

Effects of aging and a cognitive competing task on the setting of the salience-relevance balance in visual search

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IFSTTAR

Context: the car driving activity

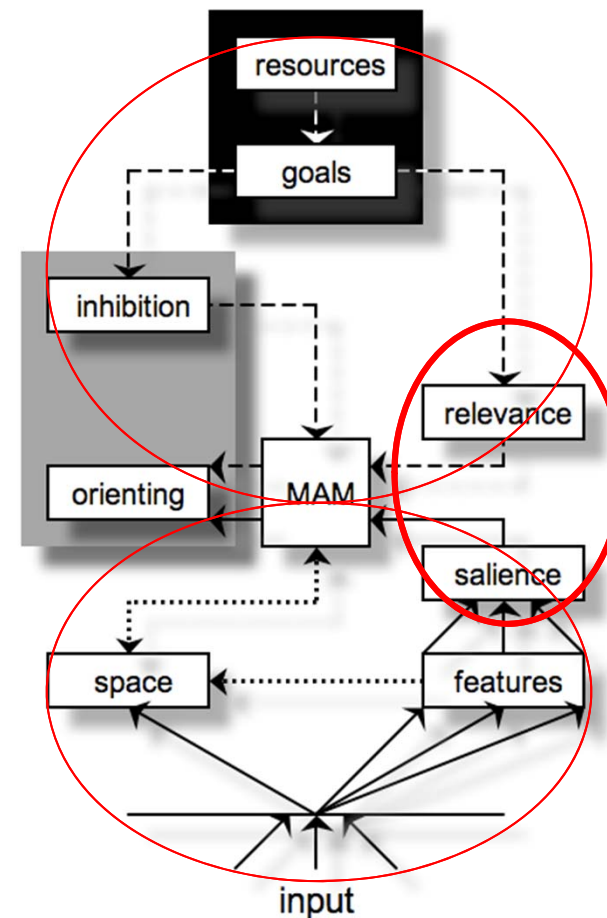
- Driving is a dynamic situation realized under time constraints; it requires a dynamic adjustment of cognitive control to situational features
- The adaptation = cognitive compromise to maintain task difficulty at an acceptable level
- Human errors happen when the attentional resources are overexhausted
- The driving performance depends mainly on the attentional capture in vision
 - How does age and the cognitive competing task affect this process?
 - Is the attentional decline observed when aging influencing it? By which mechanisms?
 - Are older drivers behaving differently from younger ones under dual task condition?



Context: the attentional capture in vision

Goal-directed and stimulus-driven processes interact during the deployment of attention while driving

- Existence of an index to measure bottom-up contribution (Peters et al., 2005)
 - scanpath superimposition on salience map
 - index = Normalized Scanpath Saliency
- No index for the study of the relevance influence - **creation of the Normalized Scanpath Relevance index**



Michael G.A. et al, 2006



Purpose and Hypotheses

- Purpose

Investigate the issue of the salience/relevance balance in visual search by seeking to understand the influence of age, task demand and scene presentation condition (using the jumbled scene paradigm)

- Hypotheses

- The more jumbled the image, the higher NSS and the more the NSR will drop
- Older people would compensate physiological losses in vision with more efficient visual strategies involving top-down processes
- Dual tasking causes an additional cognitive load advantaging bottom-up mechanisms (less costly in attentional resources)
- In dual tasking, the attentional resources of older drivers would still be sufficient to use top-down processes



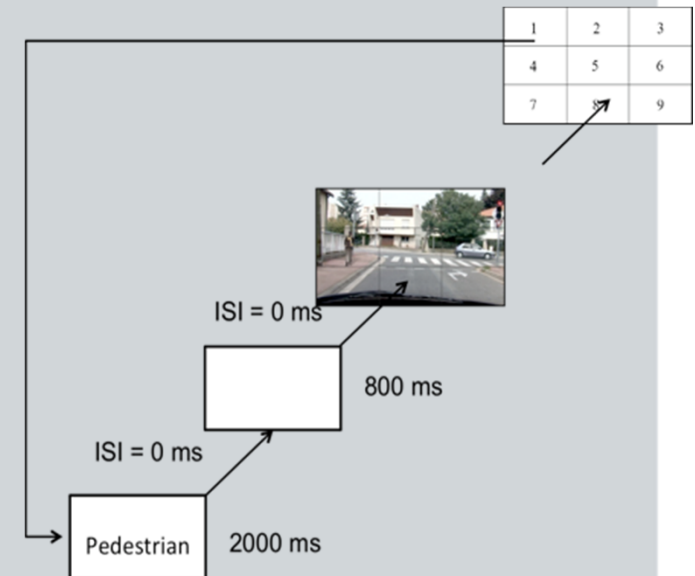
Material and method (1/3)

- **Participants**

- 23 older drivers (mean age 71 ± 4)
- 20 young drivers (mean age 35 ± 3)

- **Procedure**

- Task: localisation of a road element (pedestrian, vehicle, road marking or traffic light)
- Jumbled scene paradigm



Procedure : Original condition



Procedure: Partly condition



Procedure: Fully condition



Material and method (1/3)

- **Participants**

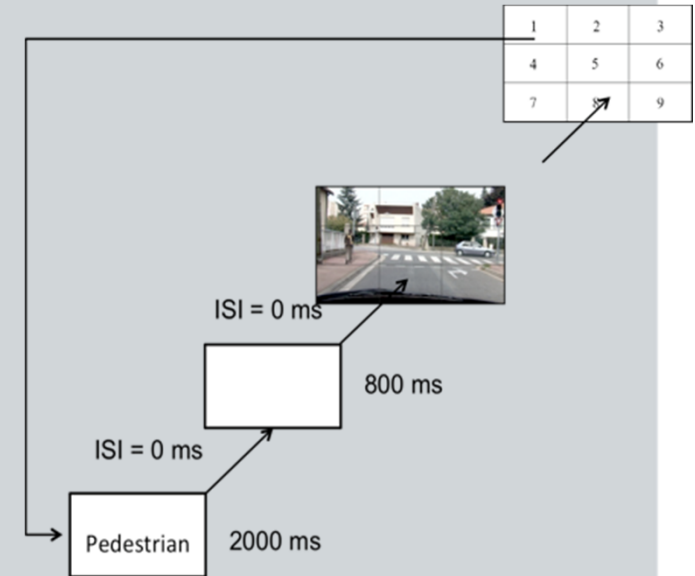
- 23 older drivers (mean age 71 ± 4)
- 20 young drivers (mean age 35 ± 3)

- **Procedure**

- Task: localisation of a road element (pedestrian, vehicle, road marking or traffic light)
- Jumbled scene paradigm
- Single or dual task condition (semantic judgment)
- 72 trials per participant

- **Visual fixation measurement and definition**

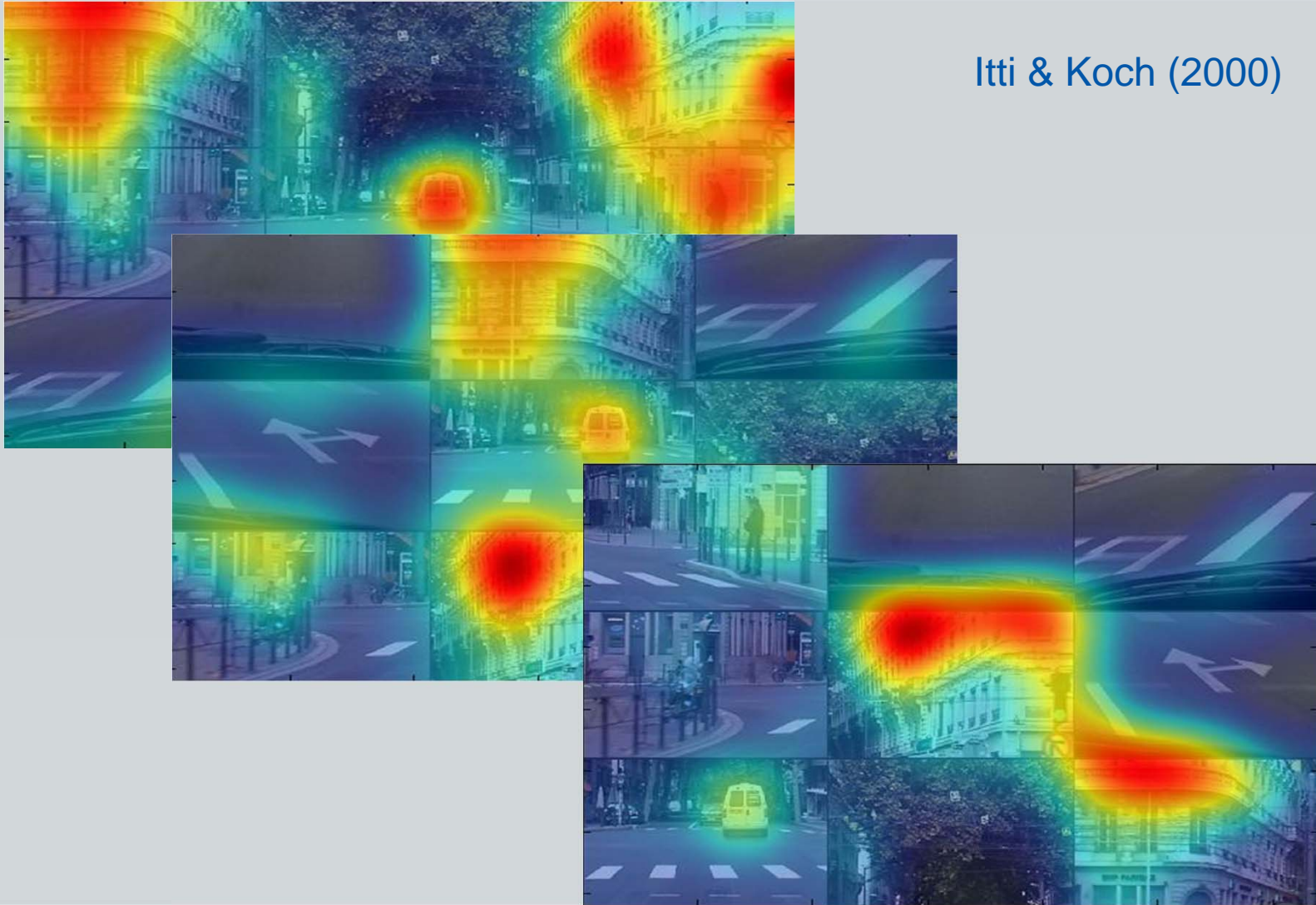
- FaceLab
- mix content task (reading and observing picture)
- Visual fixation = eye movement under 30 pixels in 100 ms



Material and method (2/3)

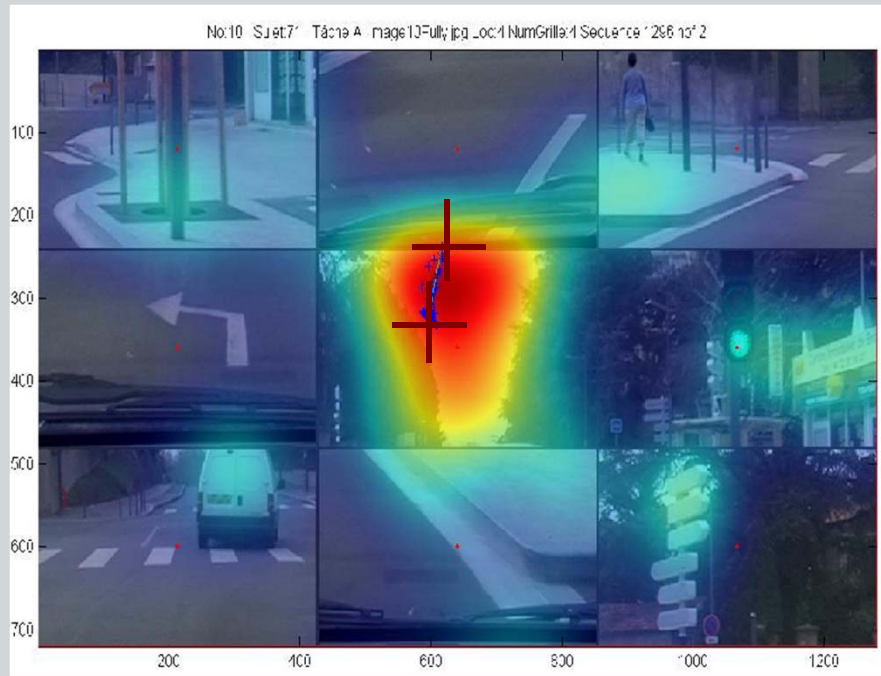
Normalised Scanpath Salience calculation

Itti & Koch (2000)



Material and method (2/3)

Normalised Scanpath Salience calculation



Scanpath guided by salience
NSS = 2.29



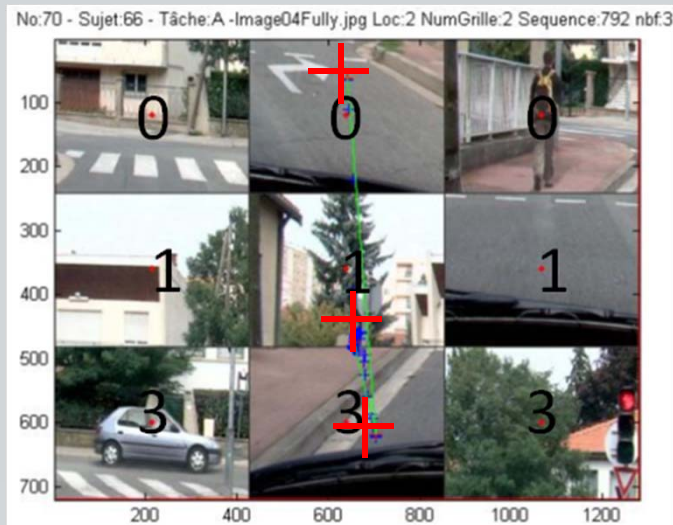
Scanpath non guided by salience
NSS = 0.54



Material and method (3/3)

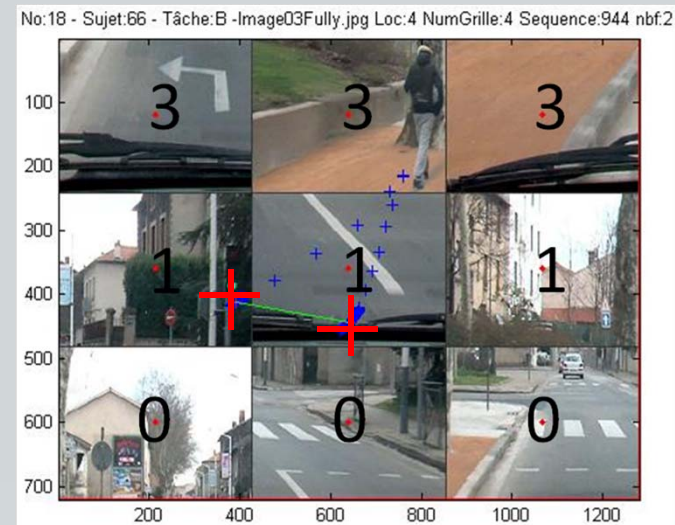
Normalized Scanpath Relevance calculation

Goal directed scanpath for road marking



$$NSR = (1+3+0)/3 = 1.33$$

Goal oriented scanpath for traffic light



$$NSR = (1+1)/2 = 1$$



Statistical analysis

- 10.2% of errors on the localization task (trials excluded from the analysis – dual tasking cause saturation of the working memory of older drivers – 21% of errors)
- Mixed ANOVA on three dependent variables
 - Number of visual fixations
 - Normalized Scanpath Salience
 - Normalized Scanpath Relevance
- Within-subjects factors
 - Condition (original, partly jumbled, fully jumbled)
 - Task (single vs. dual)
- Age as between-groups factor (young vs. old)



Results (1/3)

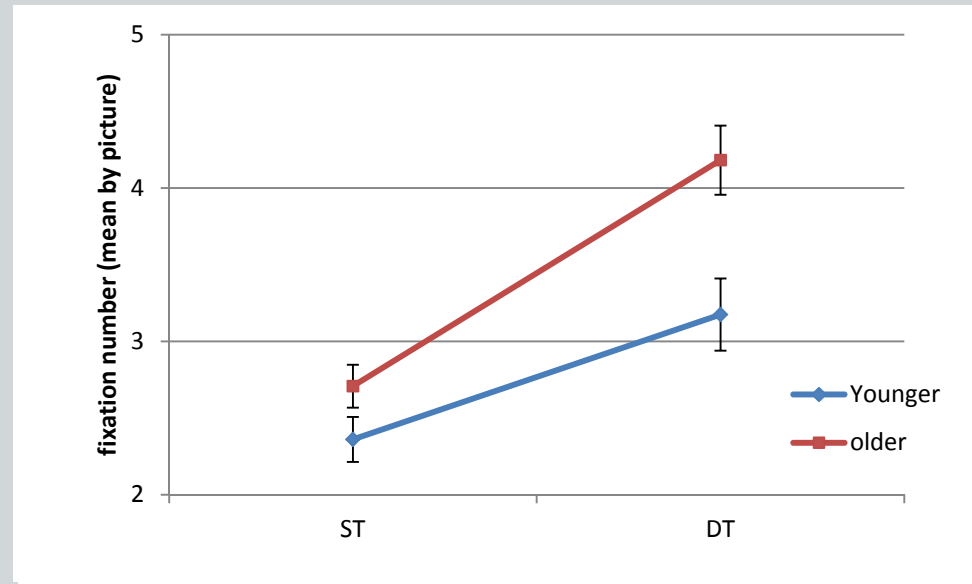
Visual fixation number

Age effect $p = .006$

Task effect $p < .001$

Condition effect $p < 0.001$

Age*task effect $p = .022$



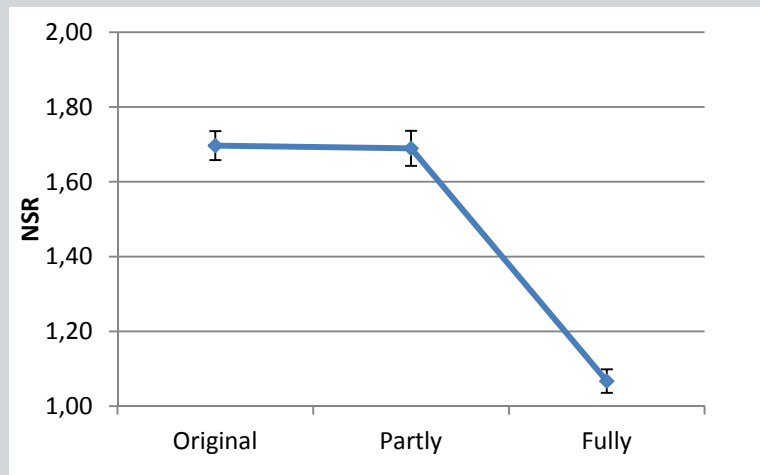
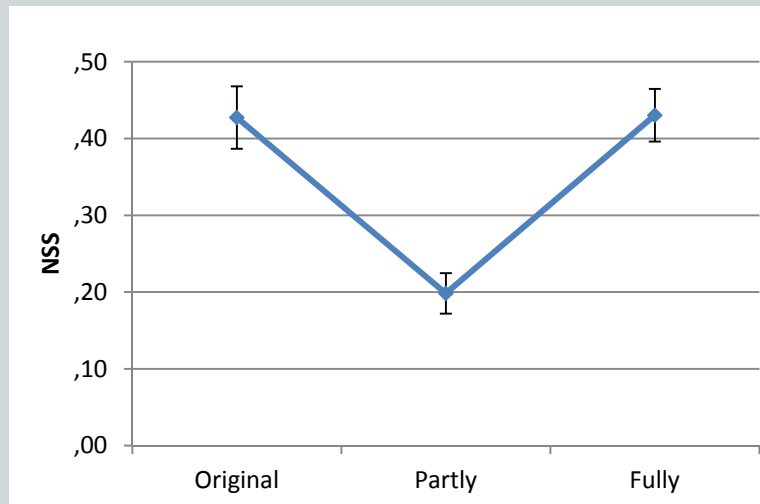
older drivers' visual search is less efficient in dual task



Results (2/3)

NSS, NSR variations

- Normalized Scanpath Saliency (NSS)
 - Age NS
 - Task NS
 - Condition $p < .001$
- Normalized Scanpath Relevance (NSR)
 - Age NS
 - Task NS
 - Condition $p < .001$



Results (3/3)

Correlations between these two indexes

- NSS-NSR correlations
 - Younger, $r = -0,64$, $p = .003$
 - Older, $r = -0,51$, $p = .014$
- Effects of condition and task on correlations

- Original

		Single Task	Dual Task
Younger	r	-0,548	0,252
	p	0,012	NS
Older	r	-0,486	-0,194
	p	0,019	NS

- Partly

		Single Task	Dual Task
Younger	r	-0,284	-0,217
	p	NS	NS
Older	r	-0,452	-0,038
	p	0,03	NS

- Fully

		Single Task	Dual Task
Younger	r	-0,021	-0,246
	p	NS	NS
Older	r	-0,279	-0,192
	p	NS	NS



Discussion

- Available attentional resources must be sufficient to enable a proper adjustment between salience and relevance maps (negative effect of dual task)
- In older drivers, the decreased availability of resources led to make a greater number of fixations and tended to disrupt visual search, suggesting that inappropriate visual search may exist while driving
- despite the greater driving experience of older drivers, there is a deleterious effect of the competing cognitive task on the organization of their visual search, which is not compensated by a relevance-oriented adjustment
- In the absence of overall context in a visual scene, older drivers compensate most probably due to their driving experience, a pattern which is not observed in younger drivers, allowing them to direct attention to relevant information



Conclusion

- This study provided experimental evidence for the existence of salience and relevance maps, their interaction but also their independence
- A better understanding of the setting of the salience-relevance balance; possible effect of driving experience to compensate for visuo-attentional decline linked with age
- An analysis under progress to better understand localization errors (can the visual fixation number explain them?)

