time in a successful eye-tracking lab. Learn to use the equipment and the software.

Data Analysis Issues

- Define fixations and saccade
- Sampling eye position frequently – what to do with the massive amount of data
- Algorithms for analyzing data


Msec by Msec Eye-Tracking Output
600
400
200
0
Pixels
1
293
585
877
1169
1461
1753
2045
2337
2629
Msec

Msec by Msec Output

317	22	3	554	55	7
318	22	3	556	61	8
319	22	3	558	63	8
320	21	3	560	69	9
321	21	3	562	72	9
322	22	3	564	75	10
323	…….		566	77	10
544	22	3	567	80	11
545	23	3	568	81	11
546	25	3	569	78	10
547	27	4	570	77	10
548	29	4	571	78	10
549	32	4	572	78	10
550	37	5			
551	42	5			
552	49	6			

Fixation 1: 317 – 544 = 227 ms

Saccade 1: 545 – 569 = 24 ms; 7 letters

Fixation 2: Begins at 569

Important Variables to Examine

- Reading (word based measures):

First Fixation Duration

Single Fixation Duration

Gaze Duration

Total Fixation Duration

Go-Past Time

Skipping

Regressions (in and out)

Word based measures

- Most cowboys hate to live in houses

1	2	3	4	6	5
223	235	178	301	179	267
	413				

Variables (continued)

- Reading (region based):

First pass reading time

Second pass reading time

Go-past reading time

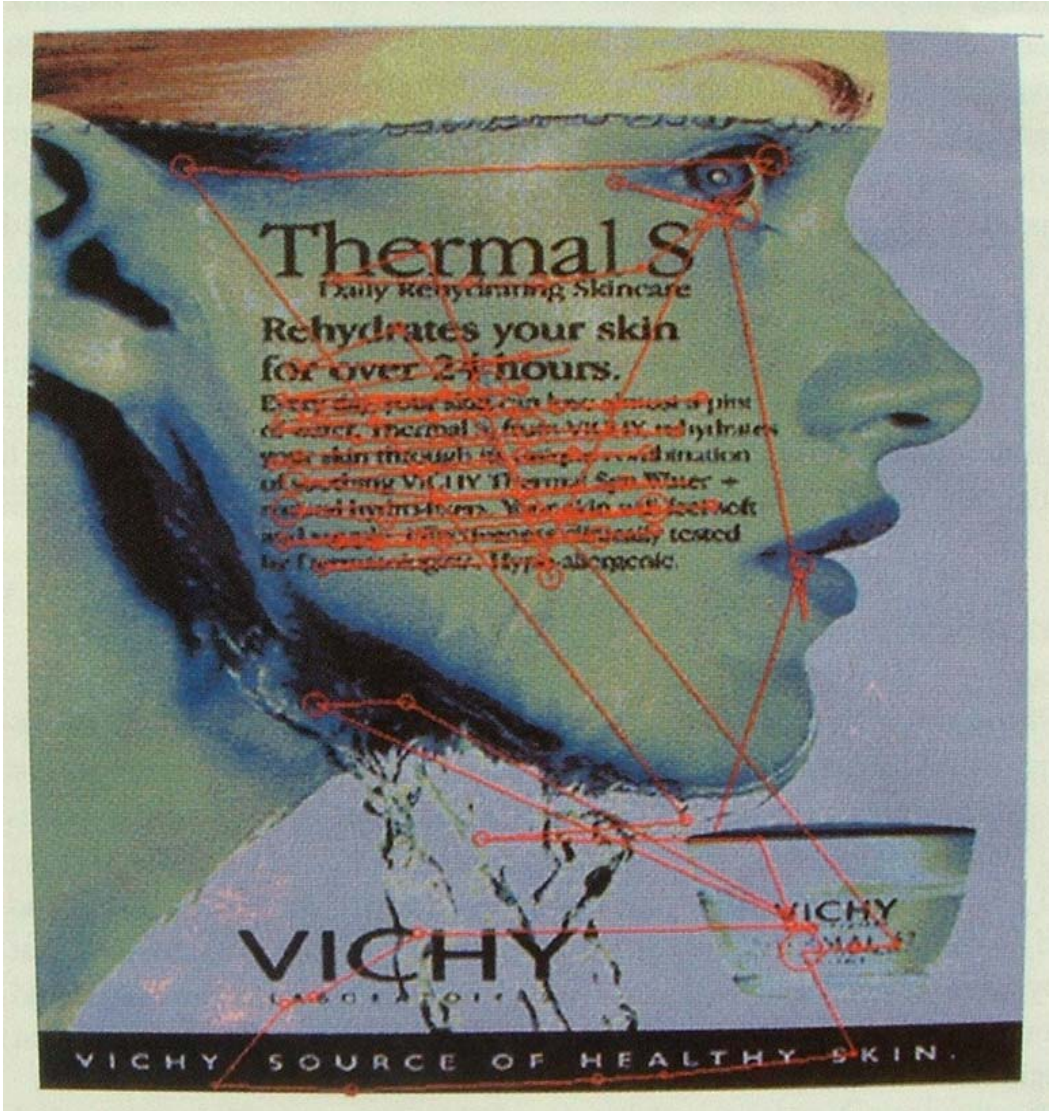
Total reading time

Reading time per character

Deviation from regression

Variables

- Scene Perception:
- Fixation time measures
- Saccade length
- Sequence of fixations
- Define regions of interest


Thermal 8
Daily Rehydrating Skincare
Rehydrates your skin
for over 24 hours.
VICHY
VICHY
VICHY SOURCE OF HEALTHY SKIN.

Visual World Paradigm

- How quickly eyes look at part of the visual scene as a function of spoken information
- Time on objects per se not as important as point in time that object is fixated

Setting Up an Eye-tracking Lab

- Two main options

1. Start from scratch:
   a. Choose hardware
   b. Develop/purchase software
2. Spend time in an established lab

Conclusions

1. Eye movements provide a good measure of moment-to-moment processes.
2. Lots of options available to record EM and lots of applications now studied.
3. Choose system that best fits your needs
4. Not easy to deal with issues regarding data acquisition and analysis.
5. Best off trying to spend time in an established lab.