Experimental Humanities II

Eye-Tracking Methodology

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First things first …

- Answer your emails ☺
- Attendance + scoring + next 2 articles
  - See me if you know you‘ve missed and/or will be missing a class
  - Active participation in discussions, readiness for the articles, sending drafts + comments, 40pt.
    - People who have not sent drafts???
  - Next 2 articles – Teo and Kamča Č.?
- Kenneth Holmqvist is coming ☺

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Reading CH5 + browsing CH6-8

- Questions?:)

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First drafts – topics FYI

- Jiří Čeněk - Priming individualism and collectivism influences perception of complex visual scenes
- Petra Kostovčíková - Perceptual issues in autism spectrum disorder
- Kamila Čížková - Eye tracking as a tool to study wayfinding in nature with a focus on landmarks
- Anestis Karasaridis – Are abstract God concepts imagined as humans? (mental imagery)
- Teo Mitrevski – anxiety, threatening information (selective attention)
- Jan Sebera - written translation of metaphorical expressions from English to Czech (reading/translation)
- Kateřina Kadlecová – Leadership in political marketing
- Bára Gavendová - Tištěné versus online zpravodajství očima jejich čtenářů (perception/reading)

Final project - deadlines

- **18.4. 23:00** Send comments to your peers + me
  - The time when you deliver the comments is the time when your peers can start working on their final project! Be on time!
- **23.4. 23:00** DDL final project

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Peers match-up

- Anestis + Jiří Č. + Kamila Č.
- Teo + Petra + Jan S.

- Bára and Kateřina will get comments just from me ☺

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Comments – how to?

- Comment the first drafts of two peers
- I will connect you through email
- Send the comments in Word/PDF to the SAME conversation (button „Reply all“)
- Same rules apply as when you present / do the critique of the articles in class
- When commenting, you are both presenting and critiquing – bring out good experimental decisions, warn against less optimal experimental decisions, suggest optimization
- Be specific (Here your argument may not work because 1 +1 is 2, and you are saying it is 3. It would be 3 only if this and that condition would be fulfilled.
  X I don‘t like your topic.)

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Comments – how to?

- Problem formulation
  - Is there a clear problem or research question being addressed? How can this be made more clear or follow current theories better?
- Operationalization
  - Is the research question testable in an unambiguous way? Do the measures follow from the theories or hypotheses in a convincing way, or is it just a fishing expedition?
- Competence
  - Is the planned execution convincing? Is the terminology correct and consistent? Is the experiment the best, the most feasible, or the most convincing solution for the particular research question?

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Lecture 4: Event detection

- What‘s behind?
- Dispersion based algorithms I-DT
- Velocity based algorithms I-VT
- Current challenges in event detection

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What‘s behind?

- Why is event detection important?
  - Events may correspond with cognitive processes
  - Relevant measures are built on the detected events
  - Component of online stimulus manipulations (gaze-contingent studies)

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What‘s behind?

- Types of events
  - Fixations
  - Saccades
  - Smooth pursuit
  - Blinks
  - Noise and Artifacts
  - Other events (microsaccades, optokinetic nystagmus - train square wave jerk nystagmus involuntary)

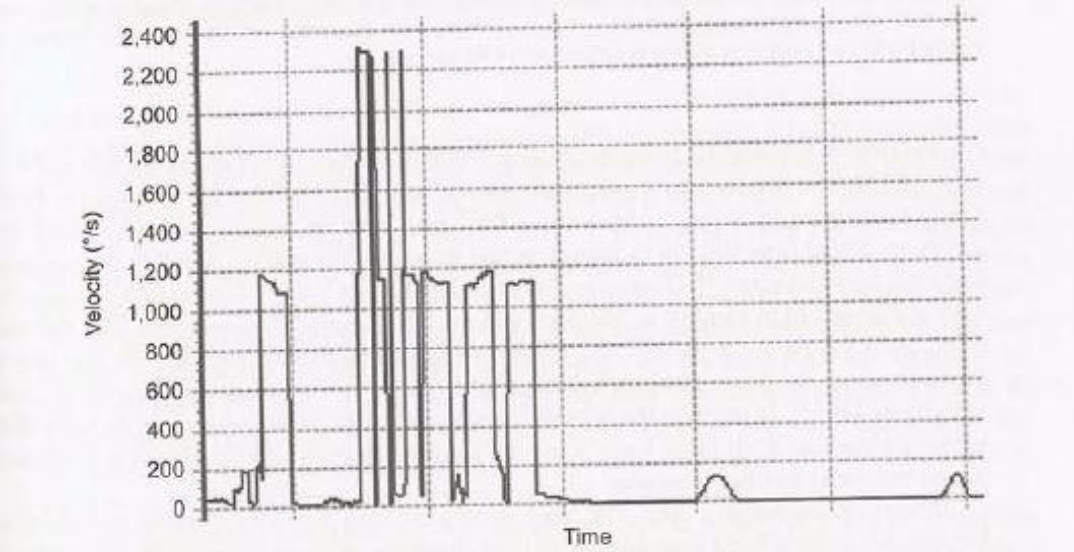
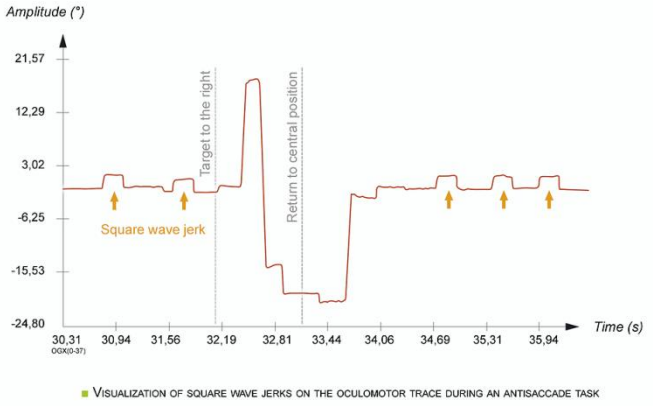


Fig. 5.14 Saccadic velocity plot showing the effect of having multiple competing corneal reflections (eye image in Figure 4.13). High-speed artefacts to the left, and slower reading saccades on the right. Recorded at 1250 Hz a tower-mounted system, participant with contact lenses.



VISUALIZATION OF SQUARE WAVE JERKS ON THE OCULOMOTOR TRACE DURING AN ANTISACCADE TASK

What‘s behind?

- Definition of event
- E.g. Fixation
  - 1. perceptual intake period (when we perceive something)
  - **2. the period when the eye is almost still (tremor), oculomotor condition – this is used in event detection**
  - 3. Other
    - Saccadic suppression
    - Covert attention is away from the fixation position (gorilla)
    - Alcohol, drugs (medicine)
    - Sleep deprivation

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What‘s behind?

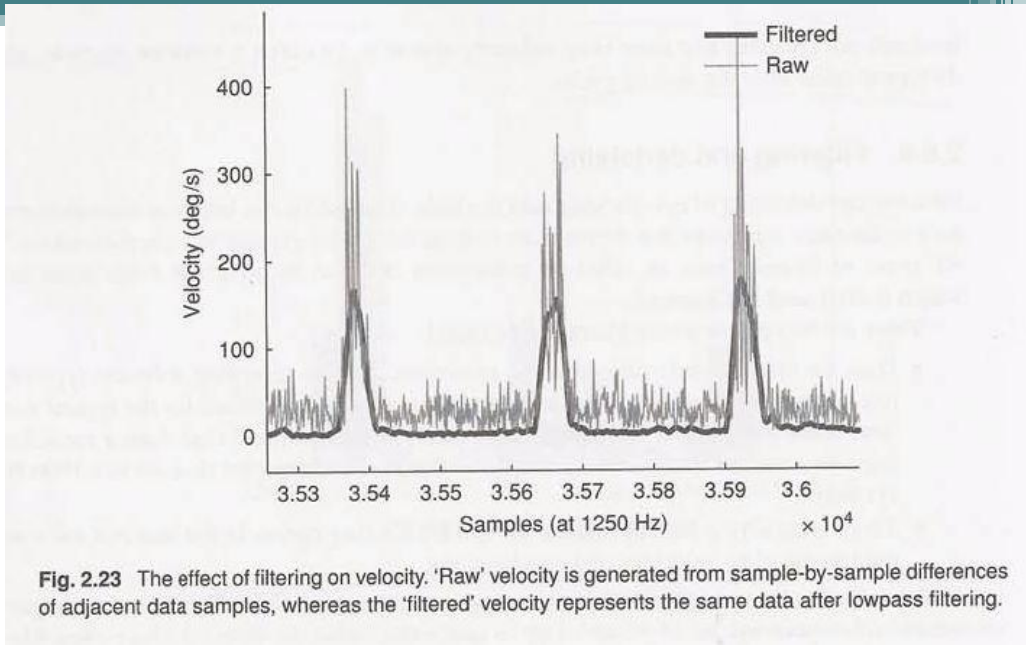

Fig. 2.23 The effect of filtering on velocity. 'Raw' velocity is generated from sample-by-sample differences of adjacent data samples, whereas the 'filtered' velocity represents the same data after lowpass filtering.

- Filtering and denoising data – all eye-trackers do some filtering
- Noise reduction – removing all variation in the recorded data which does not derive from true eye movement
  - Optic artefacts – recording imperfections (downward eyelashes, wrongly detected CR or pupil), can be rather easily spotted and this data removed from analysis
  - Eye-tracker noise (low amplitude, high frequency, stems from eye-tracker imprecision, oculomotor noise - risk of removing authentic eye movements

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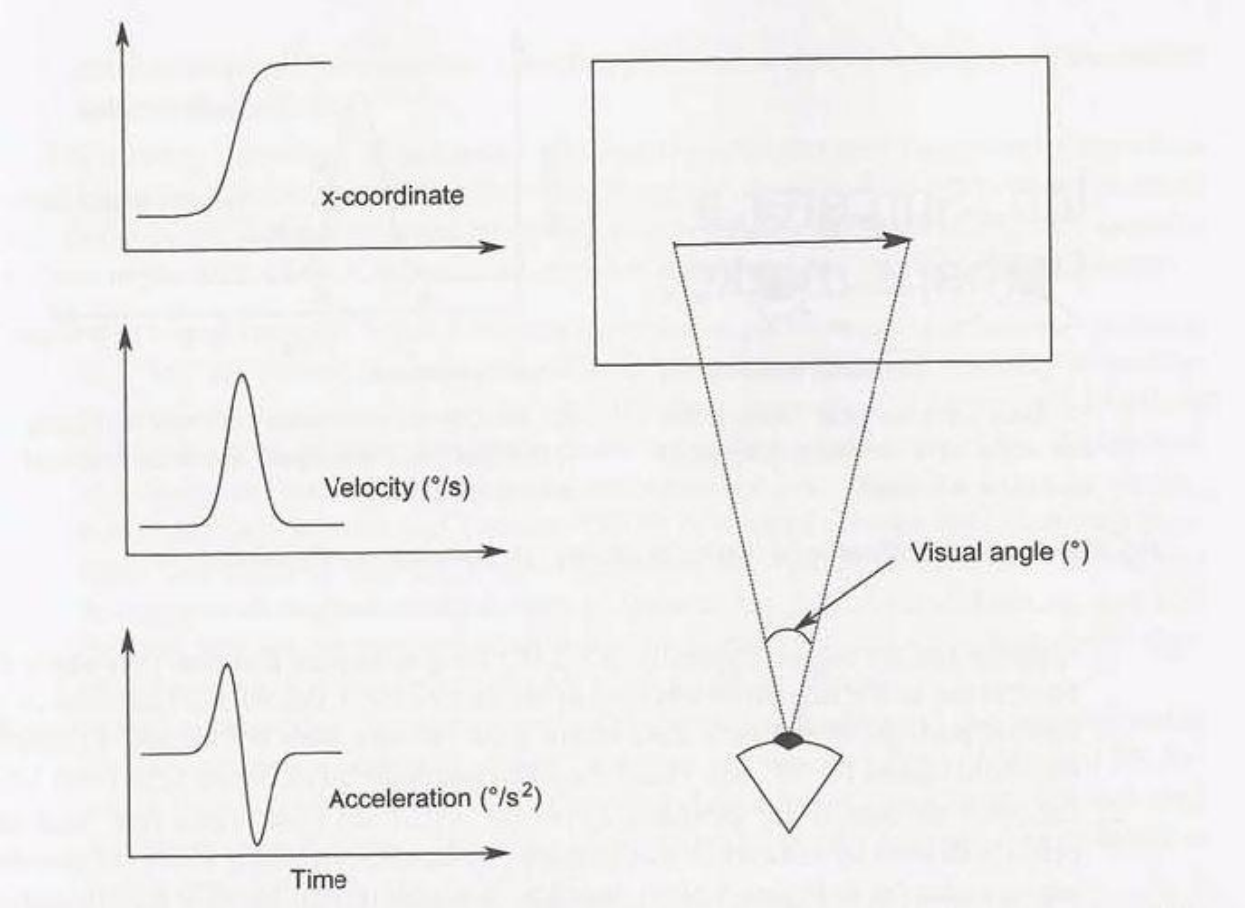
RAW data – ideal case



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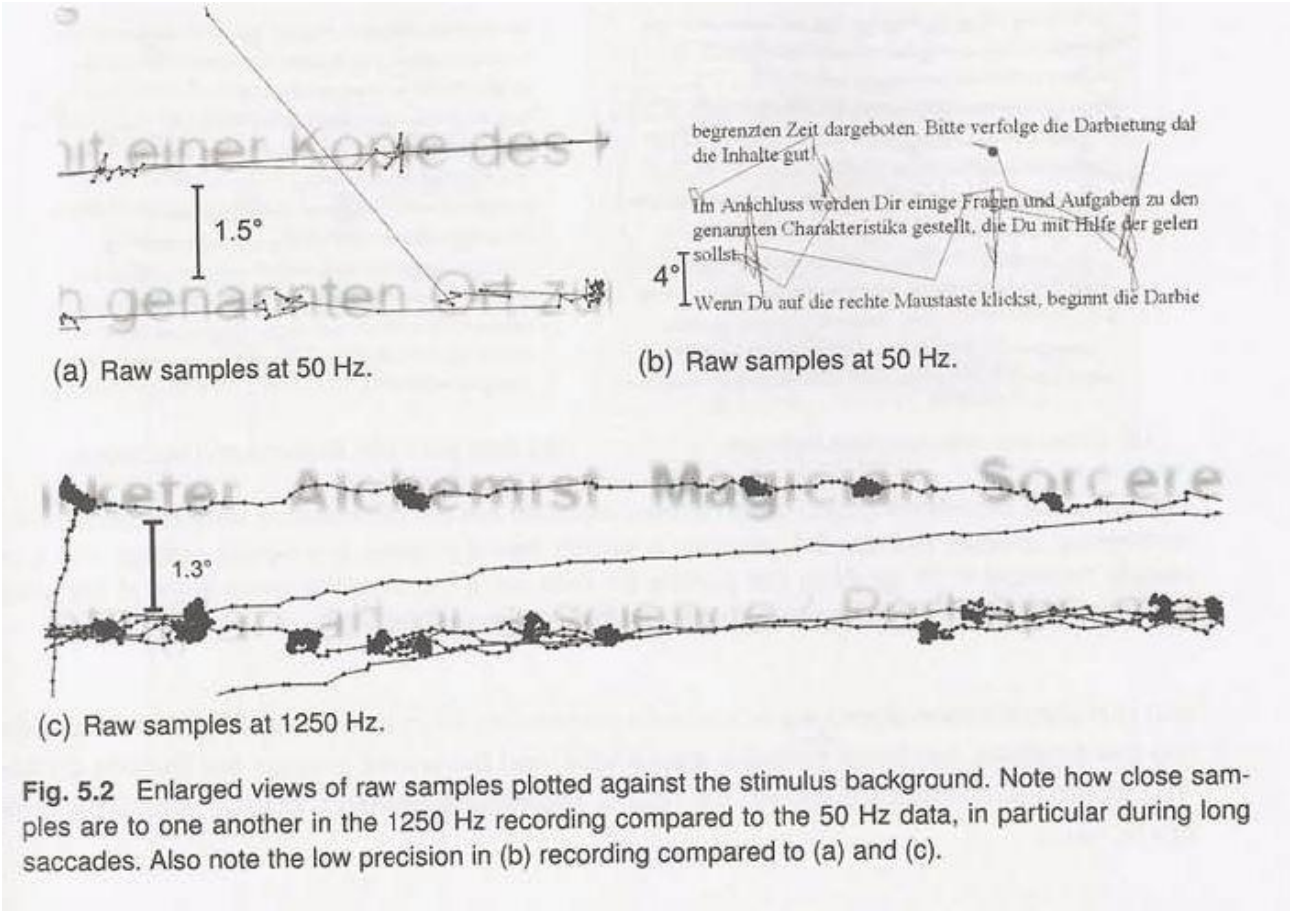
RAW data – each „dot“ is a sample



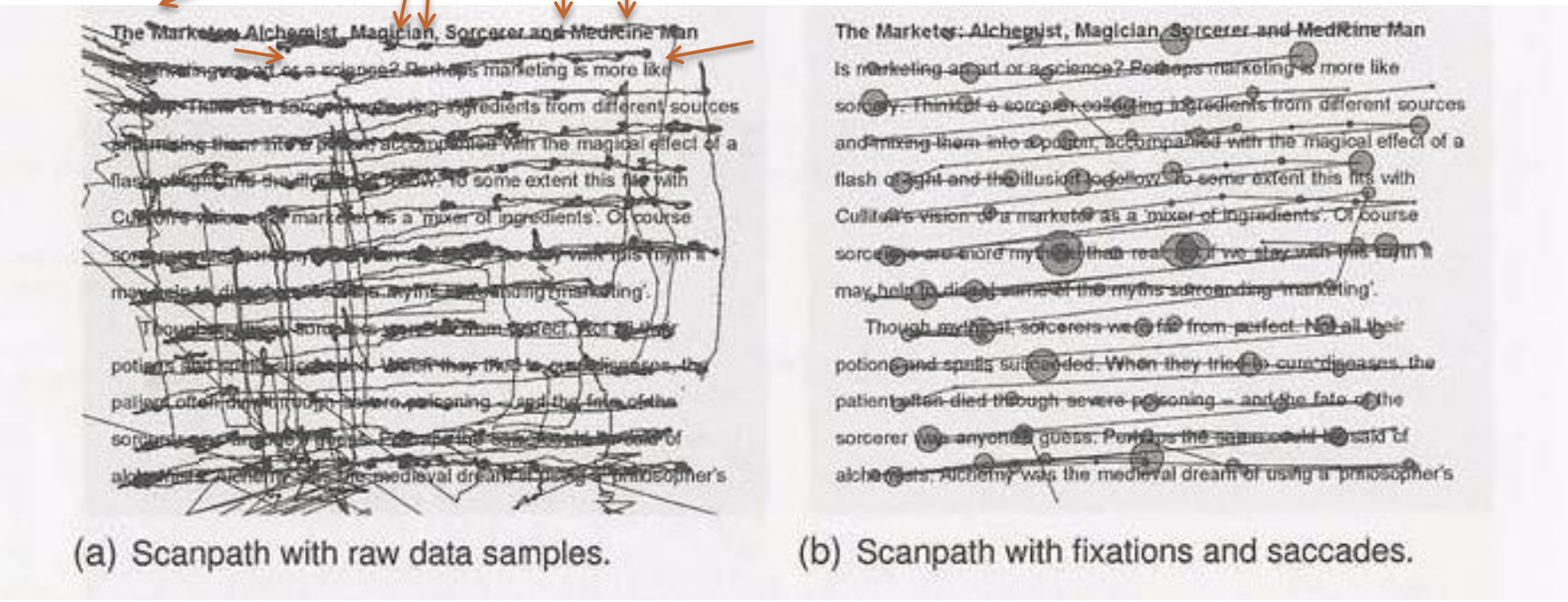
(a) Raw samples at 50 Hz.

(b) Raw samples at 50 Hz.

(c) Raw samples at 1250 Hz.

Fig. 5.2 Enlarged views of raw samples plotted against the stimulus background. Note how close samples are to one another in the 1250 Hz recording compared to the 50 Hz data, in particular during long saccades. Also note the low precision in (b) recording compared to (a) and (c).

RAW data 1250 Hz vs processed by BeGaze 2.1



(a) Scanpath with raw data samples.

(b) Scanpath with fixations and saccades.

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How are events detected?

- Dispersion algorithms
- Velocity and/or acceleration algorithms

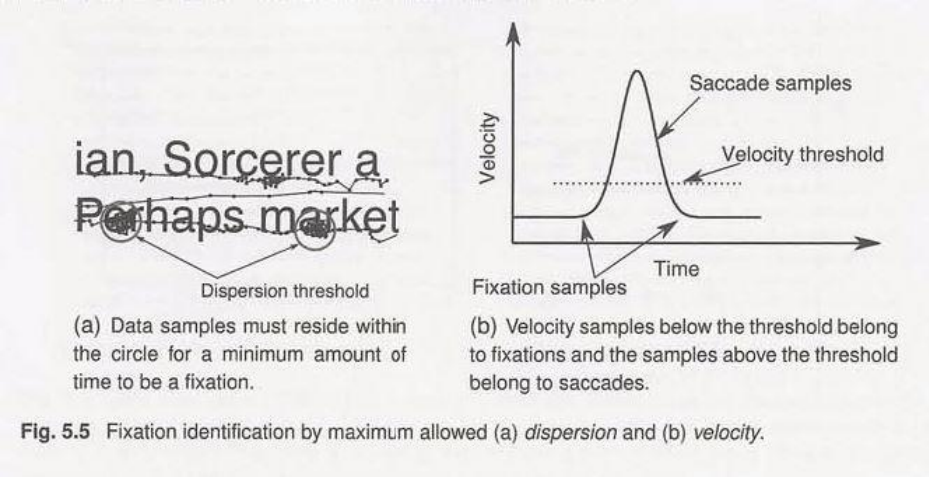

Fig. 5.5 Fixation identification by maximum allowed (a) *dispersion* and (b) *velocity*.

- Manual detection by hand segmentation

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Built-in commercial solutions

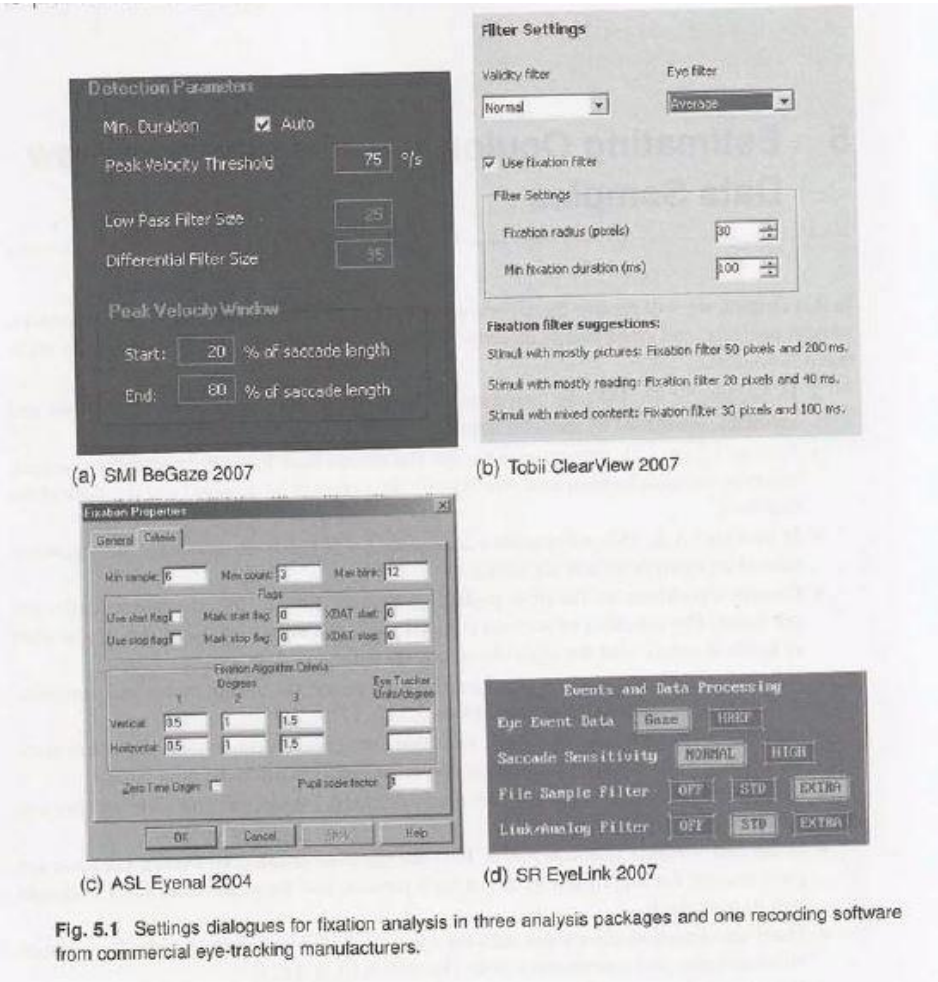

Fig. 5.1 Settings dialogues for fixation analysis in three analysis packages and one recording software from commercial eye-tracking manufacturers.

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Dispersion based algorithms

- I-DT – identification by dispersion threshold
- Dominant principle for event detection in low-speed data (≤50Hz) – because calculations of velocities due to fewer number of samples are not precise enough
- Minimum duration time of the fixation (e.g.100ms) + maximum space it can take~dispersion (e.g. 30pts), window moving over samples
- Detects fixations, assumes the rest are saccades
- Used by: ASL, SMI, Tobii, NAC, faceLab, OGAMA

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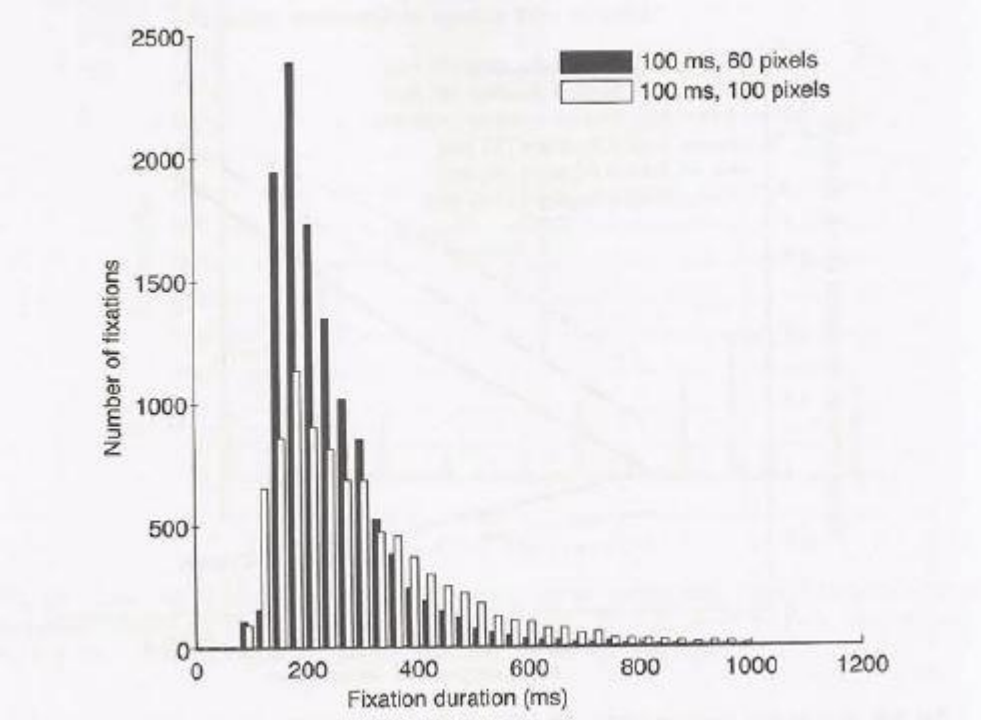
Dispersion based algorithms

- Effect of settings on fixation duration



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Dispersion based algorithms

- Optimal settings?
- Dispersion
  - Most studies use 1-2º
    - Various metrics (distance between points in the fixation furthest apart, any two consecutive points, distance between points and centre of fixation...)
    - Fixation stability - individual
- Minimum fixation duration
  - Most studies use 80-120ms
    - Fixations can be shorter

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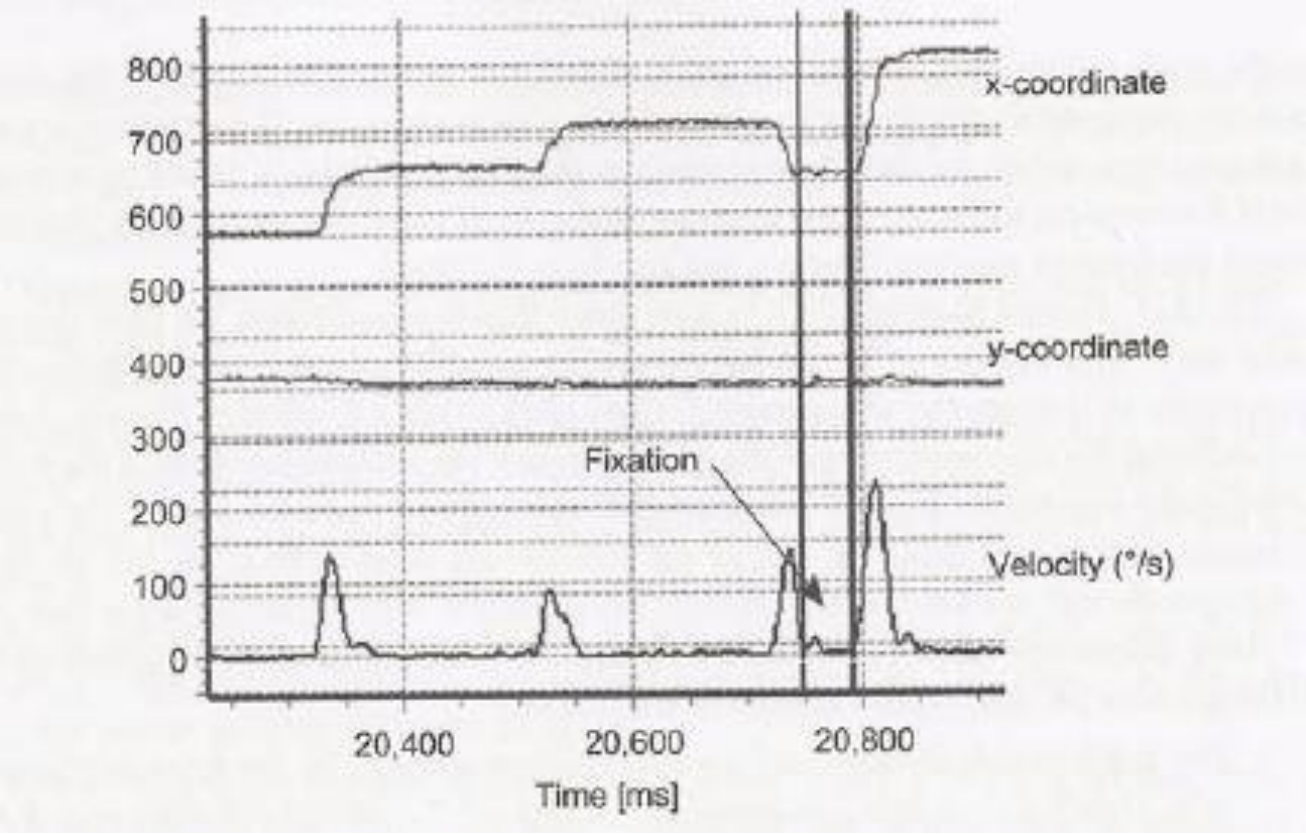
Dispersion based algorithms



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Dispersion based algorithms

- Effect of I-DT settings on events estimation

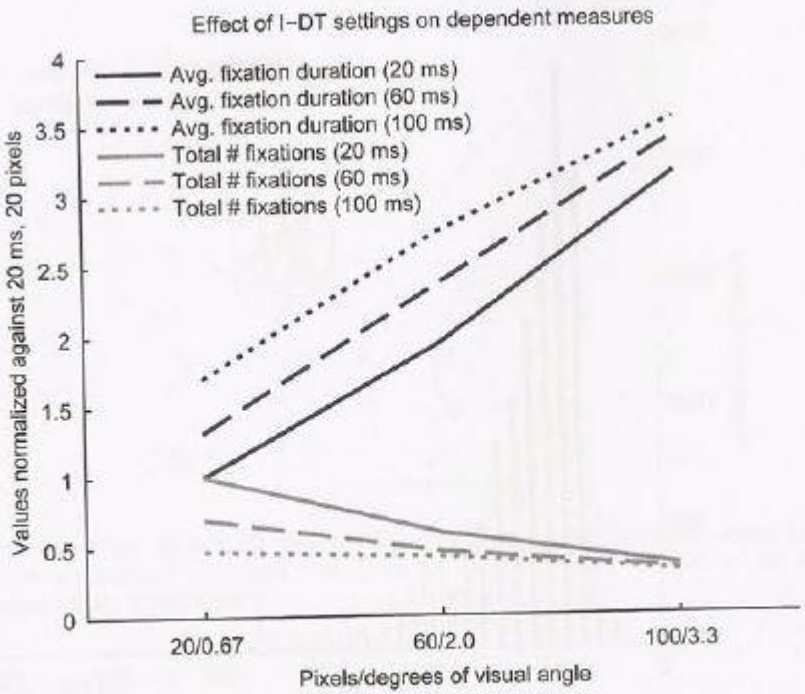

Fig. 5.8 How fixation measures differ with different dispersion diameters and duration settings in a commercial implementation of the I-DT algorithm (1250 Hz reading data from page 5). The slope is similar to that from 50 Hz data in Shic, Scassellati, and Chawarska (2008).

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Dispersion based algorithms

- Example of I-DT – wrong event parsing

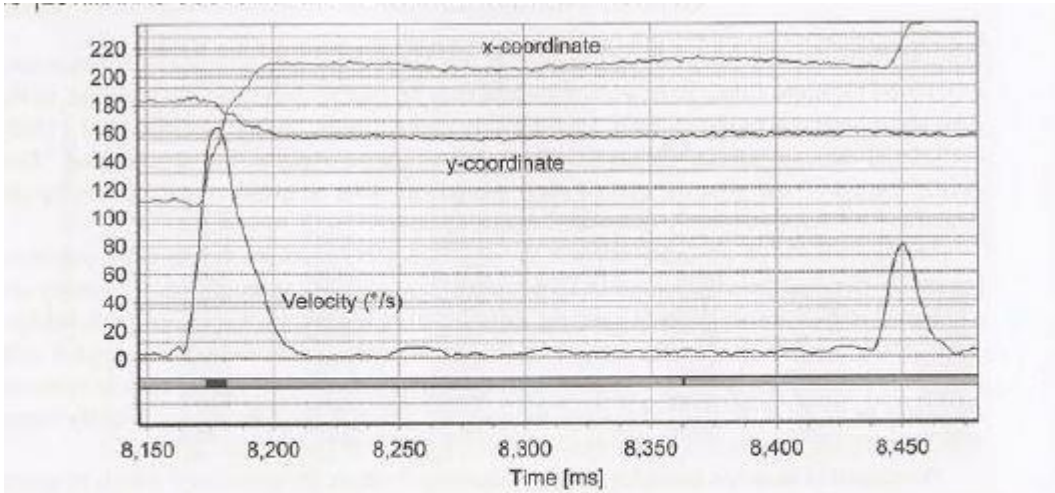

Fig. 5.19 Note how the dispersion algorithm reduces the duration of saccades, and even inserts false 'saccades' in the midst of a fixation in this reading data recorded at 1250 Hz with a tower-mounted system. Grey lines depict the x- and y-coordinates in the coordinate system of the scene video. The dark line is eye velocity. The bottom bar indicates 'fixations' (light) and 'saccades' (darker) according to the I-DT algorithm with 100 ms and 80 pixels settings.

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Dispersion based algorithms

- Check the papers you are using as a source – what settings are they using?
- Pilot settings before you choose
- Plot fixation next to your raw data and examine what the algorithm does at different settings

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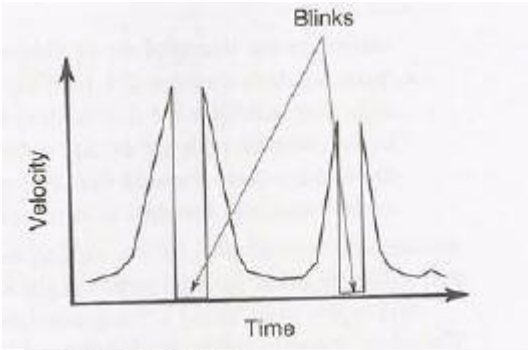
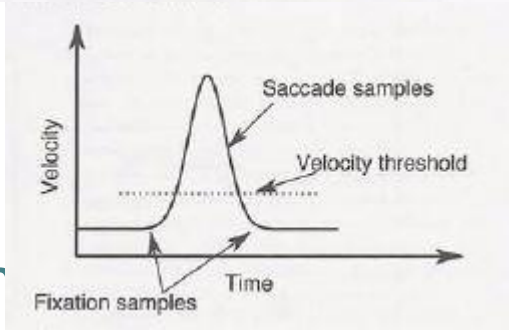
Velocity and/or acceleration based algorithms

- I-DV – identification by velocity threshold
- Most common for high-speed data
- Detects saccades, eliminates blinks (period of „no data“ between two saccades, also pupil size goes to 0)
- Assumes the rest are fixations
  - Calculates the velocity/acceleration of the eye, and assumes all velocities above the threshold are saccades
  - Everything with a velocity/acceleration below the threshold is assigned to be a fixation





Velocity and/or acceleration based algorithms – threshold settings

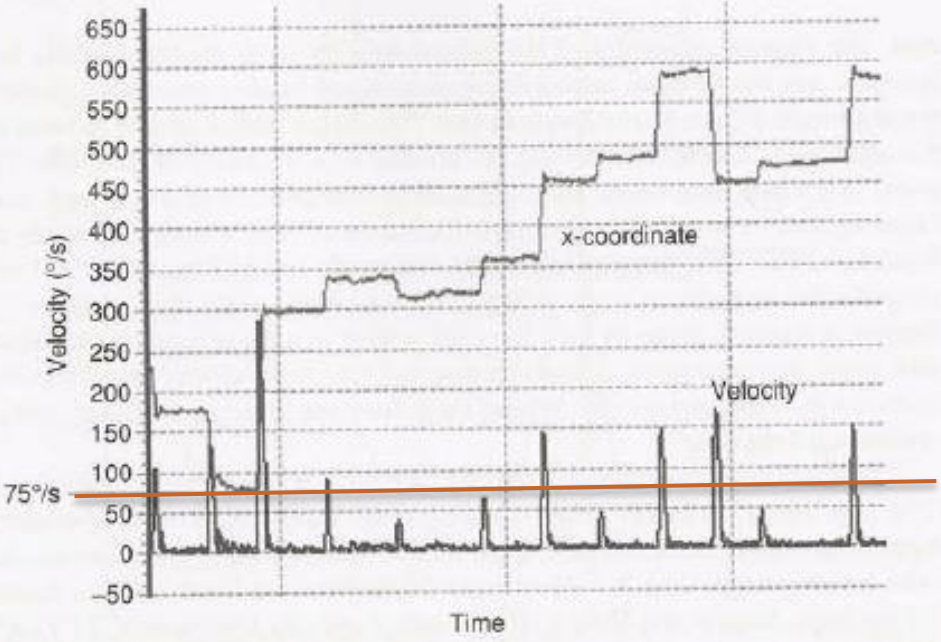


Fig. 5.7 Gaze velocity (black) and gaze *x*-coordinate (grey) for reading data. The vertical scale is in °/s and pixels, respectively. The horizontal scale is samples (time). 75°/s is marked by a line, which is clearly too high for many of the saccades. 1250 Hz data from a tower-mounted system.

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Velocity and/or acceleration based algorithms

- Effects of I-DV settings on dependent measures

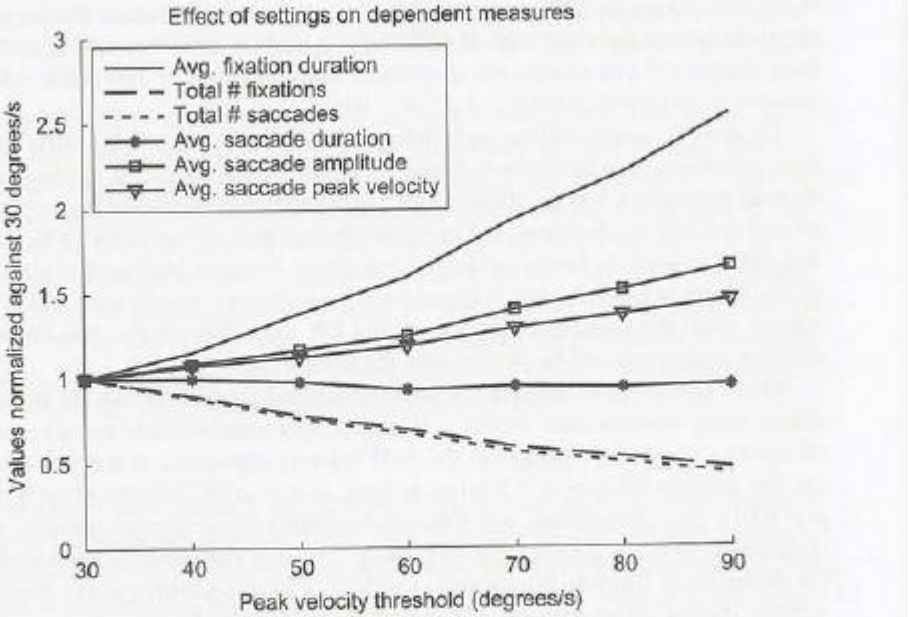

Fig. 5.10 How important dependent variables change with the setting of saccade velocity threshold in the SMI velocity algorithm (a commercial implementation of Smeets & Hooge, 2003). Reading data recorded at 1250 Hz and described on page 5.

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Velocity and/or acceleration based algorithms

Threshold type	Values	Relevant questions
Lower velocity threshold	20-130°/s	How small saccades do you need to detect? Small saccades -> lower threshold. How much noise is there in the fixations? Much noise -> higher threshold.
Upper velocity threshold	750-1000°/s	How large saccades do you need to detect? Large saccades -> higher threshold. Are there velocity artefacts in the data? Yes -> threshold below the values of artefacts.
Acceleration threshold	5000-8000°/s^2	Do you need to differentiate between saccades and smooth pursuit?

Velocity and/or acceleration based algorithms

- Acceleration threshold
  - Acceleration more noisy than velocity measures
  - Upper threshold for smaller saccades 4000º/s² (SR Research)
  - Upper threshold for reading and cognitive research 8000 º/s² (SR Research)
  - During smooth pursuit with constant velocity, the acceleration is zero
  - SR research uses velocity values for smooth pursuit:
    - „parser raises the saccadic velocity threshold during pursuit by the average velocity over the last 40 milliseconds“

Velocity and/or acceleration based algorithms

- What to do?
- Plot a velocity/acceleration diagram of your data with gaze coordinates and check
  - The lowest velocity of the saccades you want to keep
  - The highest velocity noise within the fixations
  - The highest velocity you want to keep

  - Or☺ Let the algorithm choose threshold

  - Data driven thresholds (see CH5)

Current challenges

- Head or stimulus movement
  - Smooth pursuit-like movements
- Postsaccadic oscilations („wobbles“)
- Poor data quality, (variable) precision
- Binocularity

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Head or stimulus movement

- Animated stimuli and/or head movement results in smooth pursuit-like eye movements
- If present, treat event detection with extreme caution
- Solution:
  - Manual identification

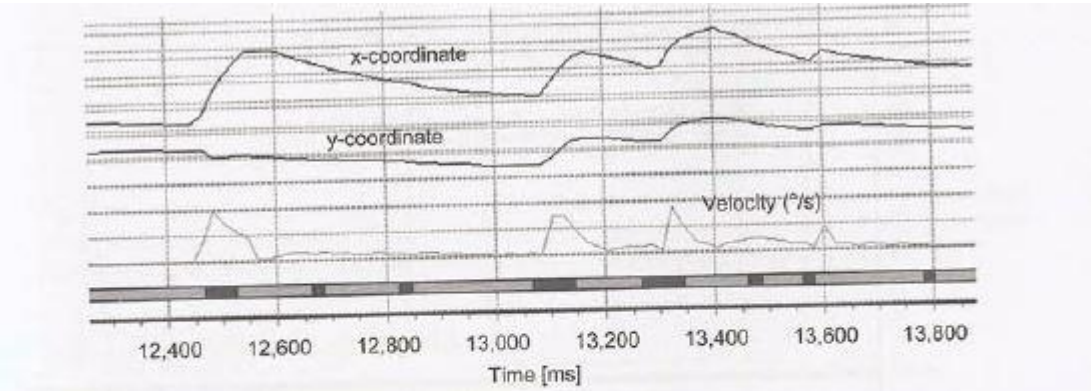

Fig. 5.20 Eye movement data from a head-mounted eye-tracker at 50 Hz on a participant walking past a shelf in a supermarket. Dark lines are the x- and y-coordinates in the coordinate system of the scene video. The grey line is eye velocity. Bottom bar indicates fixations (light grey) and saccades (dark grey) according to the I-DT algorithm with 80 ms and 80 pixels settings.

Smooth pursuit in the algorithms

- I-DT
  - Necklace of short fixations and saccades
- I-DV
  - (Very) long fixations and (very) long saccades

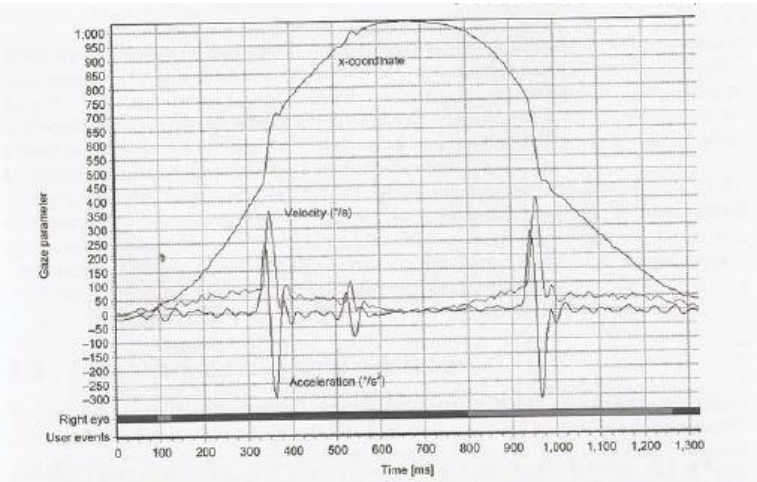

Fig. 5.27 Gaze following a pendulum movement. Recorded with the SMI HiSpeed 1250 Hz. 'Fixations' (black) and 'saccades' (grey) as detected with the SMI velocity algorithm in BeGaze 2.1 are shown at the bottom of the graph.

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Post saccadic oscilations

- „Wobbling“
- Assigned either to saccade or fixation depending on the settings.. How do you choose?

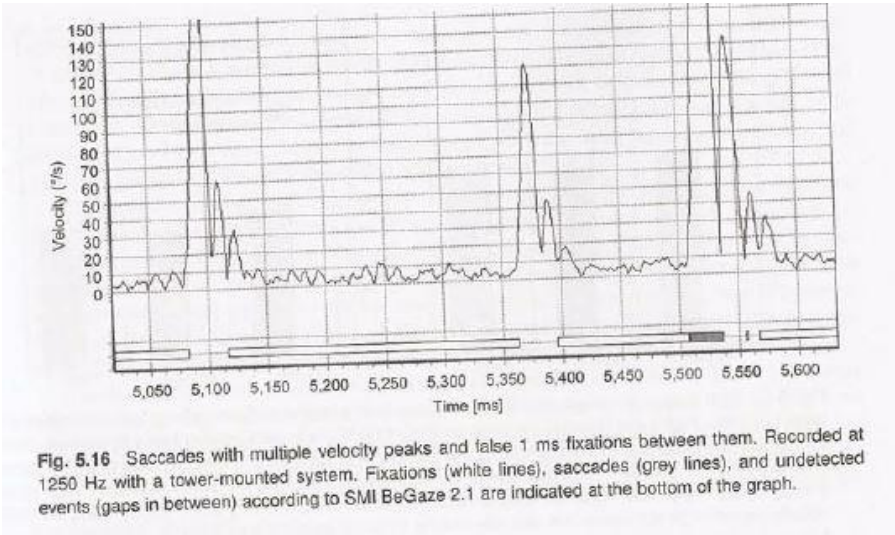

Fig. 5.16 Saccades with multiple velocity peaks and false 1 ms fixations between them. Recorded at 1250 Hz with a tower-mounted system. Fixations (white lines), saccades (grey lines), and undetected events (gaps in between) according to SMI BeGaze 2.1 are indicated at the bottom of the graph.

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Poor data quality – variable precision

- Imprecise top (fix 1&5), precise bottom (fix 2-4)

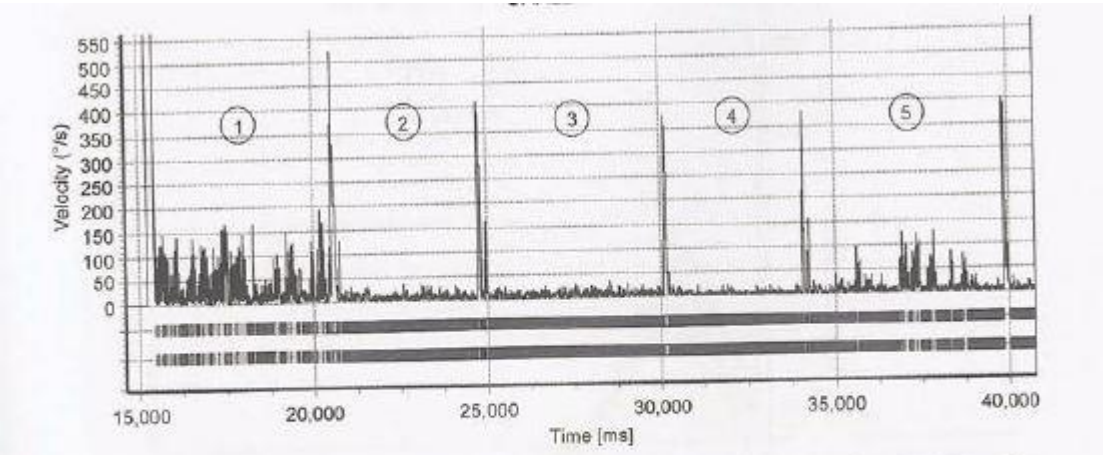

Fig. 5.13 Variable precision. Data acquired for oculomotor fixations 1–5 are noisy (imprecise) when the participant looks at the top of the stimulus (first and fifth fixations) and precise at the bottom (second to fourth fixation). Recorded with a remote system at 250 Hz and analysed with a velocity-based algorithm with a threshold of 75°/s.

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Binocularity

- Which eye should you record from?
- What is the solution to this case for event detection?

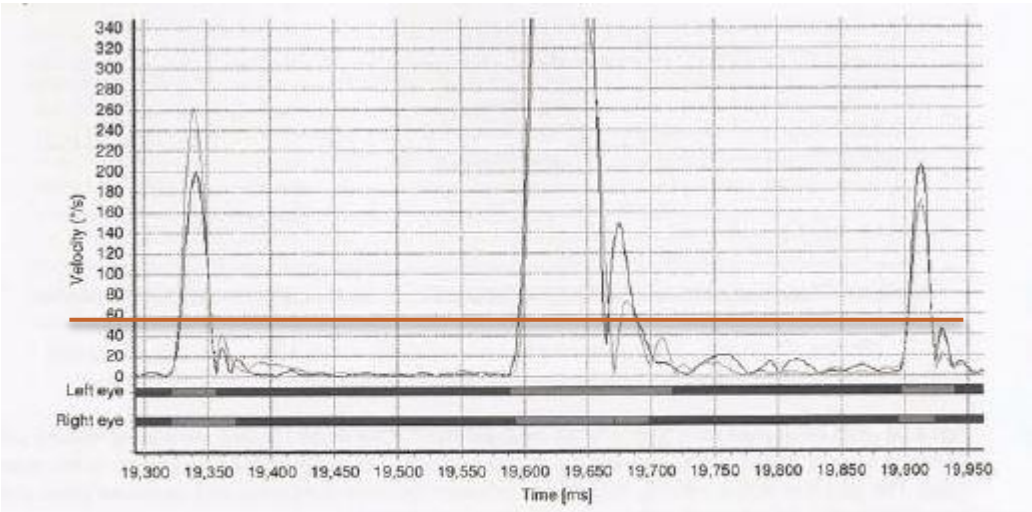

Fig. 5.22 Reading near the borders of a flat monitor: Velocities of saccade far to the right, return sweep, and saccade far to the left. Black line is left eye; grey line right eye. Recorded with a tower-mounted system at 500 Hz in binocular mode.

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What have we learned so far?

- Always plot your raw data
- Be suspicious of the default settings
- Look at XY-plots, velocity plots and histograms
- Beware of smooth pursuit and/or be ready for it
- Always report the settings
- For studies to be comparable, they need to use as similar settings as possible (common sense, yet to be proved scientifically)
- Parallel analysis with two or more settings
  - Is your experimental design balanced and robust against setting-related artefacts?
- Questions?:)

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For the next lecture…

- We'll do the „Measures"
- Lab on Data Analysis, we're running until 12:25
- I'll collect your questions about ET that have not been answered until now

- Prepare
  - Send the comments to my email address + your peers' addresses until 18th April, 23:00
  - You will receive the comments from me also until 18th April, 23:00
  - Read the last 2 articles: Imagery A and Imagery C
  - Browse CH9 to CH14

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