



Measuring the impact of subtitles on cognitive load

Digital Humanities Colloquium
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FACULTY OF HUMANITIES

#DiscoverNWU



Overview

- DH & Subtitles
- Subtitle characteristics
- Benefits of subtitles
- Measurements with subtitles
- Eye-Tracking equipment
- Eye-Tracking measurements and paradigms
- Measurements of CL
- How to measure subtitles with ET
- Results
- Conclusion

About Myself...



- Dr Gordon Matthew
- Research Technologist
- School of Languages
- North-West University, Vanderbijlpark
- Eye-Tracking Lab Manager

PhD Thesis

- *Measuring the impact of subtitles on cognitive load in an educational context*

DH & Subtitles

- *Digital Humanities (DH)*

“...form a bridge between the **traditional practices** of research and the **opportunities afforded by technology**, providing scholars with **new ways of looking at old problems**, and the **methods, tools and frameworks** to support them **in novel avenues of enquiry.**”

- Subtitles:

- Follows long history of instructional material: Audiovisual Aids for learning
- Converts speech into text on a screen
- Provides access to information in any language group

Subtitle Characteristics

Three types of subtitle presentations

1. **Bimodal or intralingual** (the dialogue and subtitles = the same language);
 2. **Standard or interlingual** (English dialogue and mother tongue subtitles)
 3. **Reversed** (mother tongue dialogue and English subtitles)
- Mostly used for entertainment
 - Recently used for education

Subtitle Characteristics

- Text in-sync with dialogue
- Different from reading **static texts**
- Standardized / Automatic (SADiLaR project)
- Visible only a short period of time (dynamic)
- Must compete for their share of cognitive resources (audio and visual)
- Optimal speed is 120 wpm (10-20 cps)
- Max onscreen visibility: 6 seconds - 2 lines
- Max characters per line: 37 (incl. spaces)



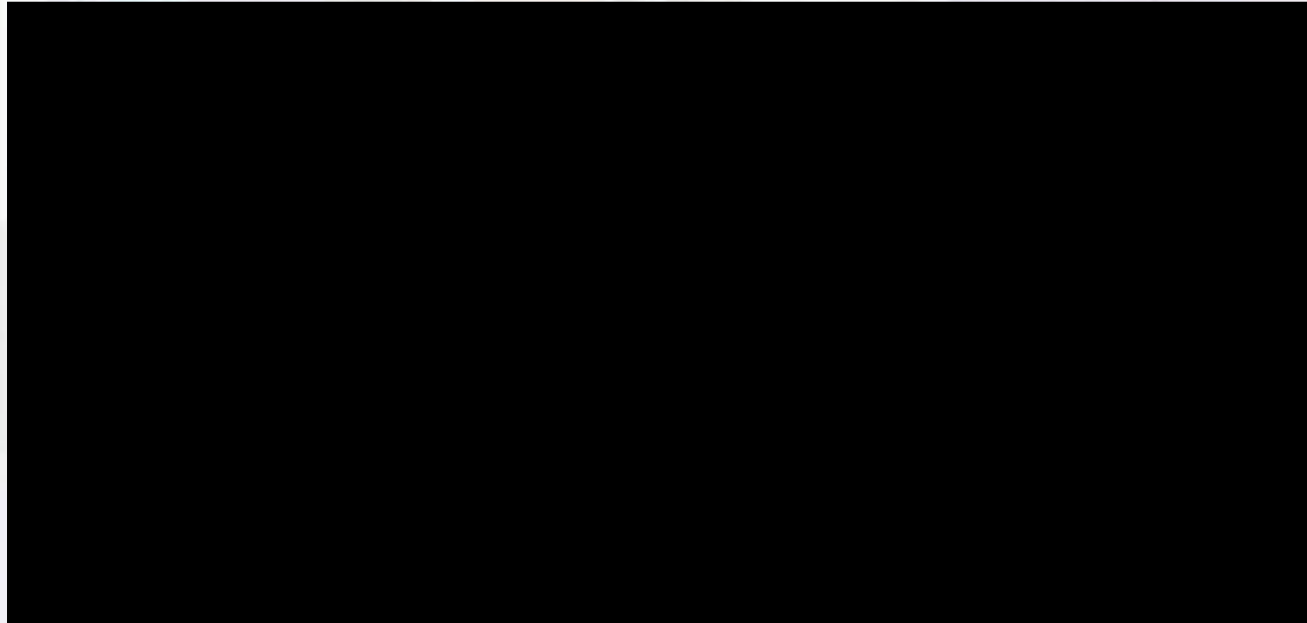
Benefits of subtitles

- Research focus
 - Language Acquisition
 - Vocabulary Learning
 - Comprehension / Retention of Information
- Can be translated to any language
- More cost-effective than other language transfer methods
 - (e.g. dubbing, voice-over and re-speaking)
- Can help with accessibility to information for lesser-known languages
- E-learning environments



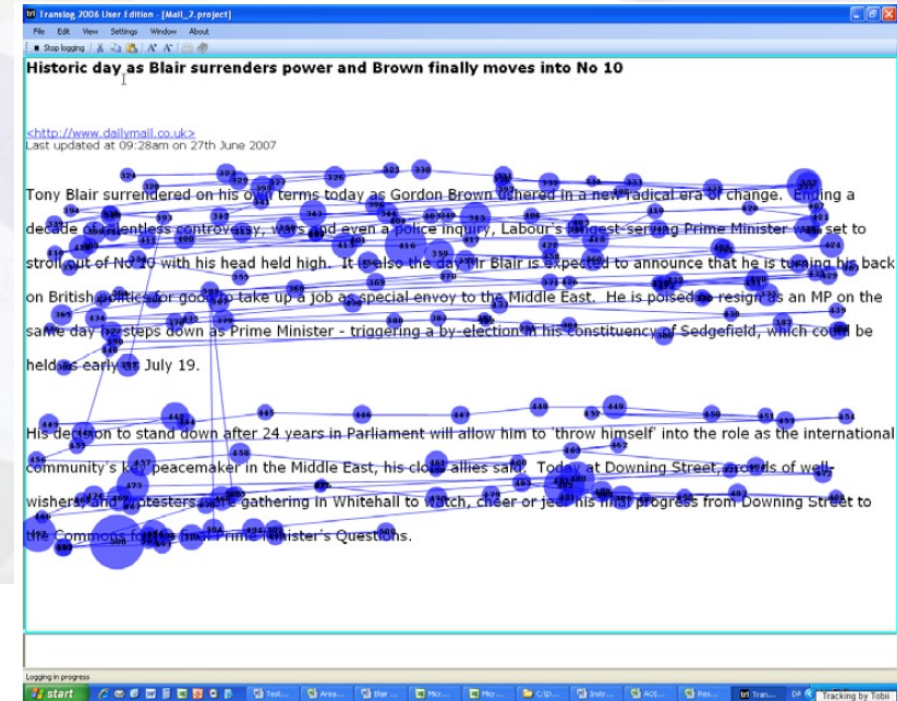
Measuring of subtitles

- Are the subtitles even processed?



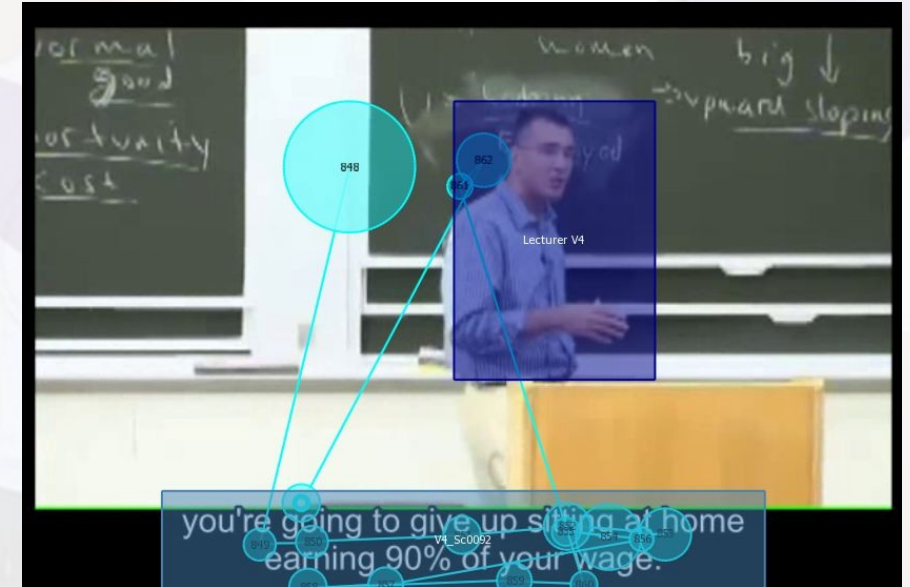
Measuring of subtitle processing

- Measuring techniques
 - Comprehension / Retention test
 - Content of video
- Other technique
 - Eye tracking
 - Eye movement on video
 - Attention on objects
 - Reading of subtitles



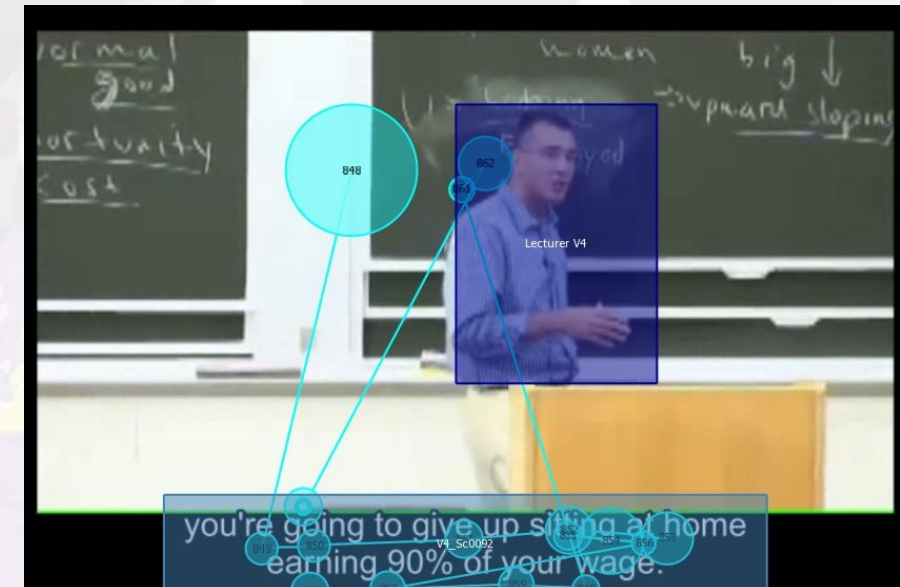
Eye-tracking measurements

- Fixation = circles
 - Bigger circle = longer fixation duration
 - Processing of information
 - Eye-mind hypothesis
- Saccades = lines (movement of eyes)
- Scan path = combination of dots and lines (directional movement)



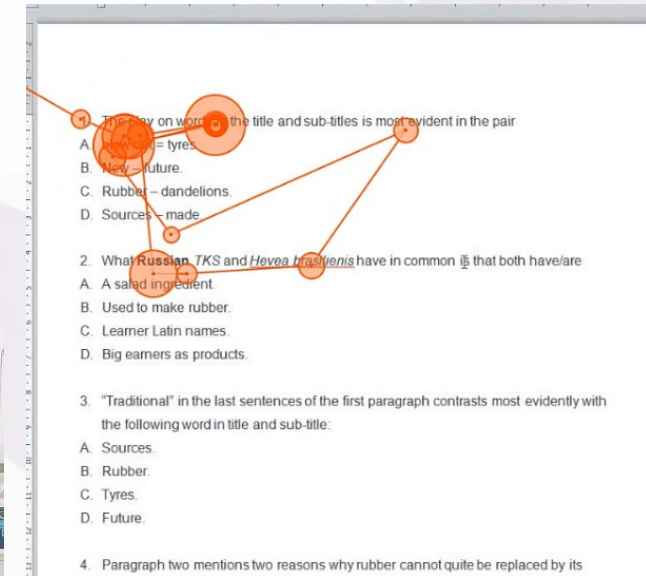
Eye-tracking measurements

- **Attention** to objects can be measured:
 - How many focus points on object (**Fixation Count**)?
 - How long those focus points were (**Mean Fixation Duration**)?
 - How a person moved their attention to objects (**Scan path**)?
 - How long did the person look at the object (**Dwell Time**)?
 - **Transition Matrix** – movement between AOIs
 - **Reading speed** (words per minute)
 - **Pupilometrics / pupil dilation** (bigger = more CL)
 - **Blink rate** (less blinks = More CL)



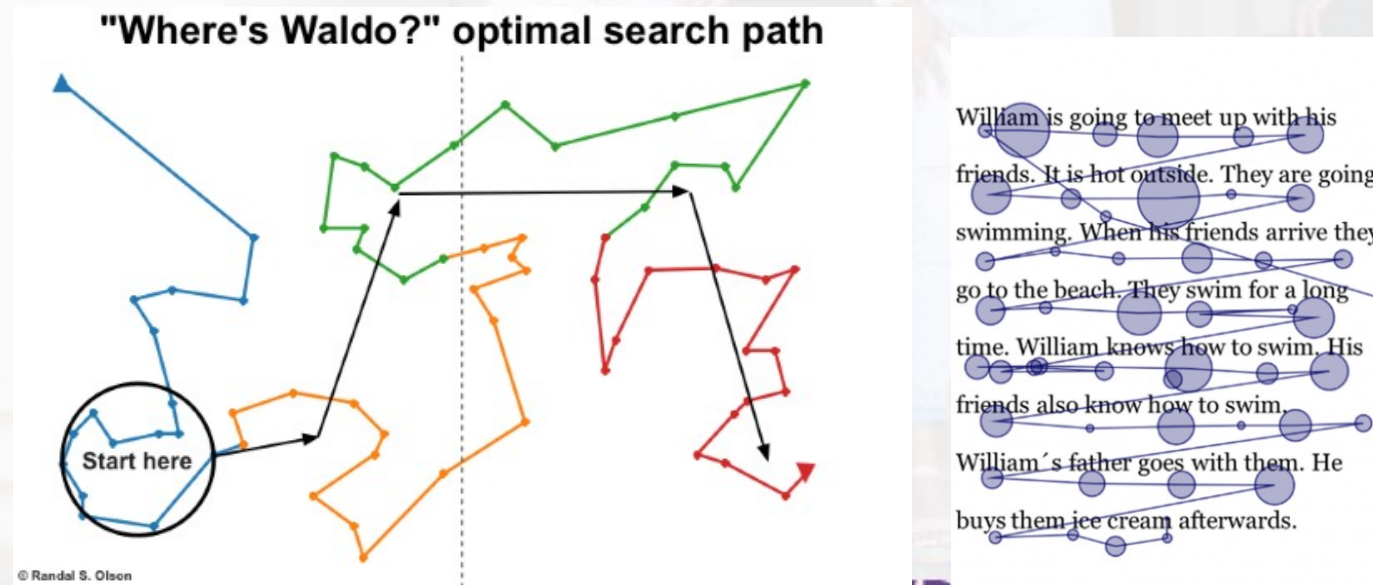
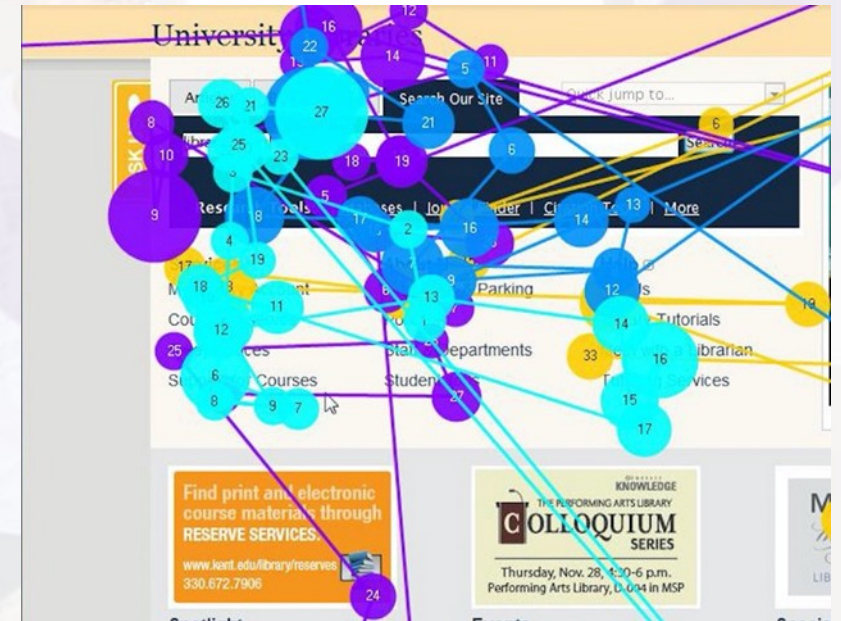
Eye-tracking Research

- **Assistive technologies**
 - For people with complex physical disabilities
 - Screen tracks your eye movements
- **Hardware and Software of eye trackers**
- **Academic Research**
 - Reading (static)
 - Subtitles (dynamic reading)
 - Editing
 - Translation
 - Usability of interfaces
 - Comprehension
 - Cognitive Load Theory



Eye-tracking paradigms

1. Visual search (Comprehension)
2. Reading (Static or Dynamic)
3. Scene-perception (Pictures vs. text)
4. Usability (interactive study guide)



William is going to meet up with his friends. It is hot outside. They are going swimming. When his friends arrive they go to the beach. They swim for a long time. William knows how to swim. His friends also know how to swim. William's father goes with them. He buys them ice cream afterwards.



Cognitive load

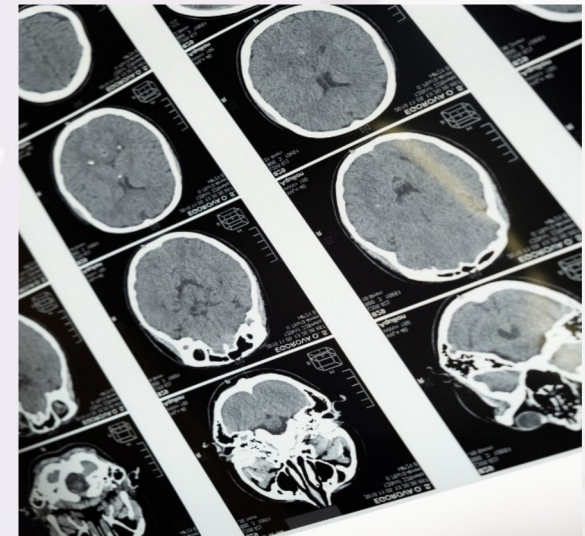
“is mainly concerned with the learning of complex cognitive tasks ...” and “... the relationship between working (short-term) and long-term memory and the effect of their relationship on learning and problem solving ...”

Types of memory

- **Working memory:** Does all the processing
- **Long-Term Memory:** Unlimited repository

Types of cognitive load

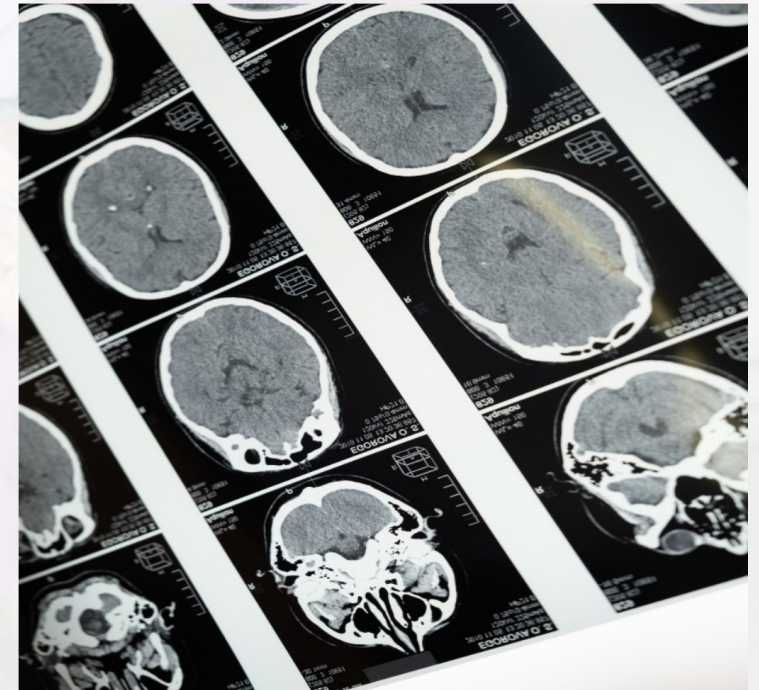
- **Intrinsic cognitive load (ICL)**- task-participant interaction
- **Extraneous cognitive load (ECL)** - presentation format of the task



Cognitive load

Measurements of cognitive load

- Subjective / self-reported rating scales
- Physiological measurements
- Psychological measurements
- Dual-task performance
- **Eye tracking measures- Physiological**
 - Fixation count
 - Average fixation duration



Measuring the effect of subtitles on CL

Problem:

- Inconclusive evidence for effect of subtitles on CL

	Native Language			Foreign Language		
Effect	+	-	=	+	-	=
Language acquisition			Kvitnes (2013)	Mitterre & McQueen (2009); Rokni & Atatee (2014)		Kvitnes (2013); D'Ydewalle & van der Poel (1999)
Vocabulary learning	Zarei (2009); Matielo et al. (2013); Koolstra & Beentjes (1999); Steward & Petrusa (2004)	Kvitnes (2013)		Harji et al. (2010); Steward & Petrusa (2004)		Etemadi (2012)
Comprehension / Retention	Kvitnes (2013); Entemadi (2012); Hyathi & Mohmedi (2014); Northorp (1952)	Miler & Levine (1952)		Kvitnes (2013); Zarei (2009); Entemadi (2012); Hyathi & Mohmedi (2014); Markham (1999); Hwang & Huang (2011)	Harji et al. (2010);	Kruger et al. (2014); Kruger & Steyn (2014); Mayer, Lee & Peebles (2014); Chan, Kruger & Doherty (2019); Matthew (2020)

Measuring the effect of subtitles on CL

Experimental setup

- Participants : n= 23,
- L2 English speakers
- 4 Groups – 4 Videos
- Randomized order of presentation
- Self perceived CL questionnaire
- Comprehension test (20)



Audio-only



Audio + Video



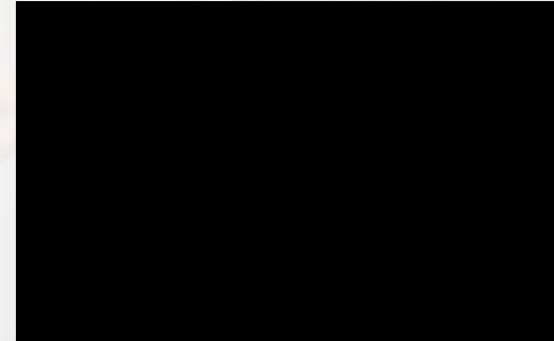
Standardized subtitles



Automatic subtitles

Measuring the effect of subtitles on CL

- Material
 - Self-reported CL Questionnaire
 - Comprehension Test
- Subtitles
 - English (Intralingual)
 - Standardized + Automatic generated
- Videos
 - English dialogue
- Research Questions
 - Effect of PM on CL
 - Effect of CL on subtitles



Results

- Between all presentation modes
 - No significance (Comp, ICL & ECL)
- But: Sig. difference for ECL - two subtitled PMs
 - Format of presentation is the same
 - Higher ECL measurement
 - Sig. lower comprehension
 - -10% for automatic subtitles
- What could be the cause?

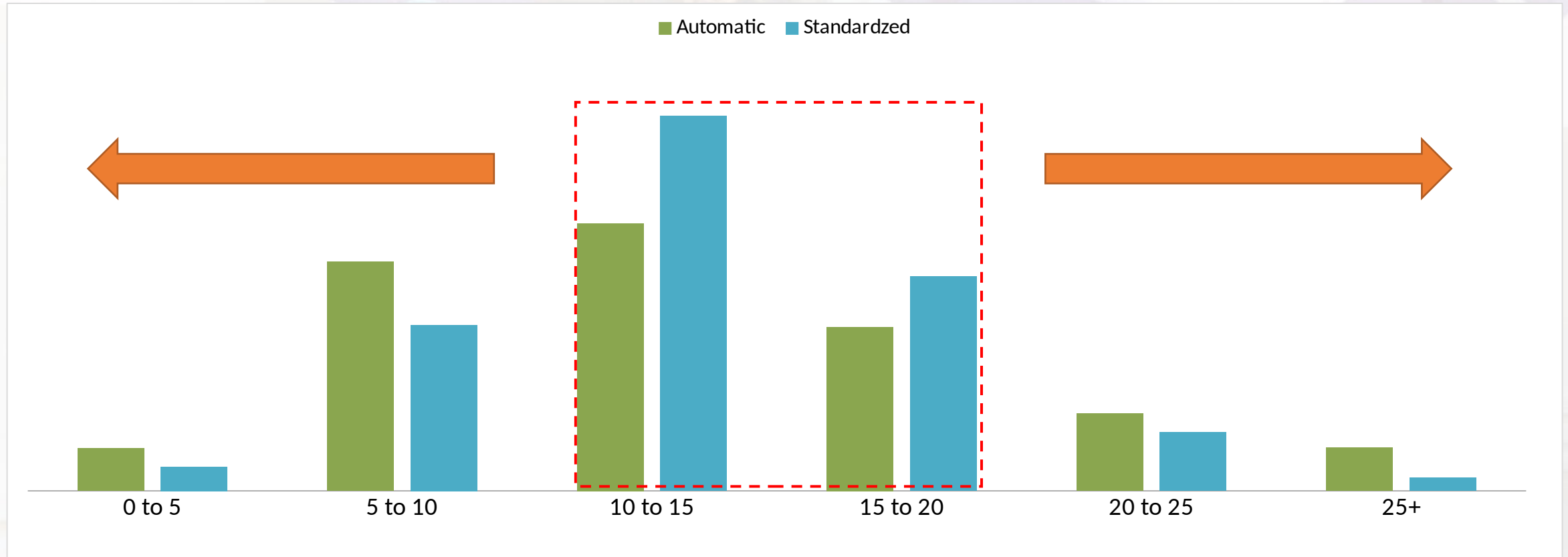
	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	3.17	0.53	5.99	1.42E-07***
PMAV	0.54	0.80	0.68	0.49
Automatic	0.86	0.70	1.23	0.22
Standardized	0.58	0.81	0.72	0.48

Results: Similarities

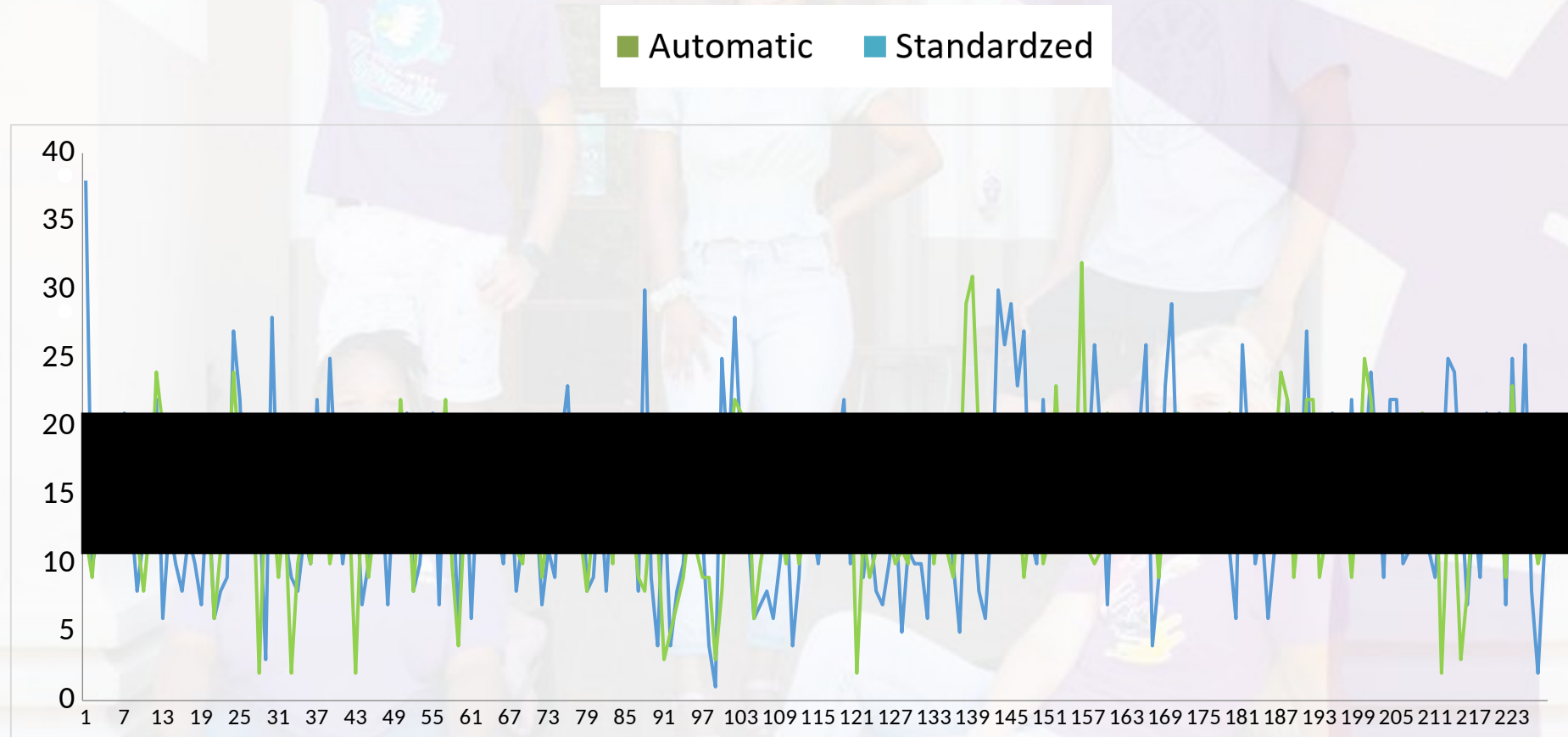
- Similarities

	Automatic	Standardised
Number of subtitles per video	229	214
Average number of word per subtitle	6,97	7,29
The average speed of the subtitles	14,20	14,4
Subtitles skipped	33%	34%

Results: Differences



Results: Differences



Conclusion

- Subtitles can help with accessibility of information
- Also in other languages
- Subtitles = no significant influence on comp or CL
- However, higher ECL for the automatic subtitles
- AND significantly lower comprehension score (-10%)
- Automated subtitles = more cost-effective to produce
 - Negative consequence for generating automatic subtitles
 - AND various other aspects of subtitles need to be controlled for

Standardised subtitles = More costly + time consuming

- Have more control over presentation speed
- More effective for information accessibility



THANK YOU

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