FernUniversität in Hagen

Video Analytics in MOOCs

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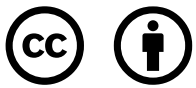


1. Introduction

2. Data gathering

3. Measurements for modeling

4. Visualize video-based learning

Slides for download: `https://www.nise81.com/`

Learning objectives

At the end of this workshop you . . .

- will know what data may be useful for video analytics.
- will understand different methods to compute the watching time.
- understand basic information retrieval techniques to analyze video footage.
- have made first experiences with tools like *Vi-Logger*, *ffmpeg*, and *Praat*.
- can explain how to make use of visual analytics in order to better understand video usage as well as learning activities of groups and individuals.

1 Introduction

Introduction

Video-based Learning

- *Video-On-Demand* traffic increase of 29 % between 2013 and 2018 [Ci14]
- 75 % of the university students in Germany using videos for learning (n=27,473) [PF16]
- formats: *flipped classroom* (e.g. [ES15; Ki14c; SC14]), MOOCs (e.g. [GJK14])
- many different video learning environments, `http://designingvideointerfaces.nise81.com/portals`

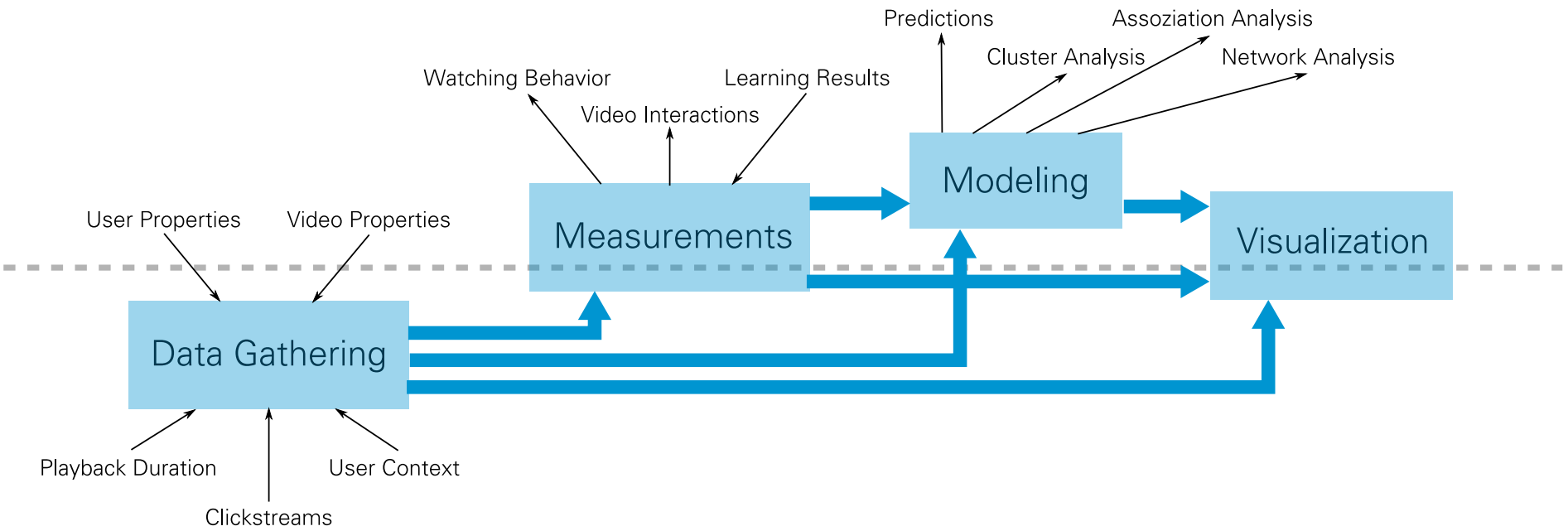
Video Analytics

Learning Analytics methods applied on video-based learning.

- inform instructors about (ongoing) learning activities
- help students to self-regulate their learning
- improve learning resources
- foster group awareness

Procedure

asynchronous

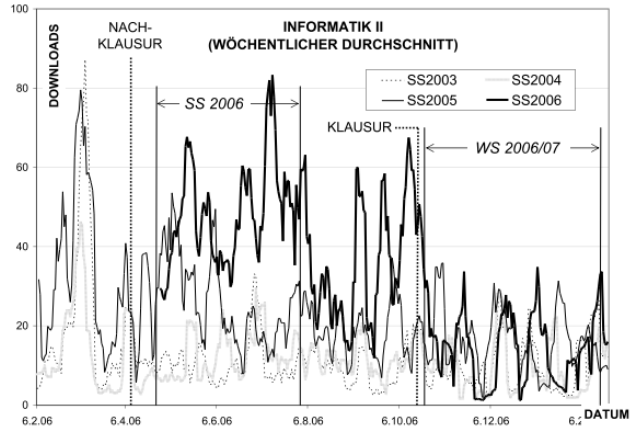


synchronous

Specifics of time [Ke10]

Granularity of time:

- hierarchical system of granularities:
  ..., ms, sec, minutes, hours, days, ...
- cycles and re-occurrences



(cf. [He07])

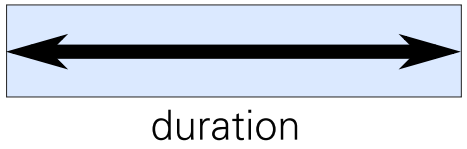
Temporal primitives: time points and intervals

Structures of time:

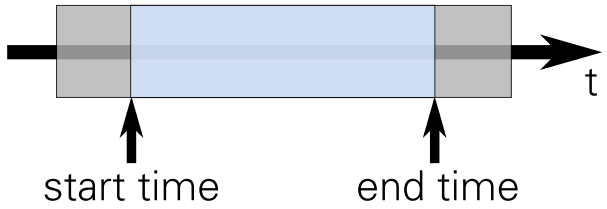
- ordered time: hierarchy and cycles
- branching time: describe or prepare planings or predictions
- multiple perspectives: subjective views on the same event

Presentation time

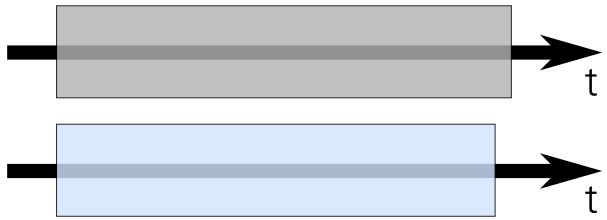
Media element time



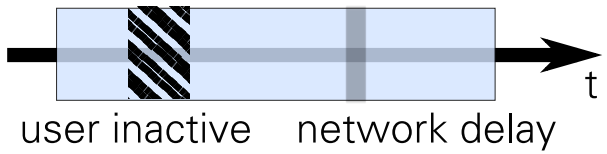
Document time



Rendered time



Run time



(cf. [Ha99])

2 Data gathering

Gathering data from online video players

HTML5 Video

```
<video id="myvideo" width="320" height="240" controls>
  <source src="video.mp4" type="video/mp4">
</video>
```

Javascript

```
var video = document.getElementById( "myvideo" );
video.addEventListener('timeupdate', function(e){
  console.log( video.currentTime );
});

// heartbeat
function write(){ console.log( video.currentTime ); }
setInterval(write, 2000);
```

Typical result in a log file

```
utc             phase  group  user  video  action      playback-time
1477209428123   6      d      34    45     playback    5.012
1477209423121   6      d      12    45     pause       9.432
1477209418125   6      a      23    46     addComment  9.432
```

Approximating playback duration

Method	Source	Inadequacy
Timeupdate	(W3C)	No active watching; too detailed;
Clickstream	[Se14]	Long periods without clicks are not considered;
Heartbeat	[Br11; BTG13]	No active watching; beat frequency; interactions between the beats;
Section visits	[KE16; MKB10; WL15]	Partly watched section count like fully watched ones;
Segments	[KE16; Ki14a; Ki14b; MKB10; Si14]	Segment size; rounding errors; no active watching;

Challenges:

- determine active watching / learning phases
- consider varying playback rates
- realize when a session ends

Determining playback duration from clickstreams [Se14]

Input:
Log: Clickstream log
ε: Tolerance

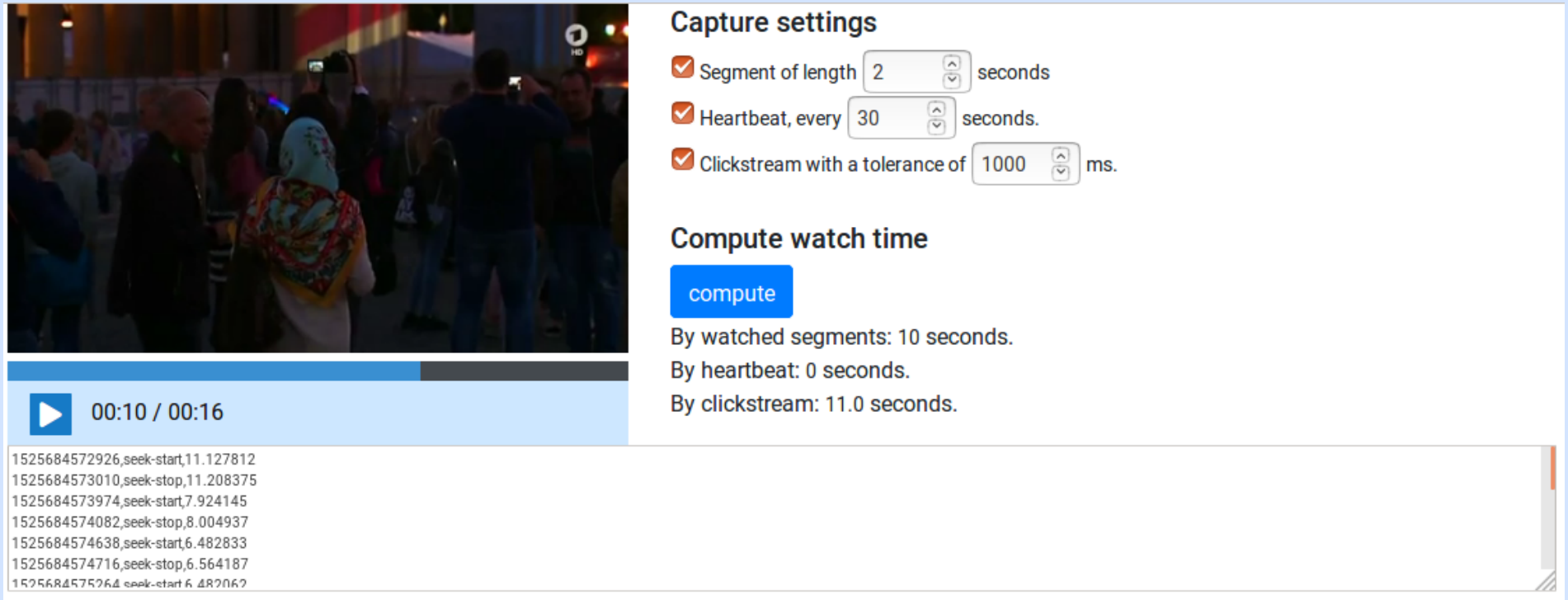
Function `getUserPlaybackTime(`*userSessionLog*`)`
  tmp $\leftarrow$ *userSessionLog*[0]
  for $i = 1; i <$ *length*(*userSessionLog*)$; i \leftarrow i + 1$ **do**
    timeDistance $\leftarrow$ *userSessionLog*[i].*utc* $-$ *tmp.utc*
    playbackDistance $\leftarrow$
     userSessionLog[i].*playbacktime* $-$ *tmp.playbacktime*
    if *playbackDistance* > 0 **then**
      if (*timeDistance* $-$ *playbackDistance*) $\leq \varepsilon$ **then**
        playbackTime $\leftarrow$ *playbackTime* $+$ *playbackDistance*
      end
    end
    tmp $\leftarrow$ *Log*[i]
  end
  return *playbackTime*
End

aUserLog $\leftarrow$ *extractUserData*(*Log*, *userA*)
aUserSession $\leftarrow$ *getSession*(*aUserLog*, 2)
playbackTime $\leftarrow$ *getUserPlaybackTime*(*aUserSession*)

Hands-on: approximation of playback duration

Assignment:
Use the *Video-Logger* and play around withe the log settings. Configure a perfect logger to determine the playback duration considering the precision, effort, and data economy.

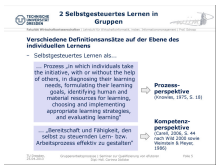
Vi-Logger: `https://nise.github.io/vi-logger/public/`



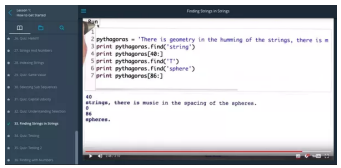
Video properties

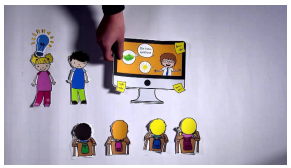
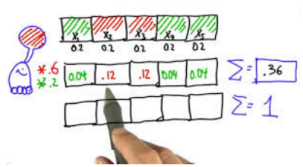
Production properties:

- length [GKR14],
- visual transitions [Ki14a; Ki14c],
- production style: classroom lecture, talking head, digital tablet drawing, presentation slides [GKR14]







Content properties:

- type of video (e.g. lecture, tutorial, documentary) [GC14; GKR14],
- speaking rate [AF17; GKR14; Ki14a],
- speech / discourse analysis [AF17; Fi12; Ki14a],
- speech / audio volume, pitch frequency [Ki14a]

Example: speaking rate

$$speakingRate = \frac{number\ of\ syllables}{video\ duration} \geq \frac{number\ of\ syllables}{video\ duration - pause\ time}$$

1. Extract audio from the the video

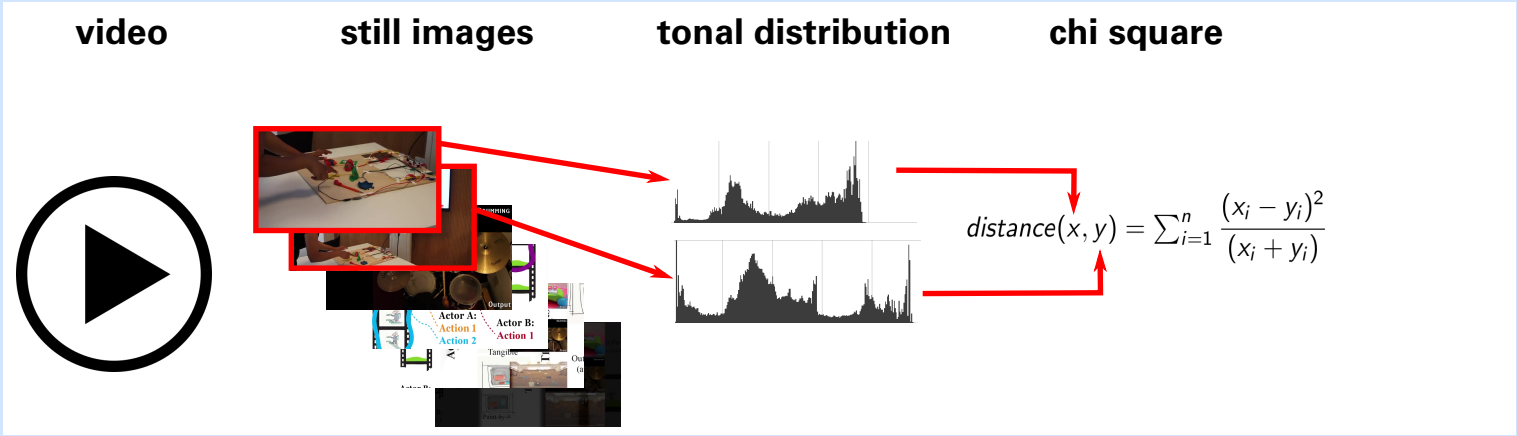
```
$ ffmpeg -i video.mp4 -ab 160k -ac 2 -ar 44100 -vn audio.wav
```

2. Install and open *Praat* from `http://www.fon.hum.uva.nl/praat/`
3. Download and open the speech rate script in *Praat*, `https://sites.google.com/site/speechrate/Home`
4. Run the script by pressing Ctrl+R and chose a directory containing a *.wav audio file

Output

nsyll	npause	duration (s)	phonation-time (s)	speechrate (nsyll/dur)	articulation rate (nsyll / phonation-time)	ASD (speaking-time/nsyll)
27999	2010	7477.91	5757.28	3.74	4.86	0.206

Example: shot detection



1. Extract still images from video

```
ffmpeg -i video.mp4 -vf fps=1/5 i%03d.jpg -hide_banner
```

(every 5 seconds)

2. Determine histogram differences using chisquare

```
sh ./histcompare.sh -p global -n 0,1 -m chisquare i001.png i002.png
```

(see `http://www.fmwconcepts.com/imagemagick/histcompare/index.php`)

3. Consider shot positions for later analysis

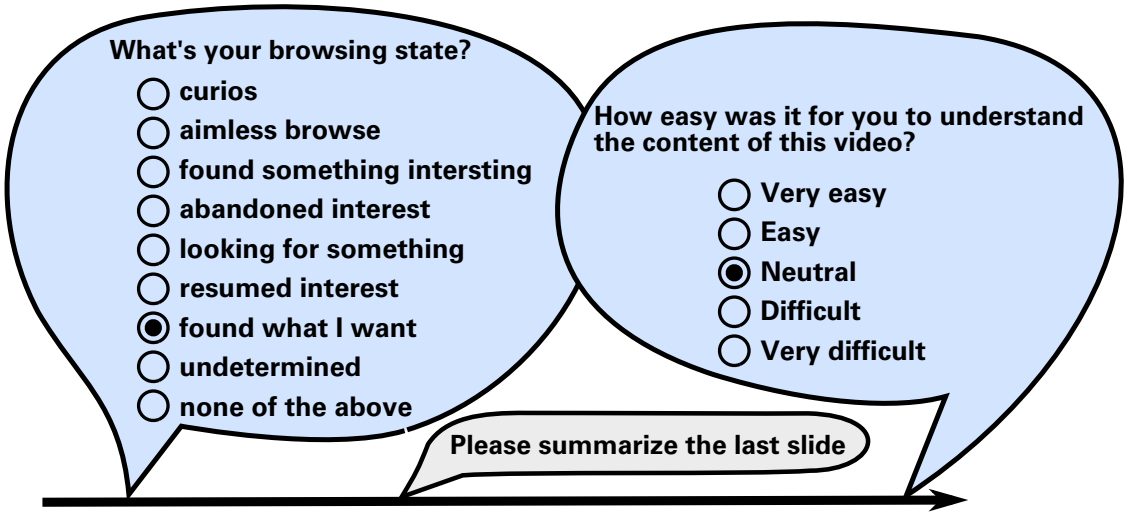
User properties and intentions

Questionnaires in advance

- demographic data [GR14; KPS13],
  e.g. age, country of origin, prior knowledge, media usage
- personality types [RM02]

Surveying during video usage

- Predicting interesting segments from browsing data that was trained with in-video questions about the current usage intention [SP01]
- Capture perceived difficulty at the end of the video [Li15a]
- Content summarization



3 Measurements for modeling

Measurements: watching behavior

Viewing duration	Time spent on watching a video. [BET99; Ch16]
Replay segments	Counting the number of segments that were played more than once. [SJD15]
Total watching time	Total number of seconds spent viewing all videos. [Dí15; RM02]
Watching ratio	Relative watching time per video. [Dí15]
Watching threshold	Minimum amount of time a video has been watched. [Br11]
Retention rate	Number of unique users who watched a video segment [Dí15; Ki14a; Li15b] / the number of views for a particular moment of a video as a percentage of the total number of views of the video. [Le17]
Coverage	Fraction of the video that the student visited. [GR14]
Session length	Time span between start and end of a session. [BET99; BT08; GKR14]
Number of sessions	Number of distinct user sessions. [BET99; Ki14a]
Session views	Number of viewings per session. [BET99]
Session length threshold	Number of sessions longer than n. [RM02]

Measurements: video interactions and learning results

Micro level: In-video interactions

play, pause/breaks, volume changes, full screen on/off, captions on/off, speed changes, seek, seek forward, seek backward, seek from, seek to, slow forward, slow reverse, fast forward, fast reverse

→ access patterns [Br11; HGM14; Se14]

→ viewing and interaction profiles [BT08; CBB17; Ch17; Li15a; Li15b; MBD06]

→ in-video drop-outs [BG17; Ki14c; Li15a]

Macro level: Inter-video interactions

→ navigation strategies [GR14]

→ course drop-outs [Br11; HGM14]

Learning results:

- video annotations: add / edit / use (e.g. [Se13])
- non-video services: comments, forum posts, wiki entries, ...
- quizzes: performed quizzes, attempts, results [GMD14; KE16; Li15b; MD13]

Learner modeling

1. Prepare data

- remove automatic pauses [Li15b]
- remove pauses longer than 10 min [Li15b]
- group seek events within a range of 1 s [Li15b; Si14]
- remove in-video drop outs (e.g. watched less then 10 sec)
- ignore sessions without interactions (?)

2. Compute video features

- prefer median over mean or sum for long-tail distributions

3. Start developing or using a model

Modeling: video features

event	frequency	duration
total events	[CBB17; Ki14b]	
play	[BET99; CBB17; Dí15; GC14; GKR14; Ki14a; MBD06; MD13; Si14; SP01]	[BET99]
pause	[AF17; BET99; CBB17; Dí15; GC14; GKR14; KE16; Ki14a; Li15b; MBD06; MD13; Si14; SJD15; SP01]	[BET99; Li15b]
volume	[KE16; Ki14a]	
full screen	[Ki14a]	
show captions	[AF17]	
speed changes	[AF17; CBB17; Dí15; Ki14a; Si14]	
mean speed	[Li15b]	
slow forward	[SP01]	
slow reverse	[SP01]	
fast forward	[BET99; De94; MBD06; SP01]	[BET99]
fast rewind	[De94; MBD06; SP01]	[BET99]
seeks	[AF17; CBB17; KE16; SP01]	[AF17; BET99; Li15b]
seek forward	[GC14; KE16; Li15b; Si14]	
seek back	[GC14; KE16; Li15b; Si14; SJD15]	
seek from	[Dí15]	
seek to	[Dí15]	

4 Visualizations

Visualizations: purpose

	Target Audience		
Scope	Learners	Instructors	Researchers
Video	self-regulate learning, reflexion	improve material, adopt instructions	*
User	self-regulate learning, reflexion, group awareness	(compare learners)	*
Groups	group awareness, co-regulation	monitor courses/groups, compare groups	*

Visualizations: foundations

Approaches [Ke10]

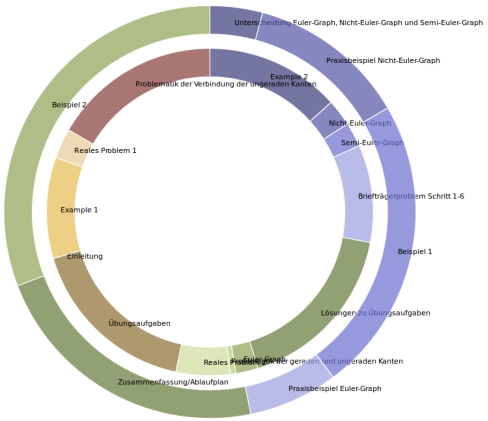
- visualize time-related data
- visualize time per se, e.g. Gant Chart

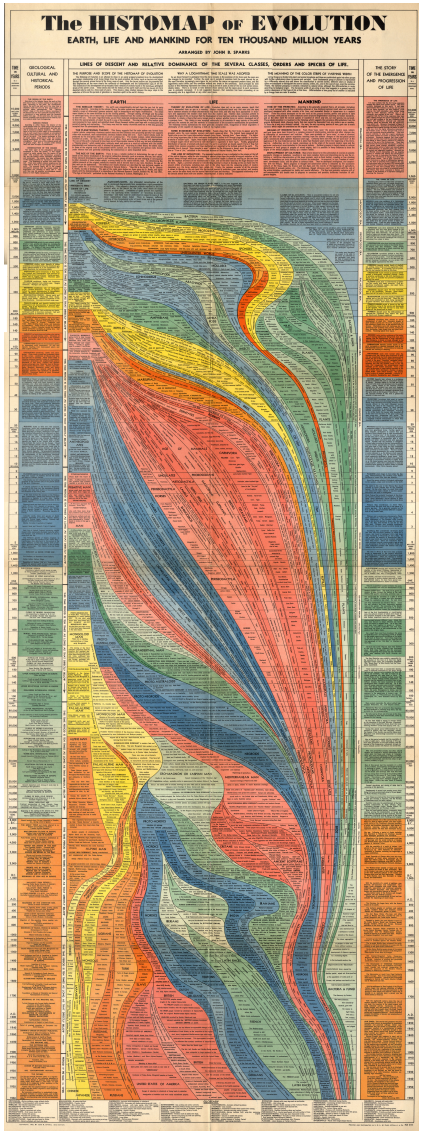
Representing time [Ke10]

- create spatial arrangements → time axis
- real world time → animation, video, etc.

Time axis:

- form: linear vs. circular
- scale: linear vs. logarithmic
- direction: left to right (cf. [RG10])





Histomap of Evolution
by John B. Sparks

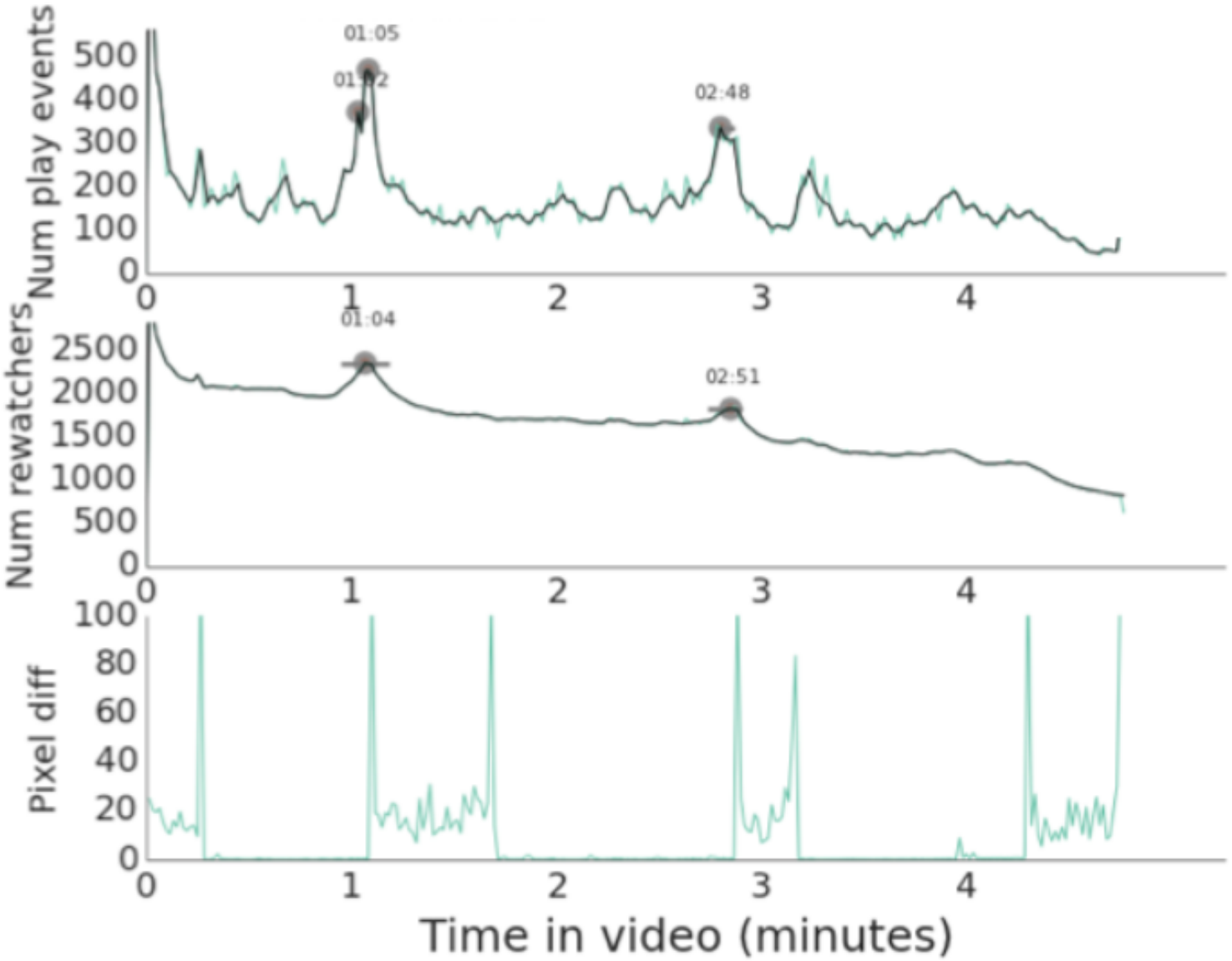
Short survey

(1) Please note possible features or dashboard elements you would like to have as an application in a learning analytics system.

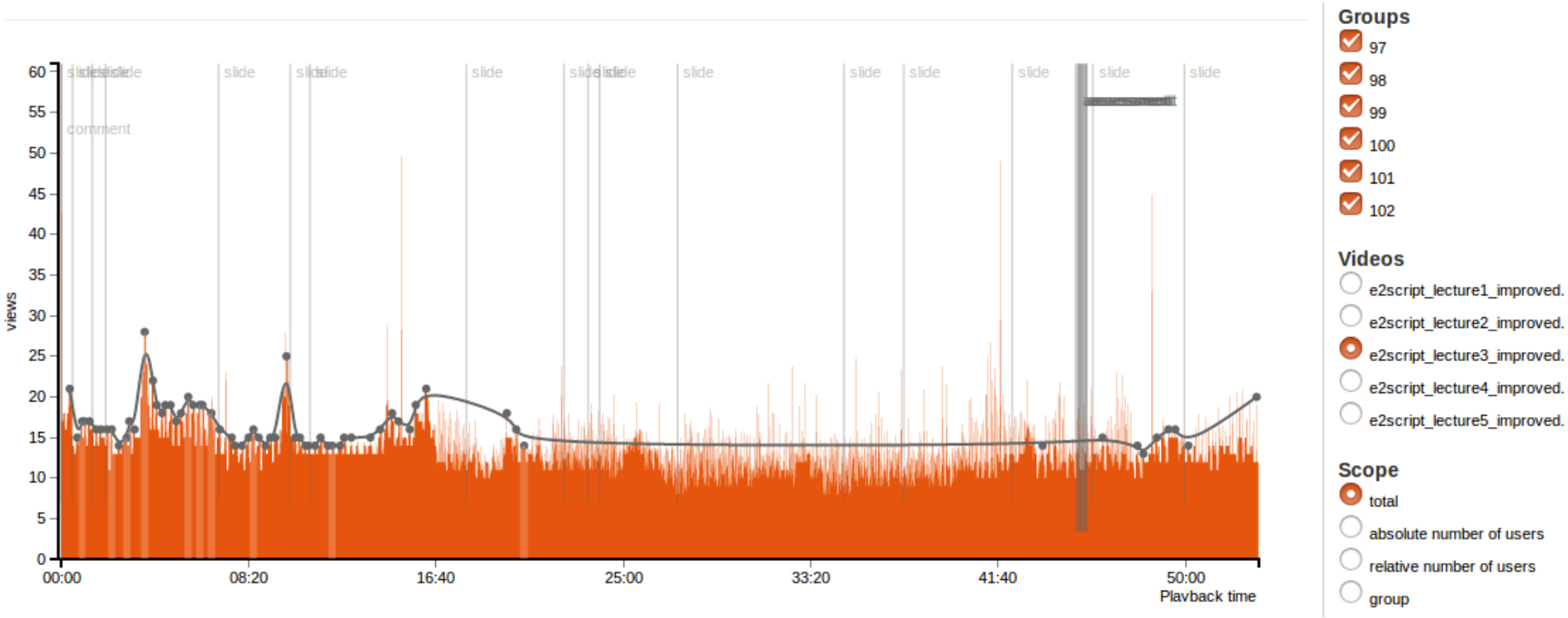
(2) Please explain which functions these elements should have.

(3) Please indicate how you think these features or dashboard elements can support learning.

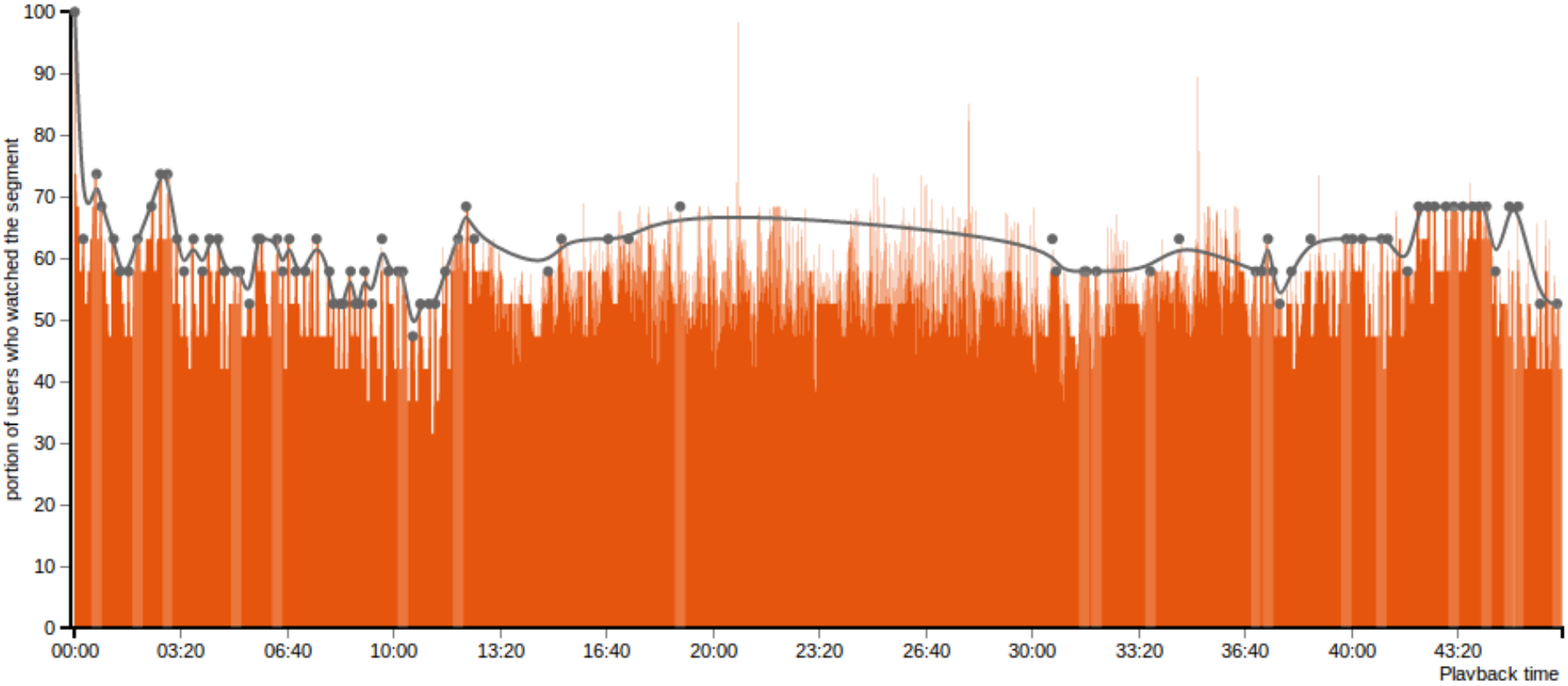
Video scope: interaction peaks [Ki14c]



Video scope: playback peaks II

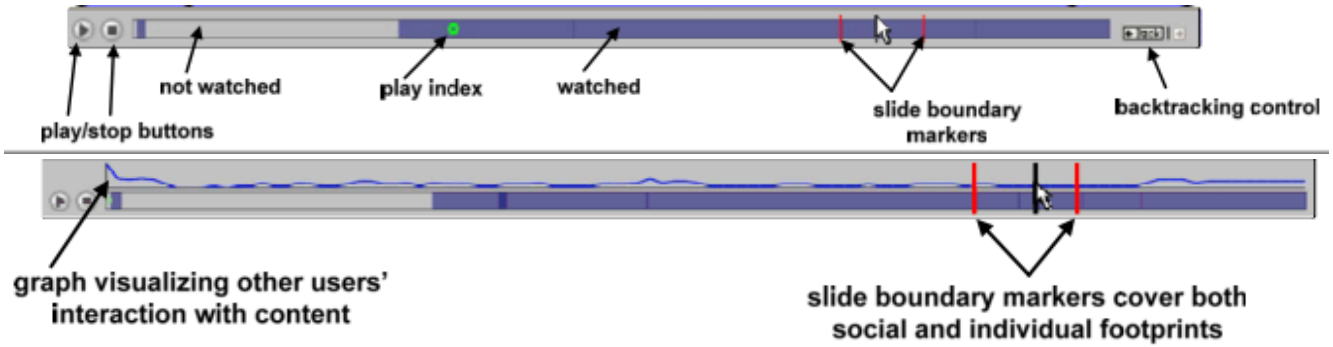


Video scope: retention rate

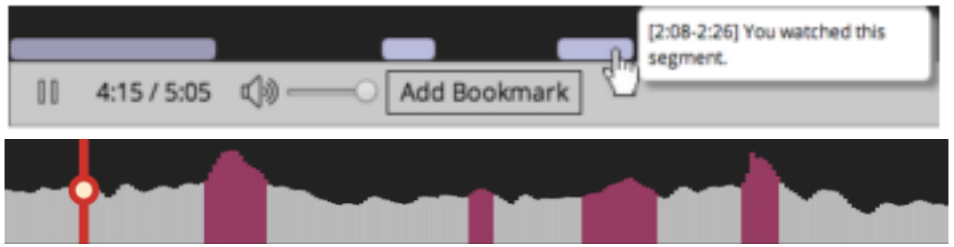


Video scope: social navigation

Mertens et al. (2010) [MKB10]

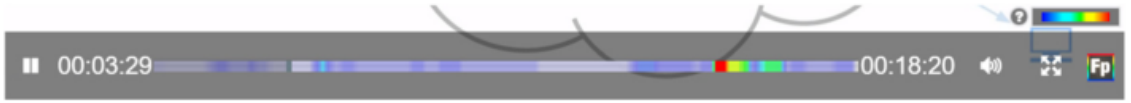


Kim et al. (2014) [Ki14b]

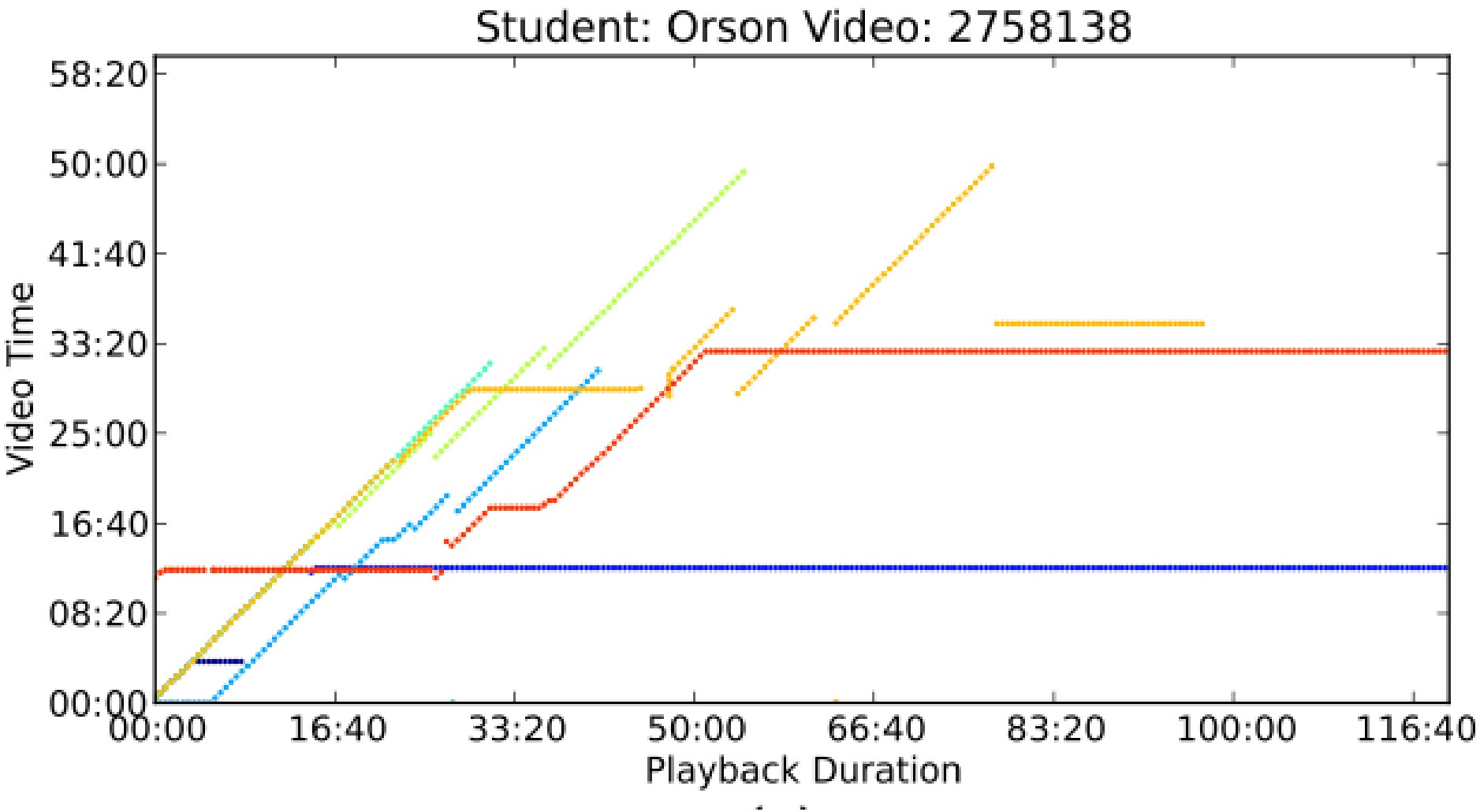


Wald et al. (2015) [WL15]

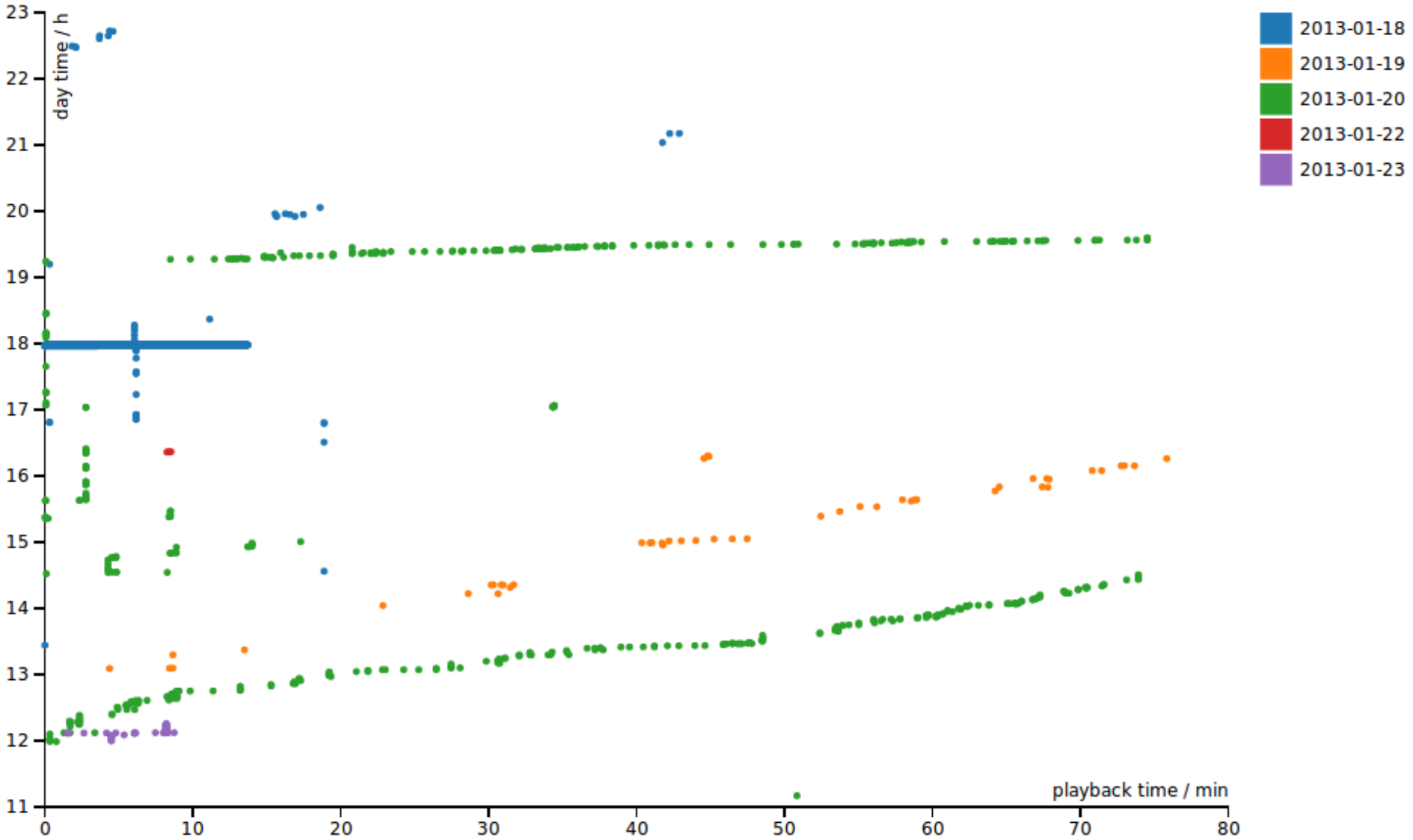
Chatti et al. (2016) [Ch16]



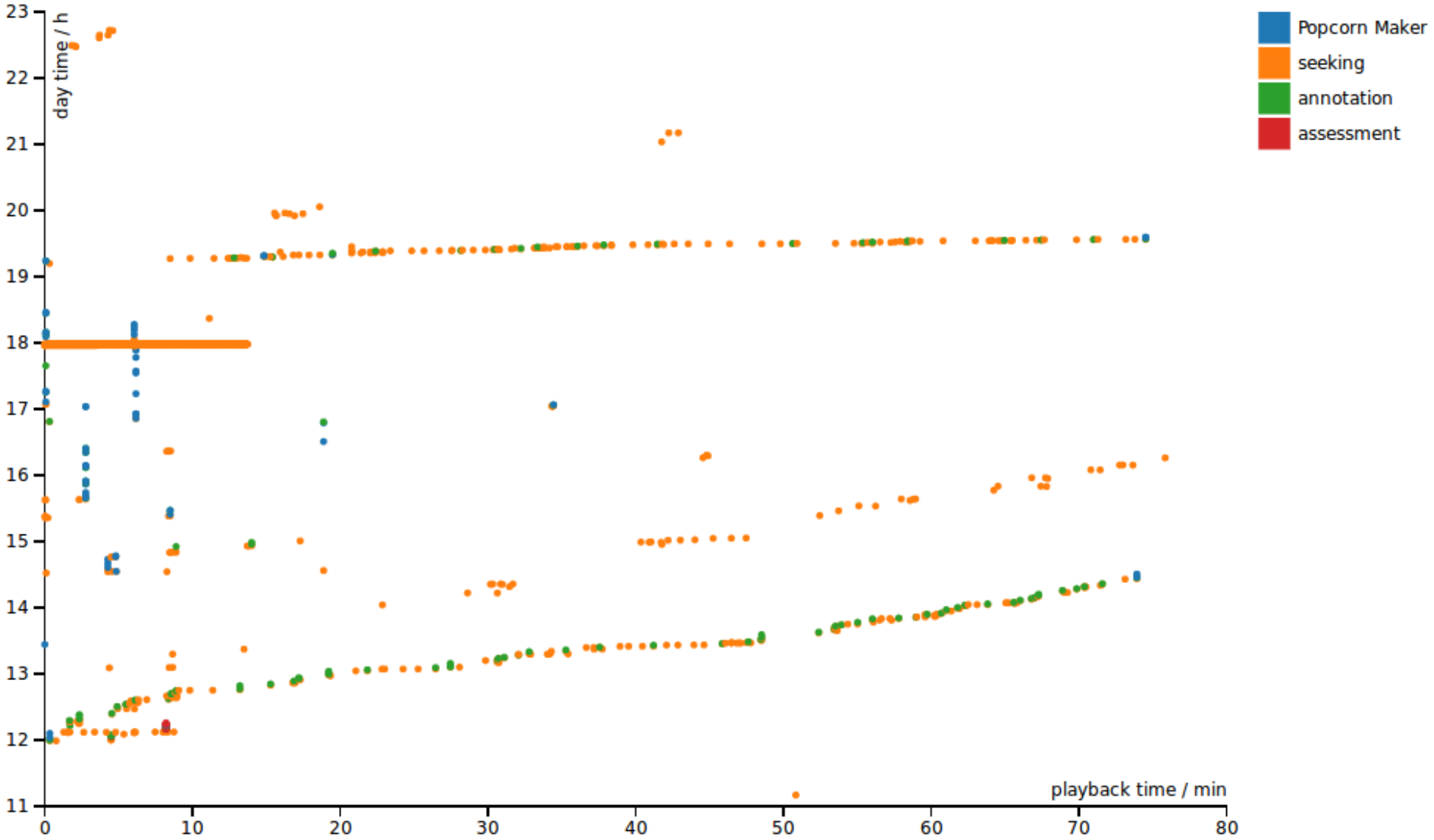
Individual scope: rewatching graphs [BTG13]



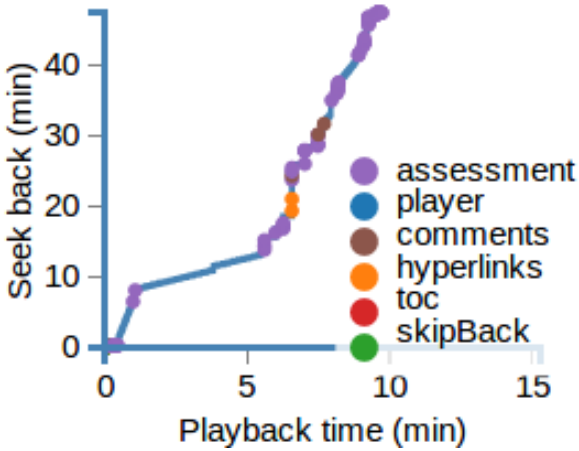
Individual scope: rewatching graphs II (by day) [Se14]

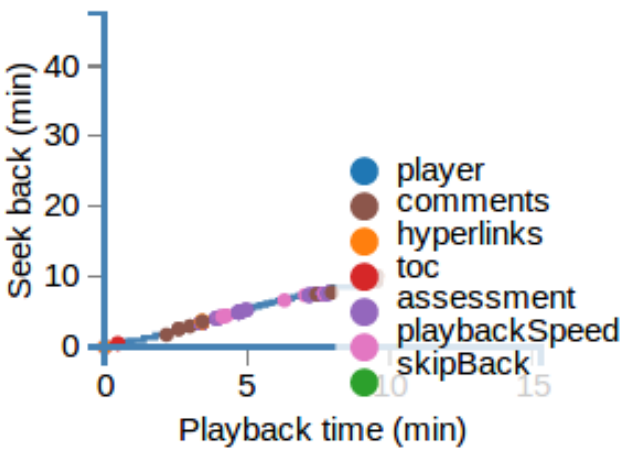


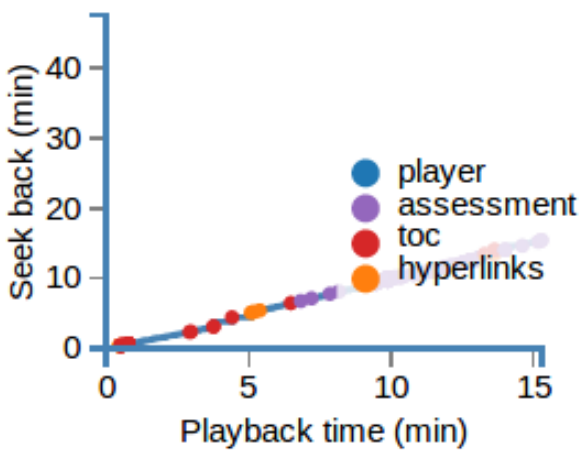
Individual scope: rewatching graph II (by tools) [Se14]



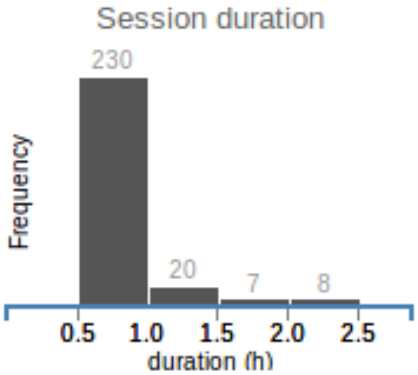
Individual scope: forward-backward diagrams [Se14]

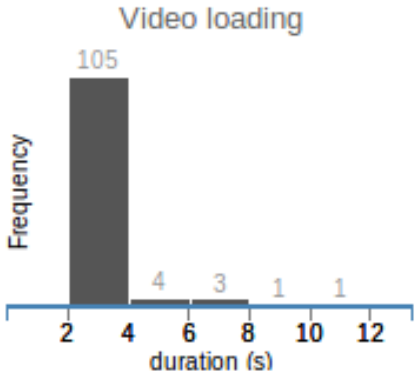


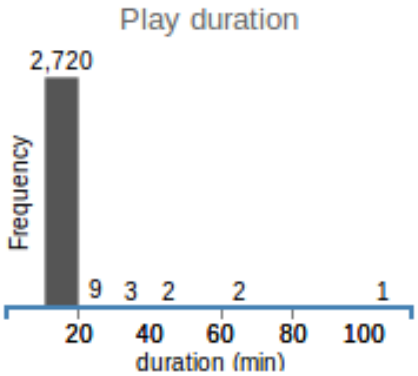


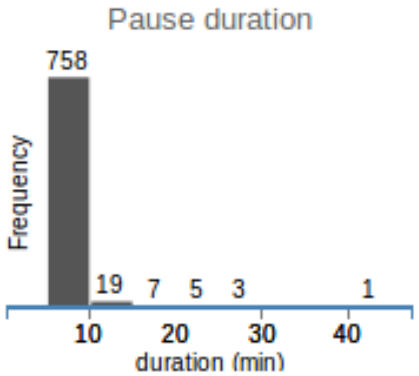


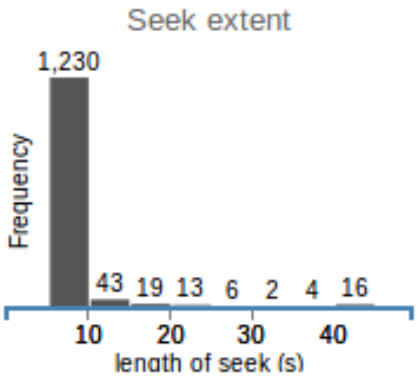
Group scope: histograms [BET99]

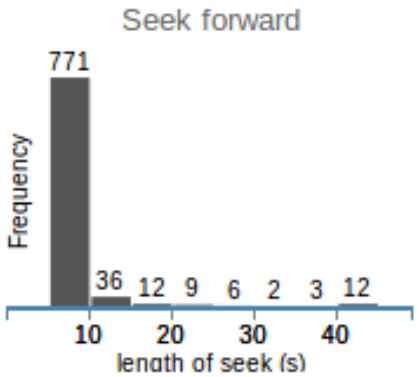


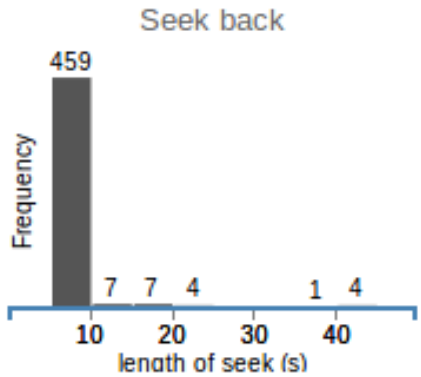




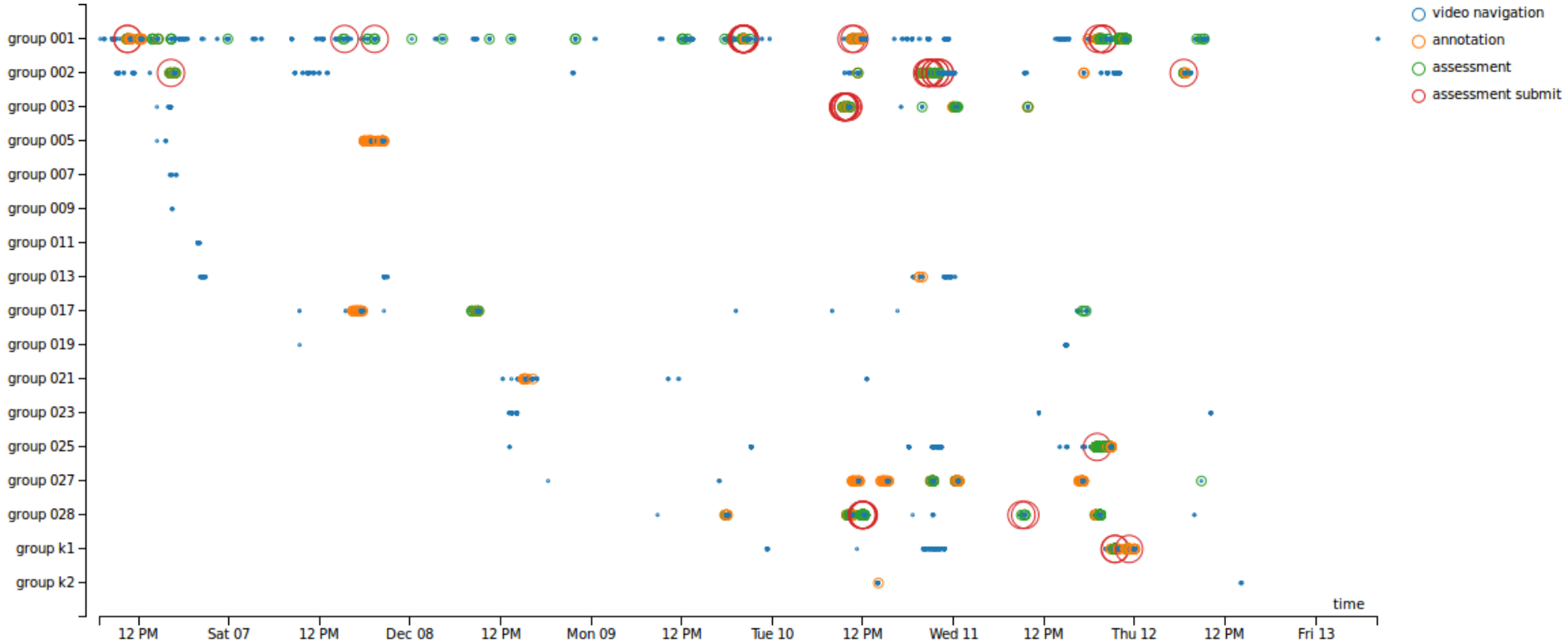




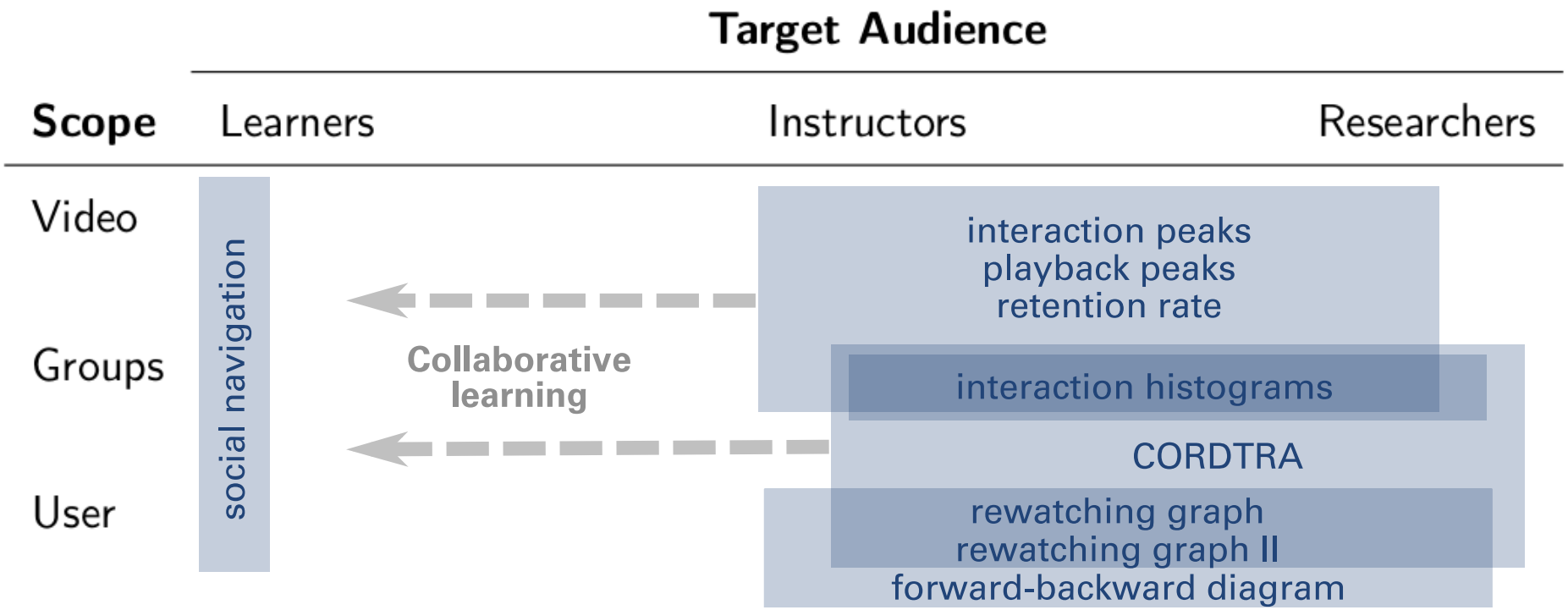




Group scope: CORDTRA diagram (cf. [PEH11])



Visualizations at a glance



Conclusion & future research direction

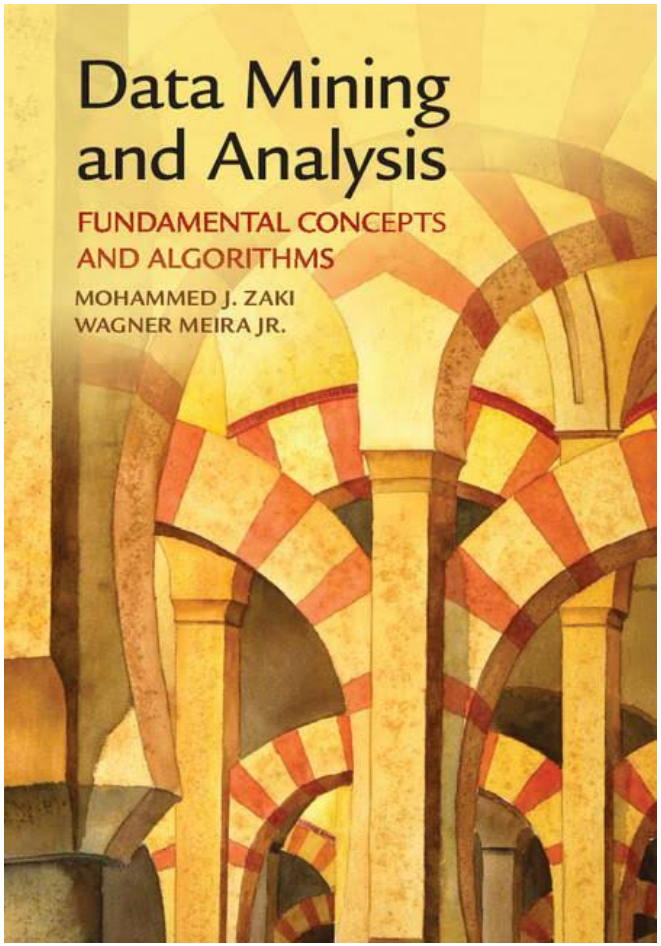
Conclusion

- Possible data sources for video analytics
- Different methods to approximate the watching time
- Analyzed video footage with information retrieval techniques
- Introduction to tools like *Vi-Logger*, *ffmpeg*, and *Praat*
- Applied visual analytics techniques in order to understand video usage and learning activities

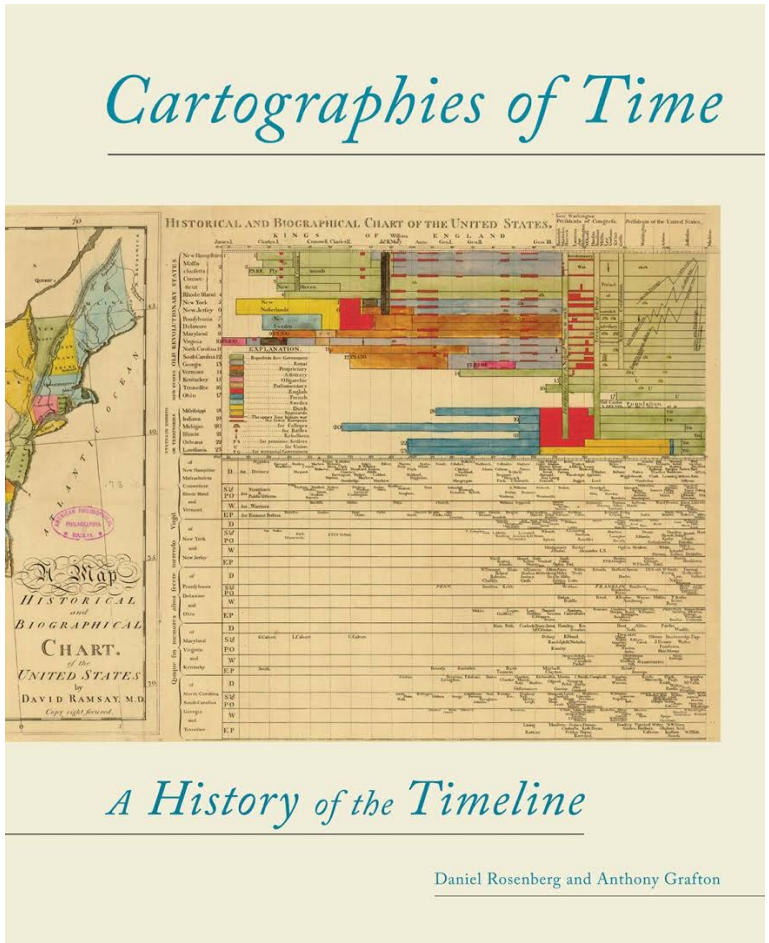
Furture research directions

- Standardization and interoperability of video log-data
- Generic learner models and viewing profiles
- Parameterization of data charts (e.g. forward-backward-diagram)
- Tooling: Log $\rightarrow$ report
- Learning analytics dashboards for video-based learning

Further reading



Zaki J. Mohammed & Meira Wagner Jr.



Daniel Rosenberg & Anthony Grafton

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