Tell me about your last birthday party without looking away...I said without looking away!

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1. Background

Autobiographical memory retrieval, i.e. remembering past personal events, requires a **mental time travel** towards a **temporary internal mental space**¹. As internal and external attention are in competition, they cannot occur simultaneously².



We call **Attentional Switch to Memory** (AStoM) the moment when attention switches from the external to the internal world in early stages of memory retrieval.



During autobiographical memory retrieval, individuals are attentionally blind to the external stimuli³. This phenomenon is referred to as perceptual decoupling⁴.



Gaze aversion

2. Hypotheses

We hypothesize that gaze aversion occurs during AStoM to support the redirection of the attention towards the internal mental space in order to initiate autobiographical memory retrieval.

scientifically studied.

4. Material & Methods

We designed a protocol to trigger AStoM in response to autobiographical memory questions while eye movements were recorded with an Eyelink 1000 eye-tracker and a camera for ground truth.

N=32 healthy participants (aged 24.06 ± 5.20; 20 females)

3. Objectives

- 1. How to experimentally **induce** gaze aversion? 2. Which method to **measure** gaze aversion? 3. Gaze aversion's **characterization**: When? How

- long? In which direction? 4. Understand **why** gaze aversion occurs. Which cognitive factors involved?



5. Analyses

OUT of the screen Gaze aversion if OUT > 500 ms IN the screen 0 2000 4000 6000 8000 10000 12000 14000 16000 18000 20000 22000 24000

How to identify gaze aversion?

With head-free eye-trackers, the eye-tracking signal is lost when the participant looks outside of the screen (= **gaze aversion**) or blinks. Blinks are short. \rightarrow Gaze aversion if the signal is lost > 500 ms.

Direction of gaze aversion is estimated from the position of the last gaze recorded on the screen before an averted gaze. Gaze aversions are classified in 8 possible directions.

To validate this method, the direction of 10% of the gaze aversions was verified with the video for every direction. The method was highly accurate (i.e. > 80%) for all the orientations, except for the orientation directed downwards (see Fig 1.). All the orientations for the downwards aversions were thus manually assessed and corrected.

Take-home message

Gaze aversion is an objective marker of autobiographical memory retrieval.

Main results

- When? Gaze aversion appears early during the initiation of autobiographical memory retrieval as expected for an objective temporal marker of autobiographical retrieval.
- How long? Gaze aversion lasts several seconds.
- Where? There is not typical direction in which everybody does gaze aversion. Individuals seem to have their own preferential direction. • Why? There could be different types of gaze aversions occurring at different moments during memory retrieval and for different cognitive reason: cognitive effort during access, reflecting Attentional Switch to Memory (AStoM) and vividness during elaboration, reflecting mental
- imagery?
- **Other strategy?** Not everybody does gaze aversion. Some participants use eye vergence instead of gaze aversion to disengage from the external world during memory retrieval.
- Role of the head? The head does not follow the eyes during gaze aversion. A role in perceptual decoupling?

Conclusion

Our results bring different elements converging in favor of the implication of gaze aversion as a strategy of perceptual decoupling. Gaze aversion is therefore assumed to support the Attentional Switch to Memory (AStoM), a critical cognitive step allowing the initiation of memory retrieval.



References

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Ethics requirements

The experiment was approved by the Ethics Committee of Lyon, France (CPP2020-21/2020-A00348-31).







A very common behavior is to look away while answering memory questions, as if the answer was on the ceiling or "in the sky"⁵. This phenomenon is known as **gaze aversion**⁶. The cognitive load hypothesis of gaze aversion⁷ suggests that gaze aversion can bring the eyes away from the external distractors to optimize the performance of memory retrieval. Despite the fact that gaze aversion is frequently encountered in daily situations, it has not really been

 100%	• • • •	90%		83%	
• 83% • •	•	•	•	100%	
87%		71%	p* \$ to to *	100%	

Fig 1. Illustration of the division of the screen in sections to determine the orientation of gaze aversion. The dots are the last coordinates before every gaze aversion. The percentages in every section represent the accuracy of gaze aversion classification in that direction after verification with the video.

x [0,1024]

Press a key to start next trial



Humanlike

social cues delivered by robots to facilitates interactions.

Clinical neuropsychology



Helping in the assessment and diagnosis of patients with memory impairment.

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6. Results





Fig 4. A) Polar plot on all the gaze aversion together. B) Illustration of the screen divided in different sections. Every section corresponds to one direction. For each direction, histogram of the participants with their percentage of gaze aversion in that direction. C) Average pattern for the 5 clusters of participants.

Cognitive effort & memory vividness as explanatory factors of gaze aversion



Fig 5. A) Boxplots of the percentage of questions where there is gaze aversion for every level of cognitive effort (spontaneous, mild, high) separately for access and elaboration phases. B) Boxplots of the percentage of questions where there is gaze aversion for every level of vividness (not at all, blurry, clear) separately for access and elaboration phases. Friedman tests with Bonferroni correction α = .016. * p < α , ** p < .001

The head does not follow the eyes during gaze aversion.



Fig 6. A naive rater evaluated, for each gaze aversion (comparing the screenshots between baseline and aversion), the amplitude of head movement. Another rater evaluated 10% of the trials. The inter-rater concordance was high (Kendall's Tau r_{t} = .37, p<.001).

Eye vergence as another strategy?

Not all the participants do gaze aversion. Since eye vergence have been related to internal attention⁹, we investigate it as another strategy to disengage from the external world.



Fig 7. Estimation of eye vergence from fixation disparity

<u>When?</u> After the question, the delay before the onset of gaze aversion is very short (median = 1.09 sec). Gaze aversion occurs precociously in autobiographical memory retrieval.

Grouping all the gaze aversions together, there is significantly more gaze aversions directed towards downleft and down directions.

Nevertheless, there is an inter-individual variability in the preferential direction. → Clustering analyses on the patterns of individuals (Kmeans).

- \rightarrow 5 clusters of participants:
- 6 doing almost all their aversions downwards
- 3 doing almost all all their aversions upwards
- 4 with a preference upright • 7 with a preference downleft
- 10 doing aversions in multiple directions

There is **no systematic direction for all** individuals, individuals have their own pattern!

> During access: relation between the apparition of gaze aversion and the cognitive effort required to retrieve memories. It could be linked to the Attentional Switch to Memory (AStoM).

When gaze aversion is linked to vividness of memories, it could be linked to mental imagery occurring during autobiographical memory retrieval.

At high eccentricities, the eyes are generally followed by the head to keep them in a comfortable oculomotor range. Otherwise, fixations become less stable and vision less accurate⁸.

But for 72% of gaze aversions, the head does not move at all. There is a lack of coordination between the eyes and the head. \rightarrow This could be related to perceptual decoupling.

> There is significant **negative correlations** between the percentage of questions where participants do gaze aversion and the one where they do either convergence or divergence.

→ Participants have **different strategies**. Those who do less gaze aversions, tend to change their vergence more often.

Fig 8. Correlations between the % of questions with gaze aversion and with change in eye vergence per participant. Each dot represents one participant.