

A fNIRS study of static versus animated presentations processing in deaf and hearing learners

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Introduction

- There are many studies on comprehension from animation vs. static pictures in multimedia learning (4 meta-analyses: Höffler & Leutner, 2007; Bernay & Bétrancourt, 2016; Castro-Alonzo & al., 2019 and Ploetzner, & al. 2020).
- Very few studies tried to investigate the underlying cognitive and physiological brain activities involved during animation processing.
- Brucker, Ehlis, Häußinger, Fallgatter, & Gerjets (2015) explored in a fNIRS technique the effect of gesture on learning fish locomotion with animations by activating human mirror-neurons; see also Makransky & al. (2018) in VR with EEG.

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Does animation enhance learning? A meta-analysis

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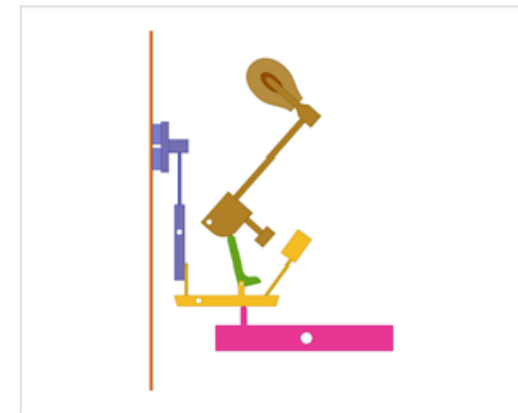
ABSTRACT

This meta-analysis investigated whether animation is beneficial overall for learning compared to static graphics, while also identifying moderator factors affecting the global effect. A systematic search was conducted for experimental studies comparing the impact of animated vs. static graphics displays in the context of knowledge acquisition. A total of 50 papers were considered, and consecutively 61 primary studies (N = 7036), yielding 140 pair-wise comparisons of animated vs. static graphic visualizations in multimedia instructional material were analyzed using a random-effects model. An overall positive effect of animation over static graphics was found, with a Hedges's g effect size of 0.226 (95% confidence interval = 0.12–0.33). Additional moderator analyses indicated substantial effect sizes when the animation was system-paced (g = 0.309), when it was coupled with auditory commentary (g = 0.336) or when the instruction did not include any accompanying text (g = 0.883).

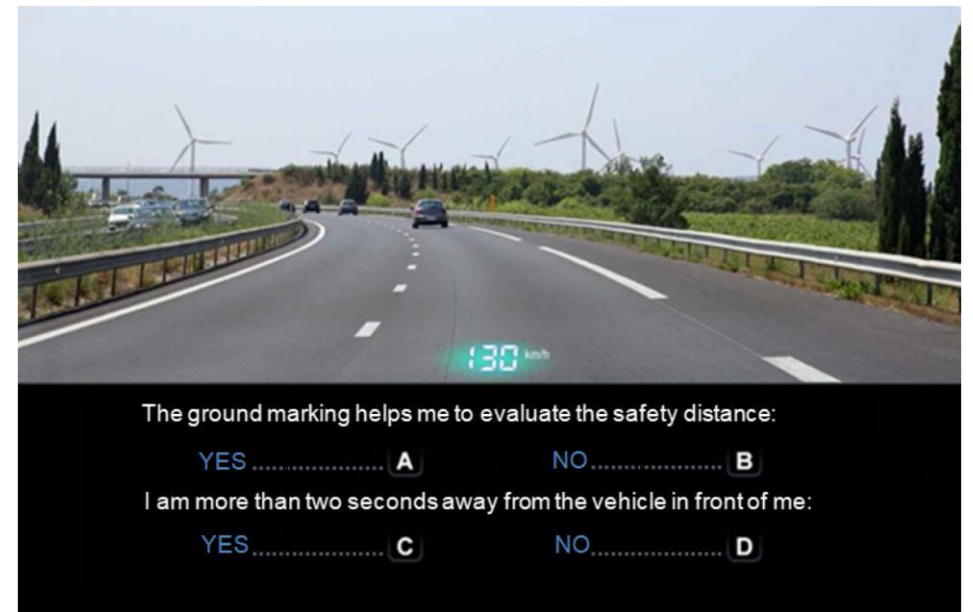
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Introduction

- Research on animated vs. static presentation of dynamic processes mainly focused on educational purposes(STEM).
- The subject matter concerns the learning of High-way Code rules in deaf candidates from multimedia presentation of road scenes.
- No research has explored the brain activities underlying the processing of animated vs static presentation: This is the goal of the present study.



A technical animation of an upright piano mechanism , Boucheix & Lowe, 2010



A conventional slide used for training candidate to the high way code rules exam

— The ambiguity of the training material for the highway code exam —



At this traffic intersection (crossroads) :

I keep my speed..... **A**

I slow down..... **B**

I brake strongly..... **C**

- The lack of animation (motion) of the static slide makes difficult the elaboration of a dynamic mental model
- In this example: inferring the dynamism of the cars and bicycle is required
- Early deaf learners could meet difficulties in processing temporal inferences (Conway, Pisoni, & Kronenberger, 2009)

Introduction



Example of sequential-static format for an “entering a roundabout” situation: successive presentation of the three pictures (a), (b), and (c) [Colour figure can be viewed at wileyonlinelibrary.com]

- Laurent & Boucheix, Argon, Hidalgo-Munoz & Paire-Ficout (2020) showed that, compared to their static counterparts, animation of road scenes compensate for temporal processing difficulties in deaf people learning the high-way code.
- In a decision task participants had to decide whether or not they could accomplish a driving action, for example overtaking, where other vehicles were involved

A: animated format, C: sequential-static format.

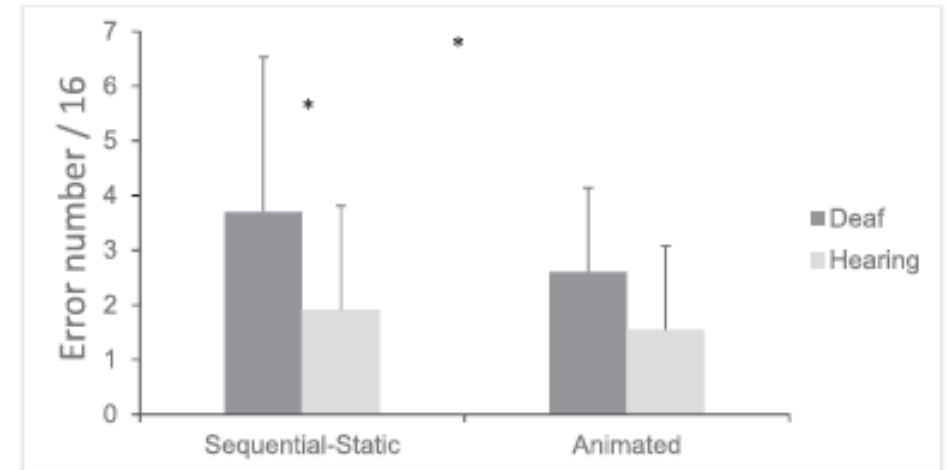


FIGURE 6 Mean number of decision making errors (and SD error bars), for each presentation format (sequential-static vs. animated) and in each participant group (deaf vs. hearing)

Animated format for roundabout



Simple case



Complex case

Introduction

- Such a task involved the elaboration of Spatio-Temporal Inference (STI) about the relation between speed and distance of the cars.
- Two cognitive mechanisms underlie STI: a Cognitive Motion Extrapolation (CME) and a Clocking Mechanism (CL).
- Processing effectively spatio-temporal relevant event-units is the core dimension of learning from animation (APM, Lowe & Boucheix, 2016).

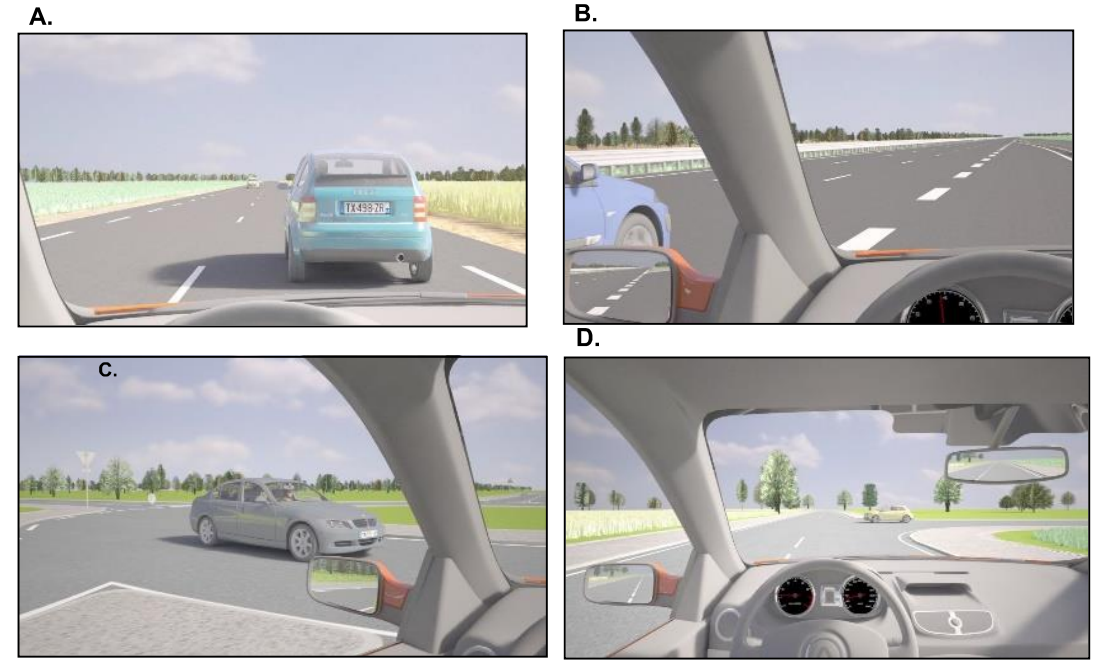
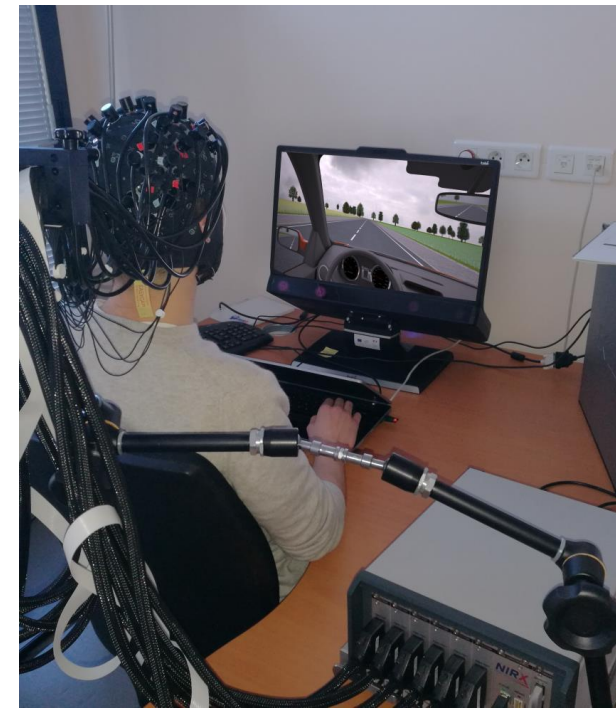


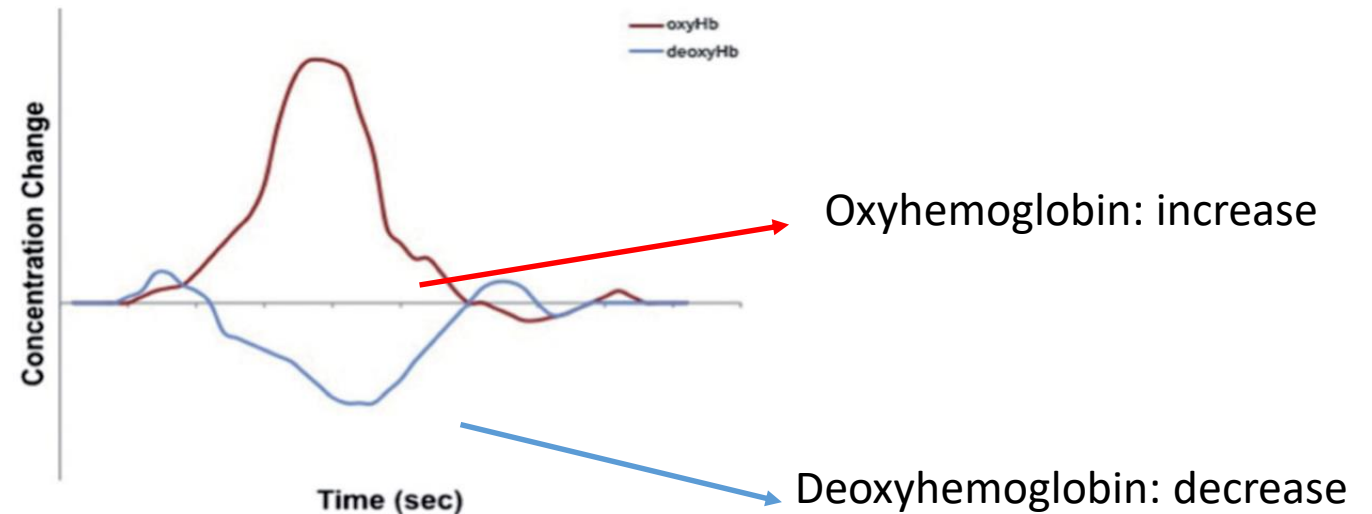
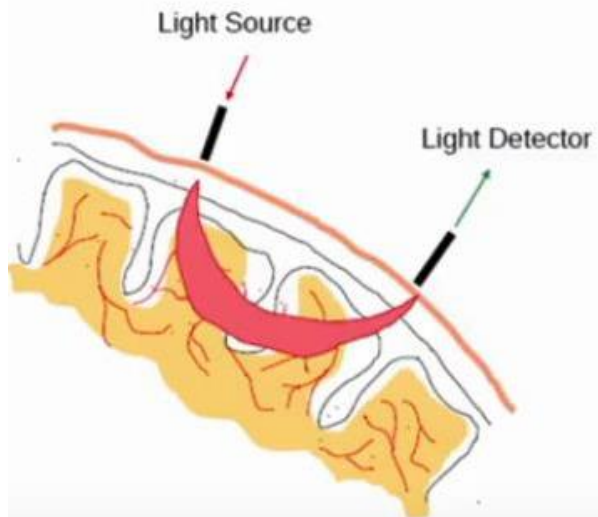
FIGURE 3 Screenshots of the four animation situations before the expected decision (the same environmental context), (a) joining a highway, (b) overtaking, (c) entering a roundabout, and (d) crossing an intersection [Colour figure can be viewed at wileyonlinelibrary.com]

Introduction

- In order to explore the physiological and cognitive underlying mechanisms of STI, we used functional near-infrared spectroscopy (fNIRS) to examine whether the cortical activity in different brain regions differ significantly in deaf people compared to hearing people.
- This was investigated during a STI and clocking mechanism involved in animated vs. static road scene processing
- **Measure: Concentration Variation in oxyhemoglobin (oxygen) and deoxyhemoglobin during the time on task.**

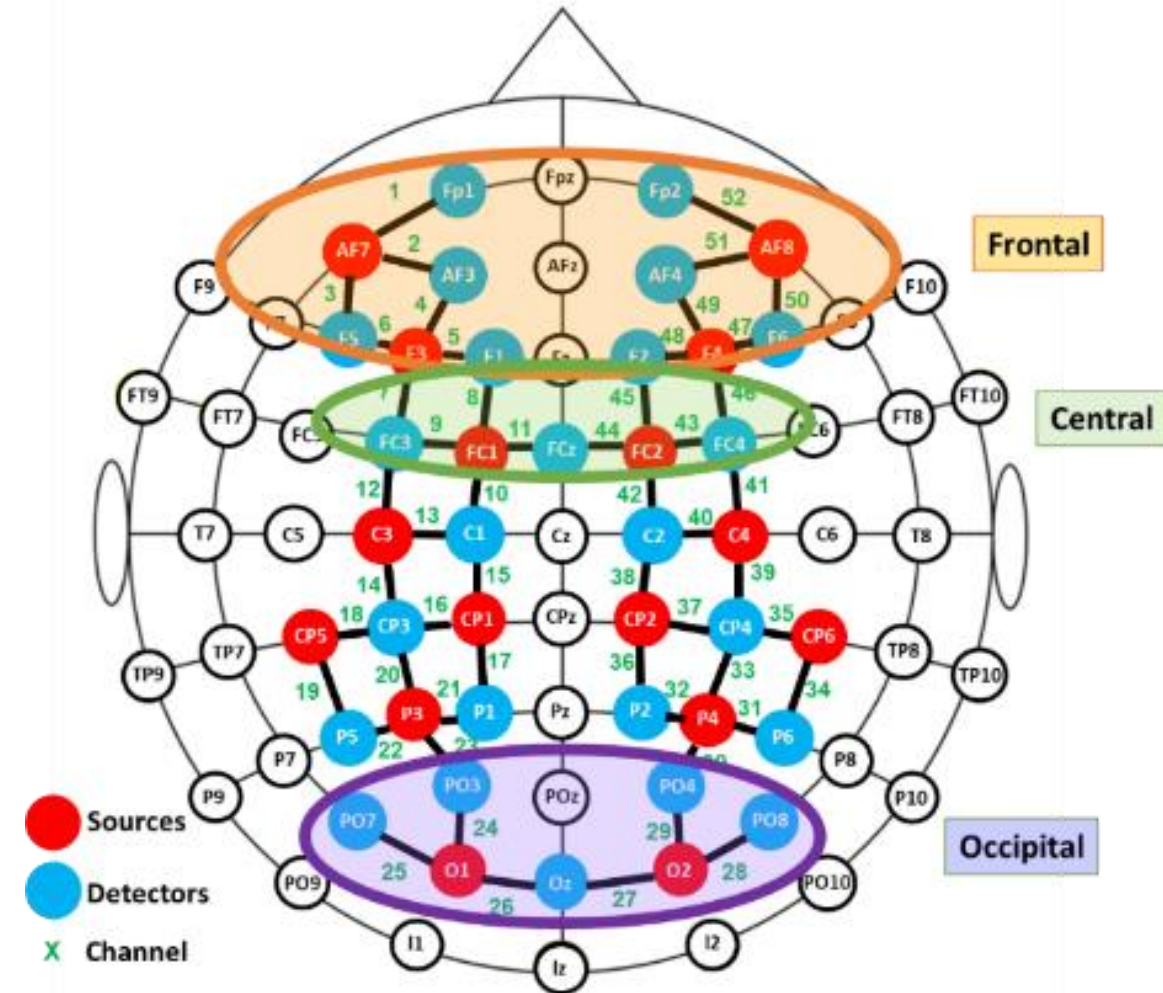


Infrared



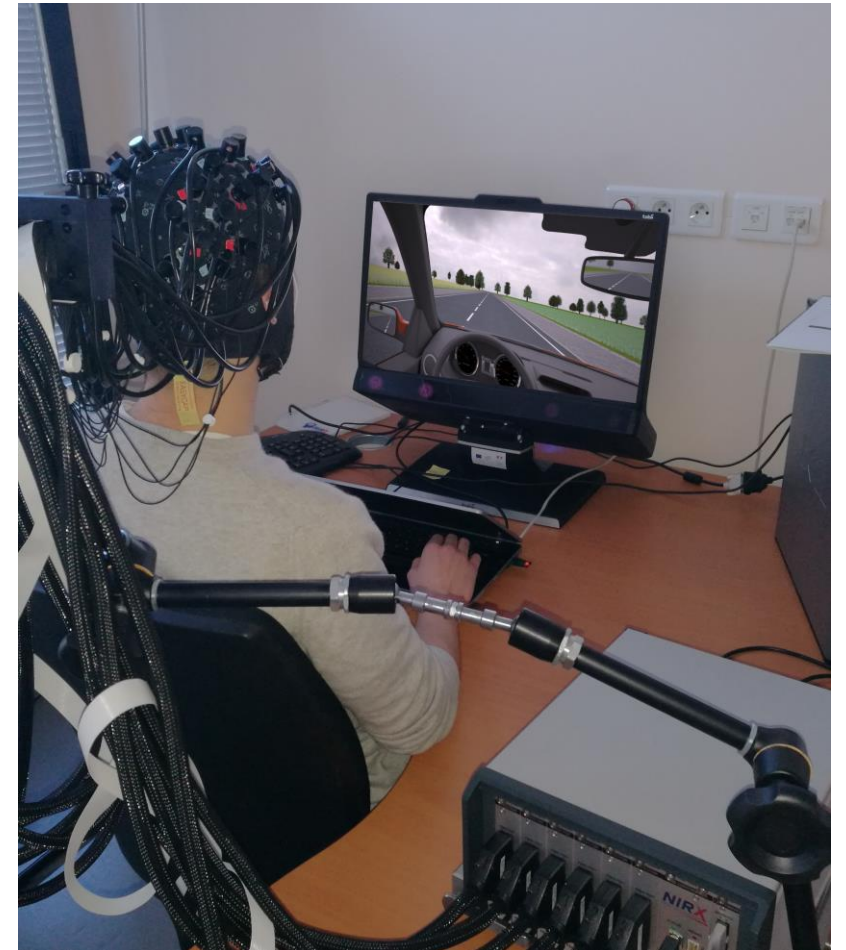
Hypotheses

- Three brain regions of interest were selected:
 - **Frontal in relation to cognitive effort-load** (Pouthas & al., 2005, Dye & Bavelier, 2010);
 - **Central in relation with Clacking cost** (DeLucia & Liddell, 1998; Daneshi & al., 2020)
 - and **Occipital region**: visual processing.
- According to the Attentional Theory of Cinematic Continuity (Smith, 2012), the continuous flow of information in animation would make easier, so decrease the cognitive cost, to build a CME and a correct STI than a motion sampled presentation with static pictures.
- A higher cortical activity was expected with the static pictures, which do not lead to better decision performances, than with the animation.
- Deaf participants could show higher cortical activity than hearing participants.



Method

- Participants were 19 deaf and 18 hearing French individuals (respectively $M = 28.1$ and 26.1 years-old), preparing the Highway Code Rule examination (prior knowledge controlled).
- Participants, taking the place of a driver, had to decide (“yes or no” button) whether they had, or not, enough time to accomplish a driving action: overtaking, entering a roundabout, joining a highway and crossing an intersection, where other vehicles were involved.



Experimental Conditions and items

All within group conditions



4 dynamic situations
overtaking,
entering a roundabout,
joining a highway
crossing an intersection



2 levels of complexity

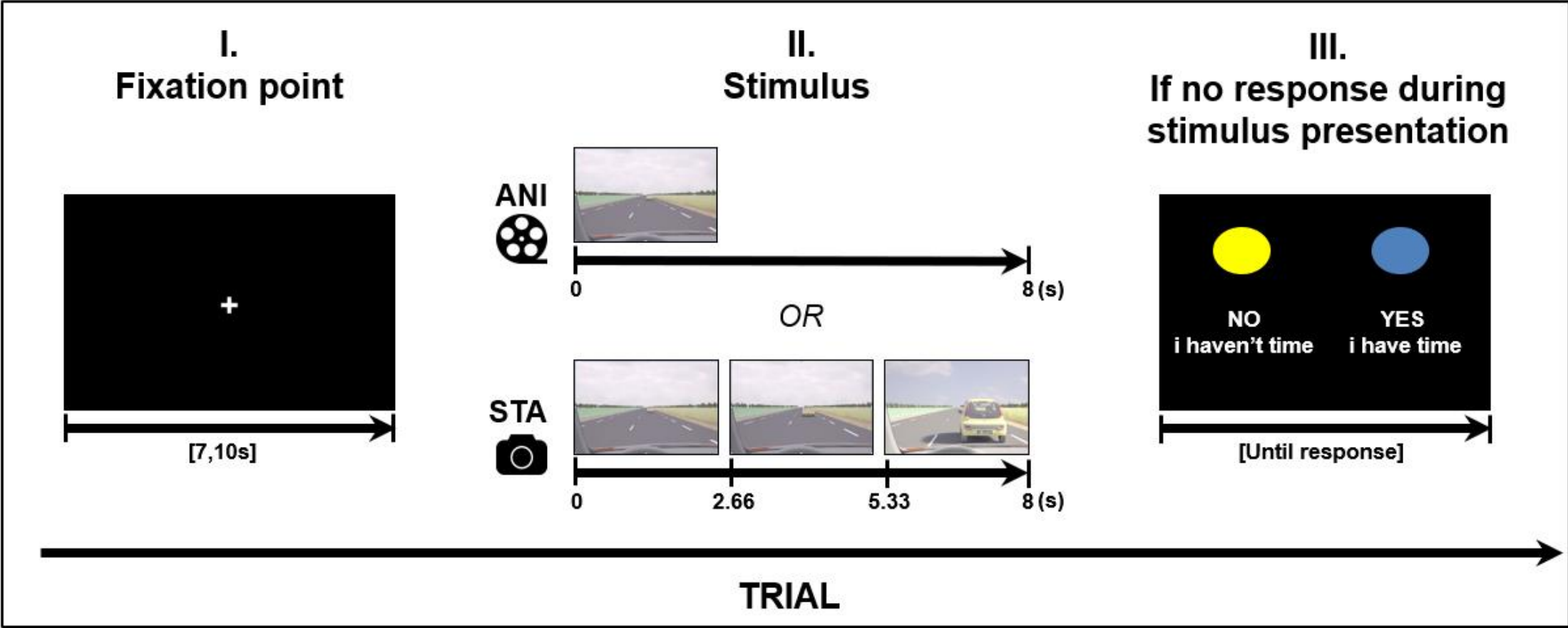
Simple to decide
Complex to decide



2 presentation formats

Animated
Static-sequential (3 pictures)

Method



Structure of a trial (road scene presentation), ANI: animated format; STA: sequence of static images



















Method

- Driving situations were modelled in accordance with French road norms and realistic distance and speed.
- 32 different scenes were created for each format.
- The order has been arranged in such a way the same road situation or the same format was never presented consecutively.
- The fNIRS cap was put on participant's head, a calibration was performed to ensure good quality signals.
- Eye-tracking (Tobii TX300) was recorded simultaneously.
- Instructions were given verbally to hearing participants or in French Sign Language to deaf participants.

Results

- Regarding road scenes decision task performance, no difference was found in favor of the animated over the static format.
- This result is different from our previous experiment: experimental protocol influence (no blocks)
- However decision times were in favor of the animated format
 - Group effect: $F(1, 31) = 22.97, p < .001, \eta^2 = .42$.
 - Format effect: $F(1, 31) = 10.44, p < .01, \eta^2 = .25$

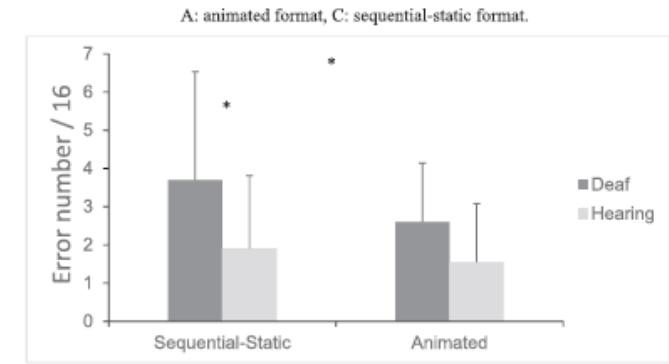
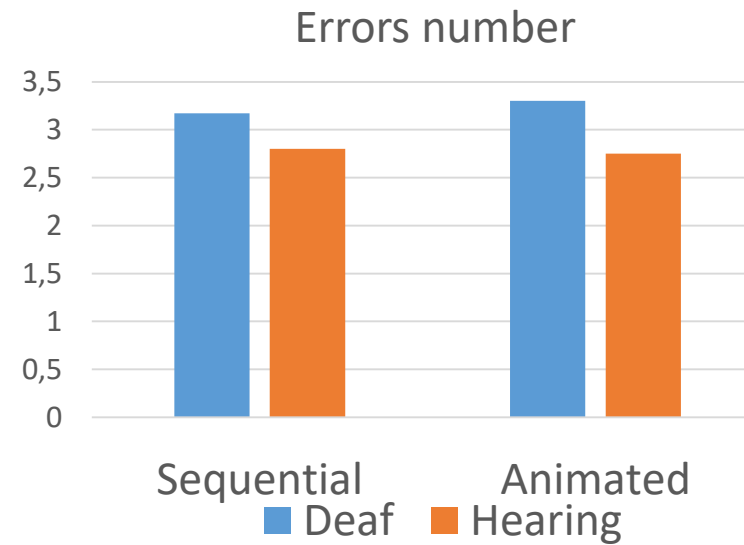
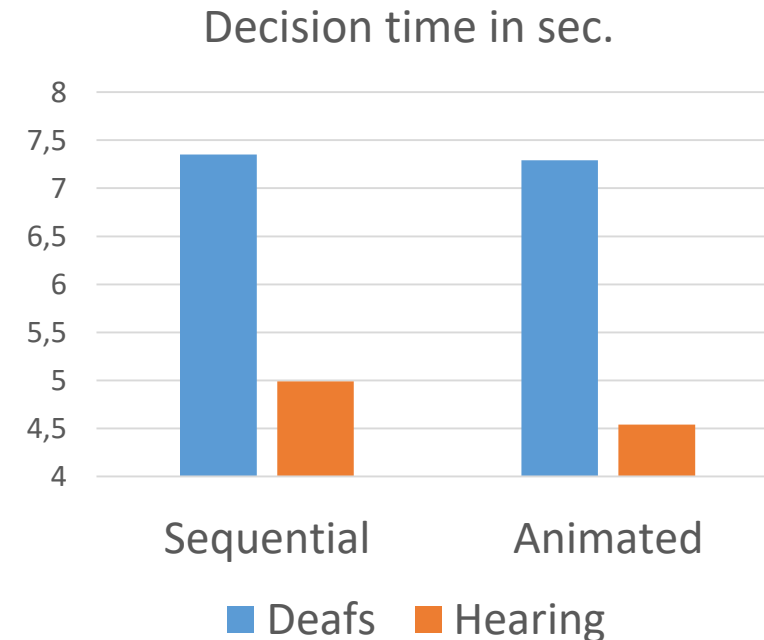
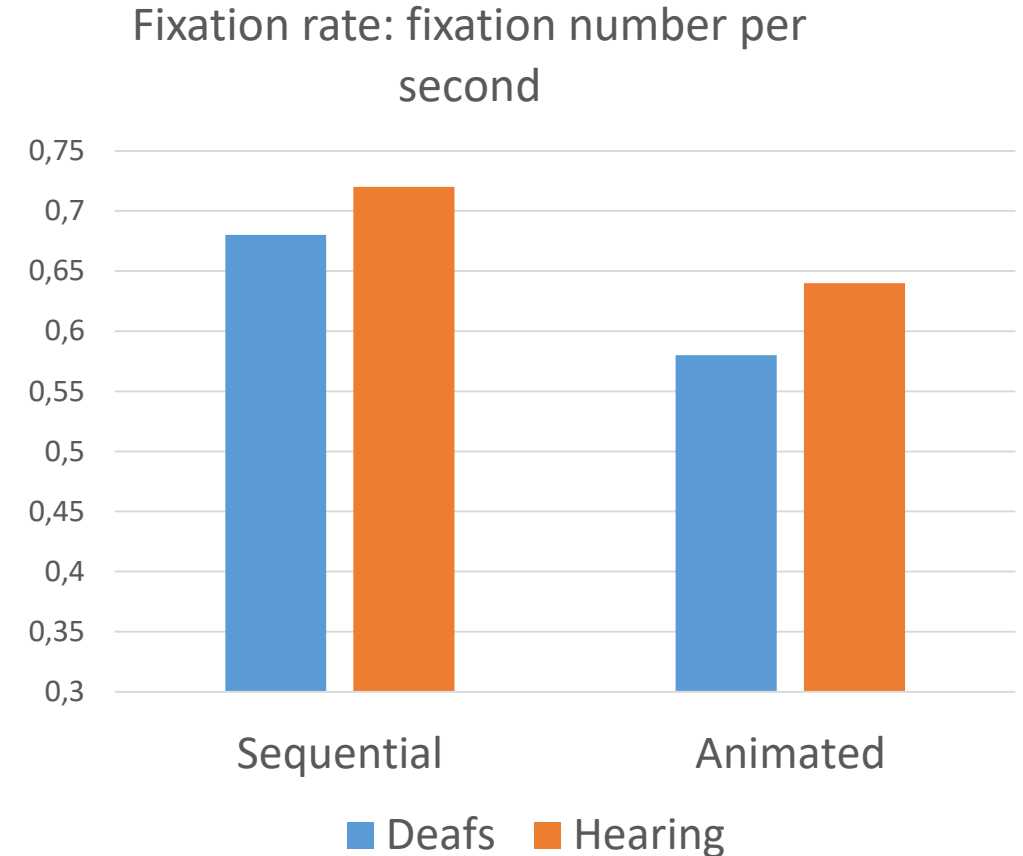


FIGURE 6 Mean number of decision making errors (and SD error bars), for each presentation format (sequential-static vs. animated) and in each participant group (deaf vs. hearing)



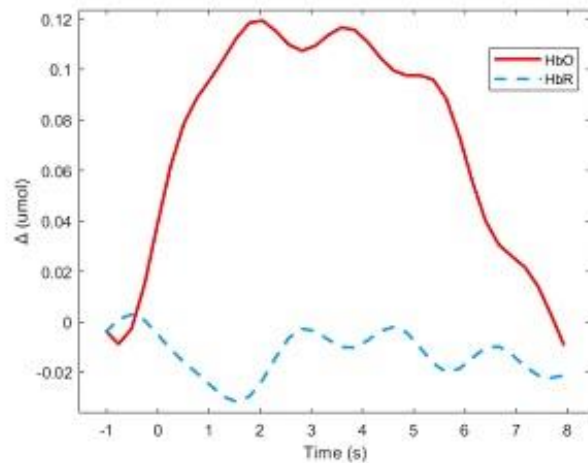
Results

- Regarding eye fixation rate, which is an indicator of cognitive load, there was a clear significant benefit of animated presentation format over the static presentation format.
 - Significant effect of format: $F(1, 26) = 30.89, p < .001, \eta^2 = .54$.
 - No effect of group: $F(1, 26) = .37, p = .54$.

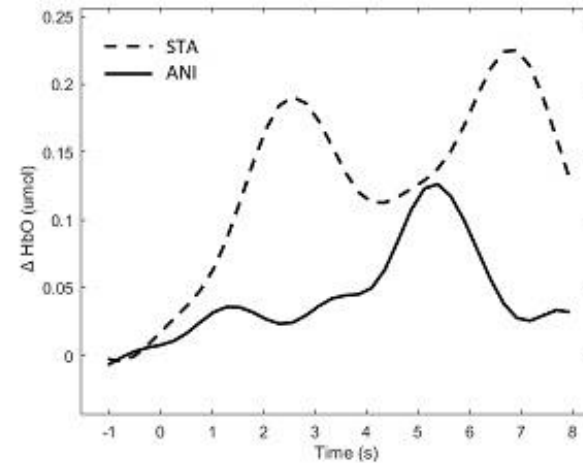


Results: fNIRS

Relative concentration changes of oxyhemoglobin: $\Delta[\text{HbO}]$; and de-oxyhemoglobin: $\Delta[\text{HbR}]$ during the task.



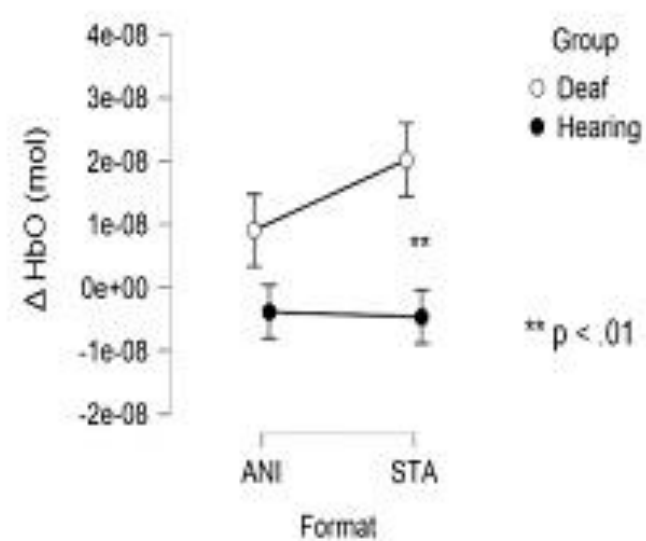
a



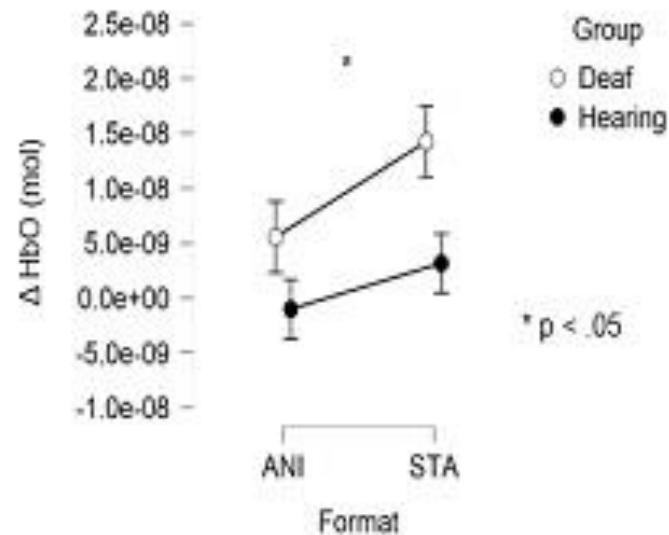
b

Figure 2. (a) an example showing a trial including $\Delta[\text{HbO}]$ and $\Delta[\text{HbR}]$ on the deaf group for frontal region and (b) the average of the hemodynamic evoked response in deaf group for the two conditions STA vs. ANI in central region, which is involved in clocking mechanism

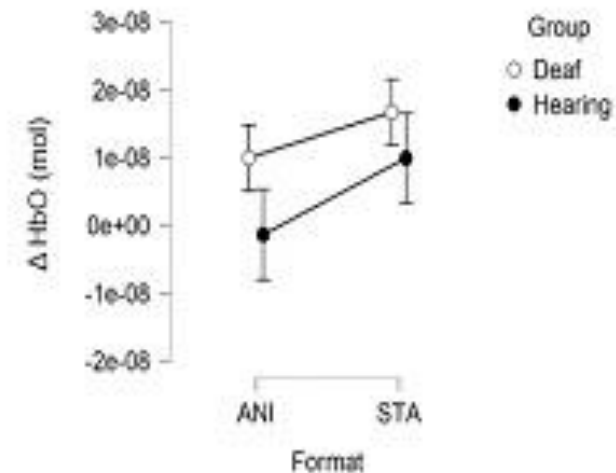
For the clocking mechanism (Figure 2b), in the static format, the two peaks suggest two clocking mechanisms and only one progressive in the animated format: a physiological illustration of the Attentional Theory of Cinematic Continuity compared to a discontinuous presentation (Smith, 2012).



a. Frontal



b. Central



c. Occipital

Figure 3. Mean amplitude values of the hemodynamic evoked responses, respectively in a. Frontal; b. Central and c. Occipital brain region for animated (ANI) and static image sequence (STA) formats for both deaf and hearing groups.

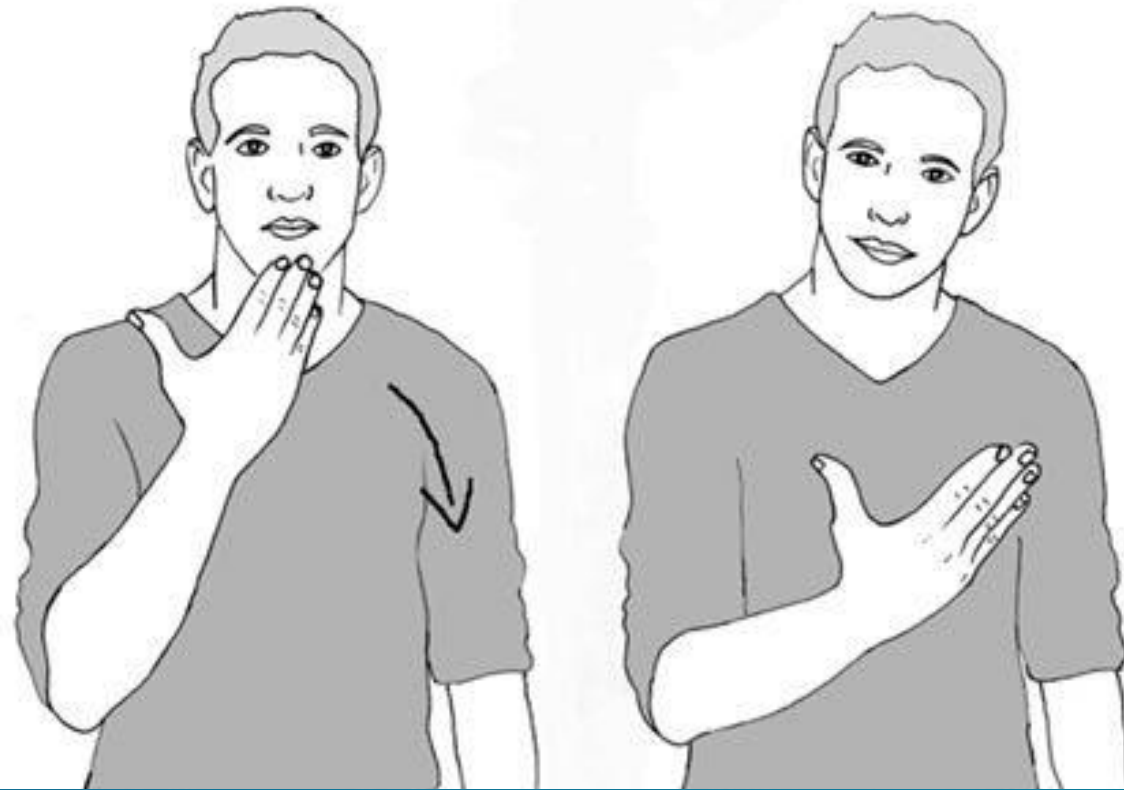
By brain regions

Discussion-conclusion

- Static format processing resulted in a higher cognitive effort-load than the dynamic format, but did not lead to higher task performance.
- In STI, temporal continuity of animations enhances the attention for, and processing of, relevant event-units.
- Animated and static presentation seem to show different brain and cognitive underlying processes.
- Preliminary results: Of course further research using physiological measures in multimedia learning should be done.

Discussion-conclusion

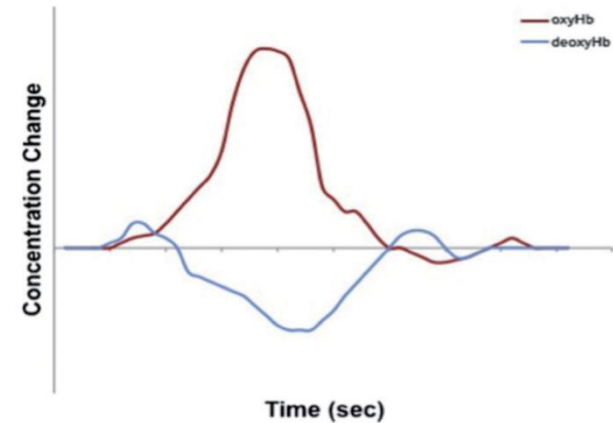
- For deaf learners performances, with regard to temporal processing performances , great care must be taken!
- Previous literature showed huge individual (and group) differences (Conway & al, 2009, 2011; Emmorey & al, 2003, 2009, 2020).
- For example, temporal processing performances might be highly depending on how early Sign Language is learnt.
- Early learning of Sign Language seems different across countries and educational systems for deaf learners: for example Sign Language learning seem to start earlier and more systematically in US (ASL) than in France.



**Many thanks for your
attention
Any question?**

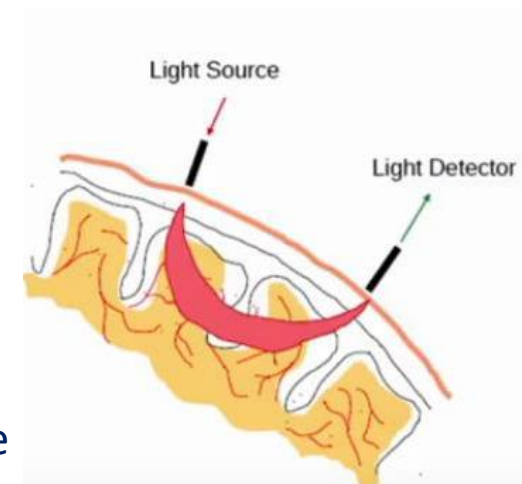
Mesure: Variation de concentration d'oxy & désoxyhémoglobine

Activation cérébrale : - **Hausse** de l'oxyhémoglobine
- **Baisse** de la désoxyhémoglobine



Etape d'une mesure

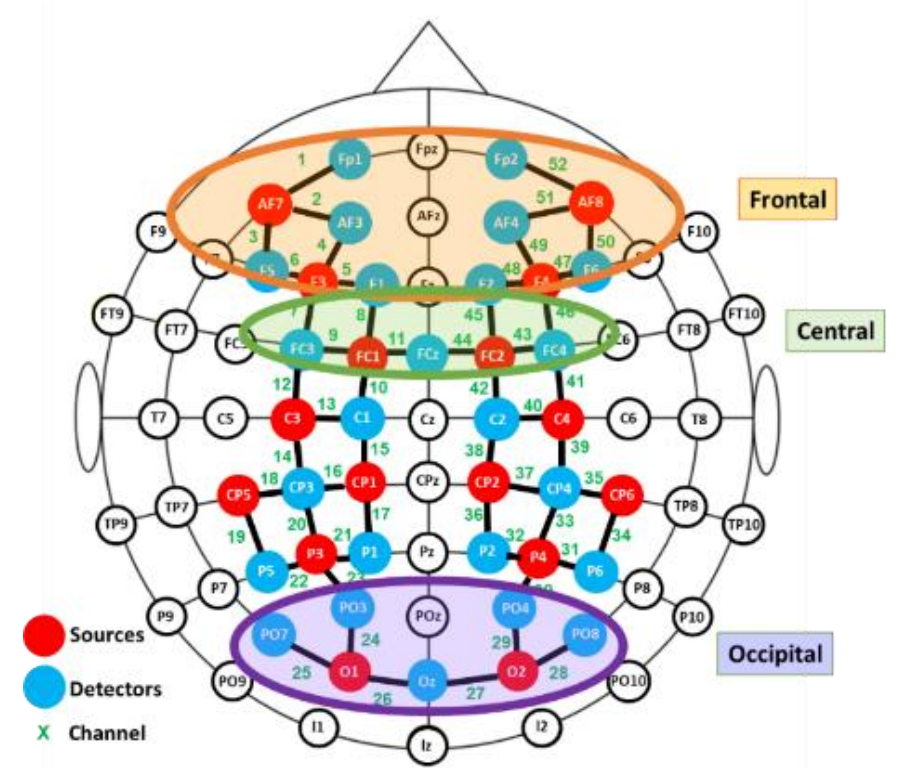
- 1) Une quantité de lumière est envoyée à partir d'une **source**
- 2) La lumière ressort au niveau d'un **détecteur** en moins grande quantité car elle est **absorbé** en partie par les tissus cérébraux



L'**absorbance** varie selon la **quantité** d'oxy & désoxyhémoglobine

Method

- fNIRS data were recorded using a NIRScout device, sampling rate of 3.9 Hz.
- The system has 40 optical sensors and 24 detectors: 52 channels were obtained (Fig. 1b).
- Signal processing was carried out with MATLAB.



b. fNIRS montage

By regions, slide 26

- For frontal region: effect of group ($F(1,26) = 8,439; p = .007; \eta^2 = .157$).
- Evoked response was higher in deaf than in hearing participants. The responses of deaf group for STA format was significantly higher than for the hearing group ($t(50.27) = 2.945; p = .005$), suggesting a higher cognitive effort –load- in deaf participants in the static format.
- For central region: effect of format ($F(1,28) = 4.281, p=.048, \eta^2 = .029$).
- Amplitude values were higher in the static than in the animated condition ($t(55.57) = 2.69, p = .009$), for deaf group.
- For occipital region, no significant effects were found, but brain activity tended to be higher in the static than in the dynamic format.