

Temporal preparation in aging: a dissociation between automatic and controlled processes ?

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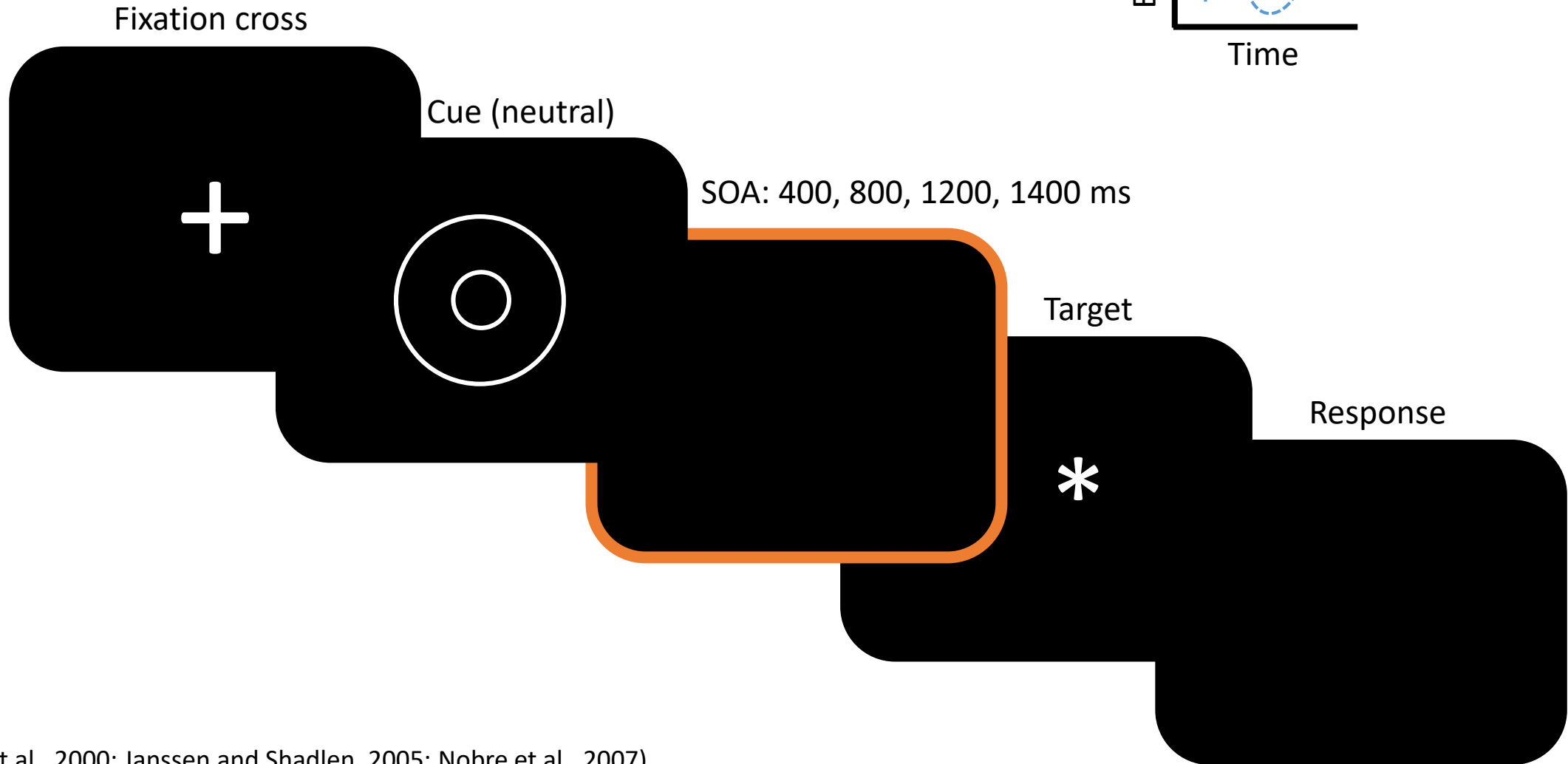
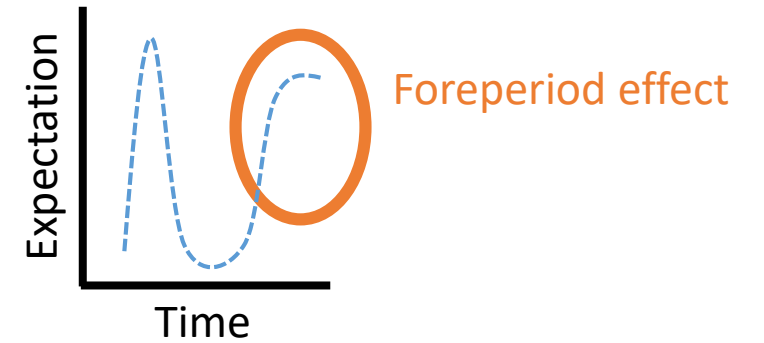
Temporal preparation



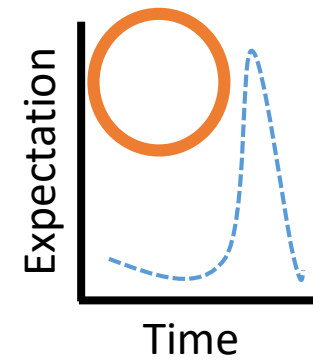
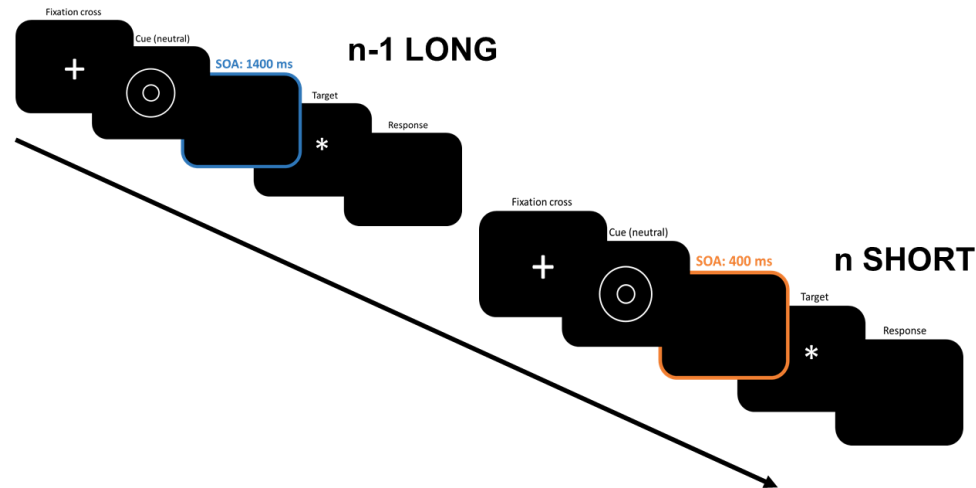
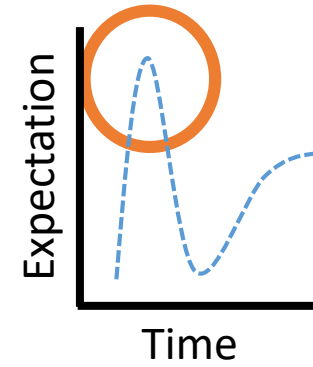
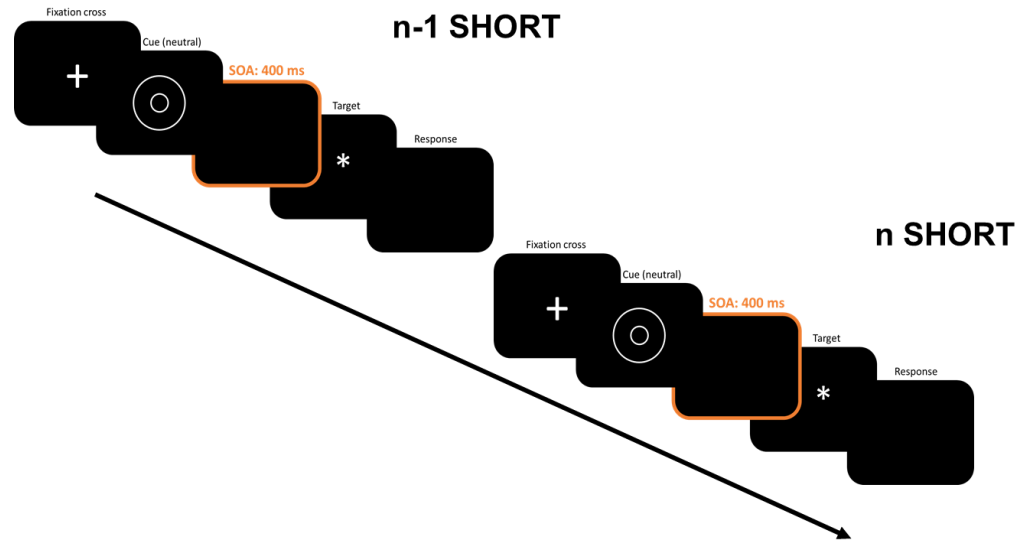
= an increased readiness to act before an expected event; consequently, reaction time should be reduced.

→ enables us to focus on specific moments in time so as to enhance sensory processing during a brief period.

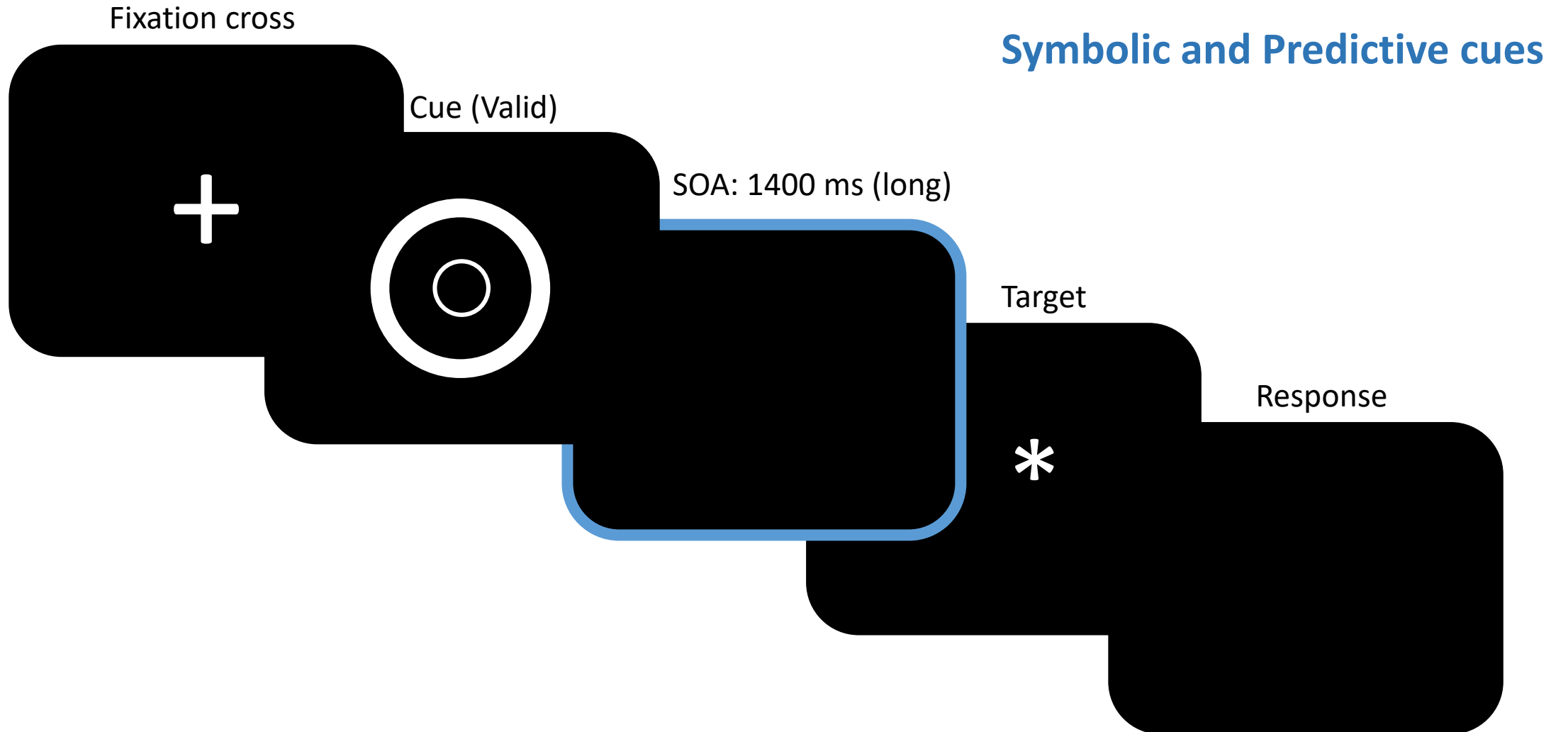
Foreperiod effect



Sequential effect



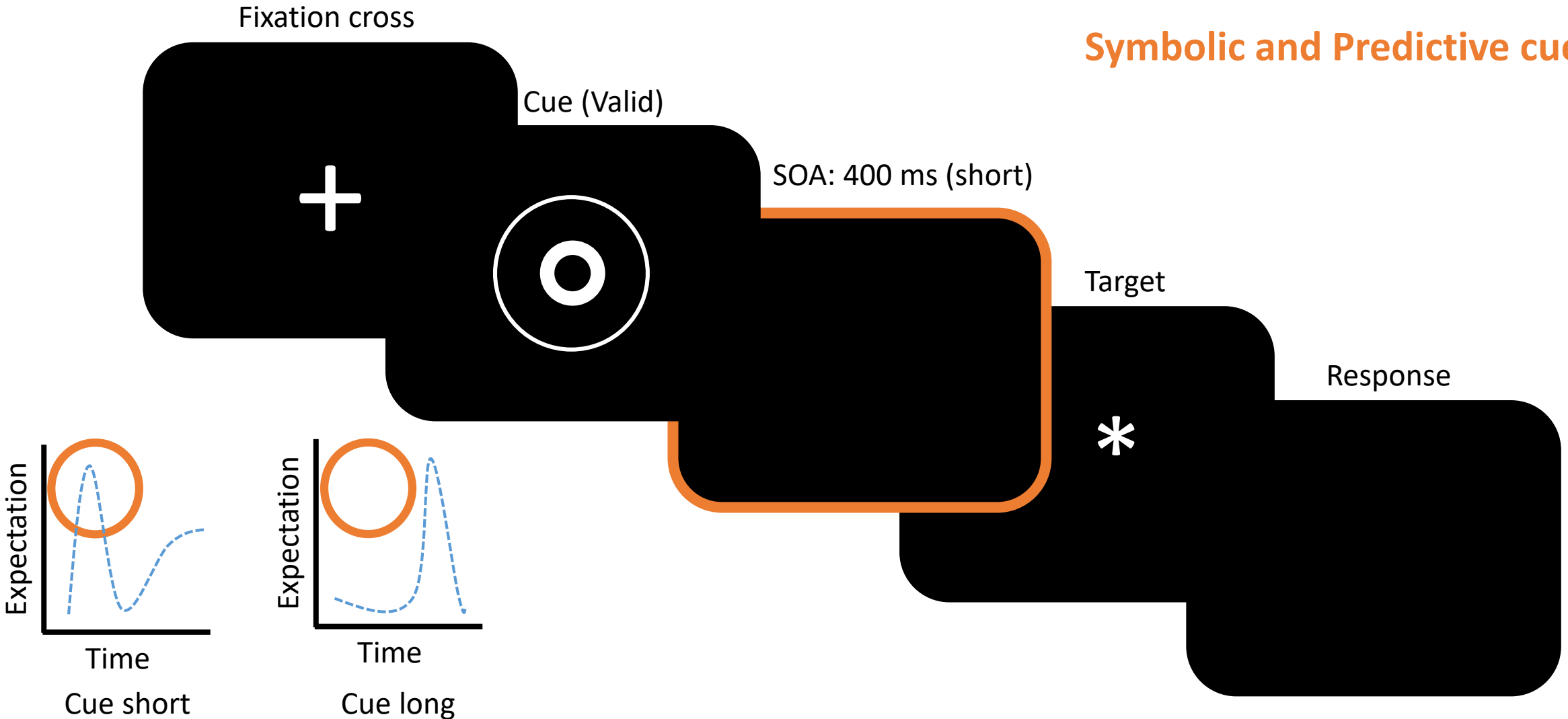
Endogenous temporal orienting



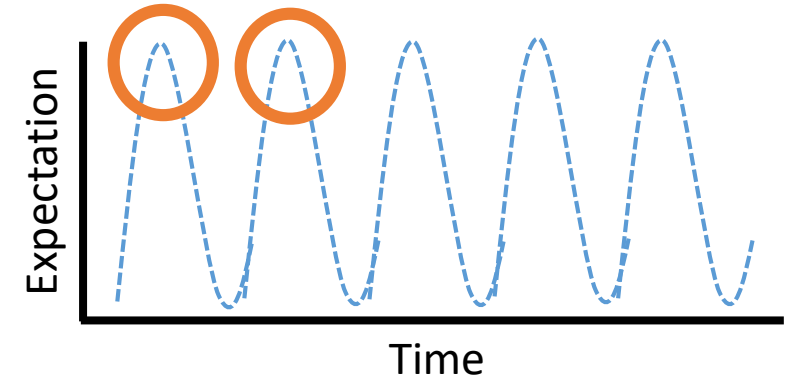
(e.g., Coull & Nobre, 1998; Miniussi, Wilding, Coull, & Nobre, 1999; Nobre, 2001)

Endogenous temporal orienting

Symbolic and Predictive cues



Rhythmic temporal orienting



Fixation cross

Rhythmic Cue

SOA 1000 ms

Target

Response

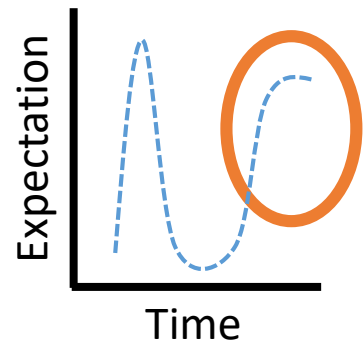


Regular vs. Irregular Rhythm

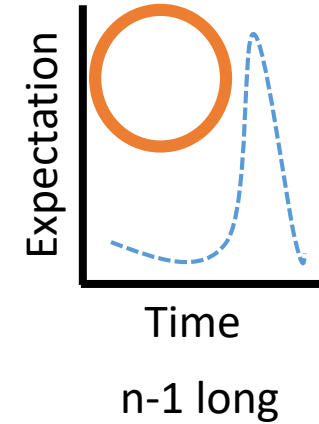
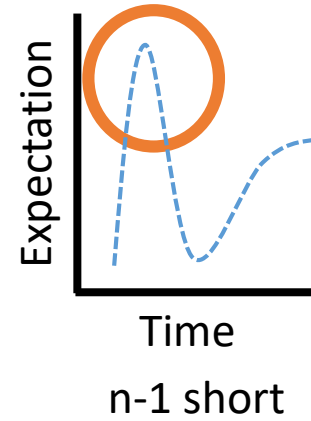
(e.g., Jones et al., 2002; Sanabria et al., 2011; De la Rosa et al., 2012; Rohenkohl et al., 2012; Breska and Ivry, 2018)

Temporal preparation : 4 components

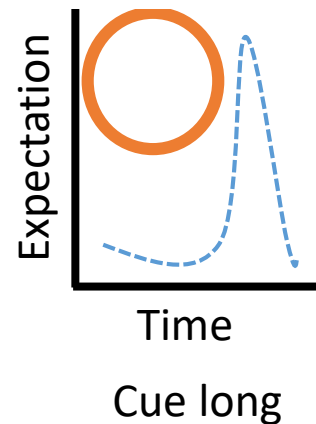
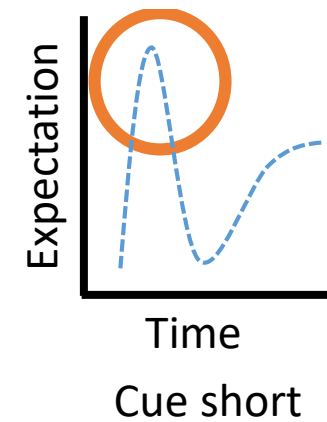
Foreperiod effect



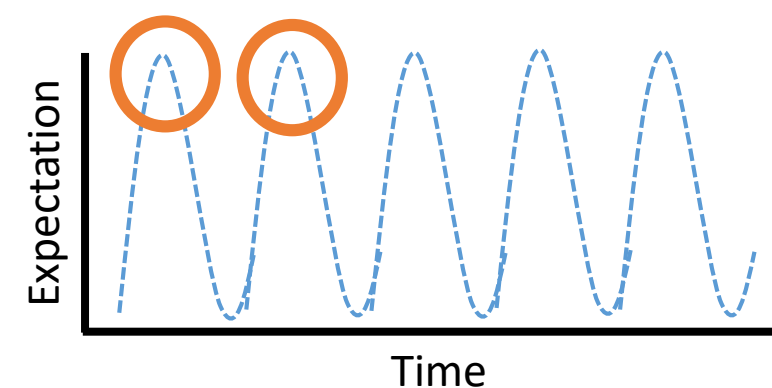
Sequential effect



Endogenous temporal orienting



Rhythmic temporal orienting



Objectives

1. To assess the 4 components of temporal preparation.
2. To test the trajectories of these components in aging.

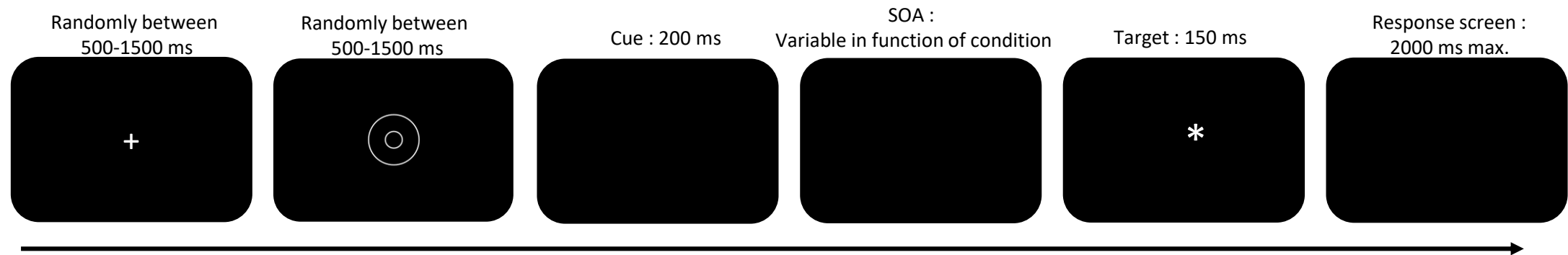
Experiment 1

Young adults : A same paradigm to assess the 4 components

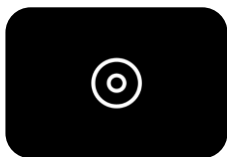
XP 1: Method

Single paradigm : **Foreperiod; Sequential; Endogenous TOE; Rhythmic TOE**

 119 young adults (20 +/- 4 years old; range: 17-45) – 106 women



(a) Neutral cue for the Foreperiod and the Sequential effect



Neutral cue

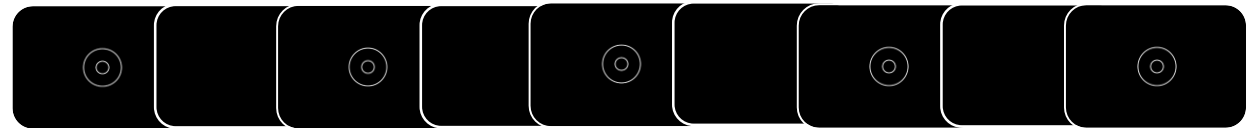
(b) Cues for short or long SOA for the endogenous temporal orienting effect



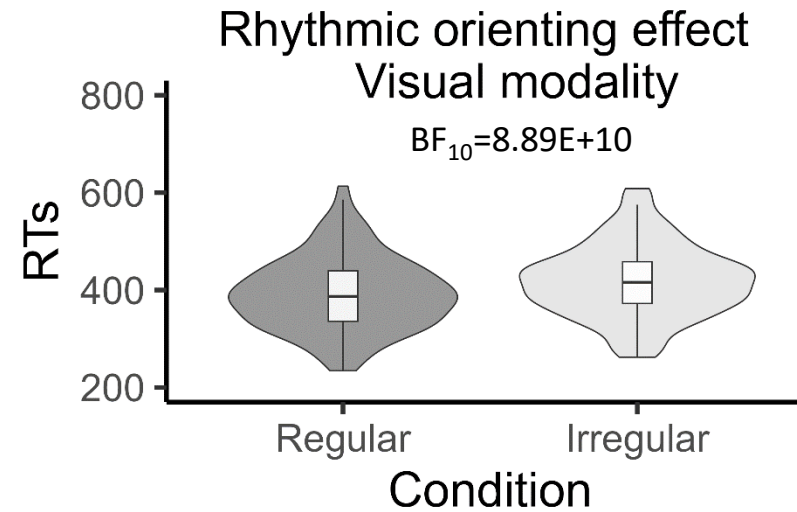
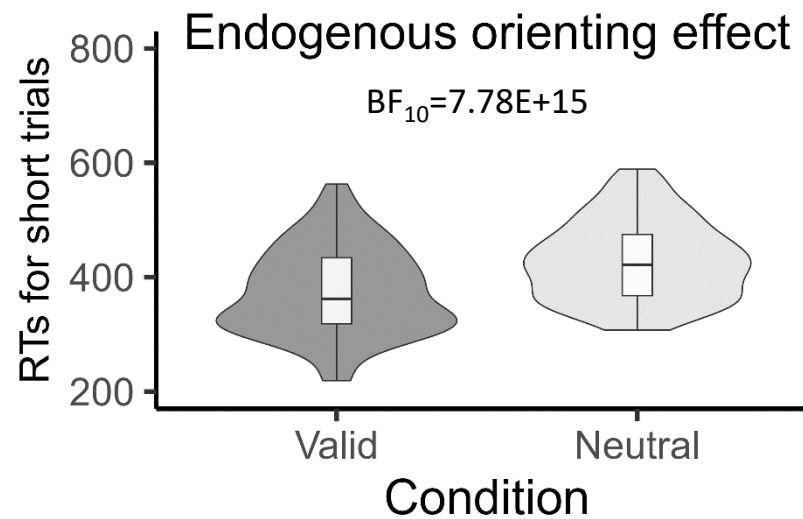
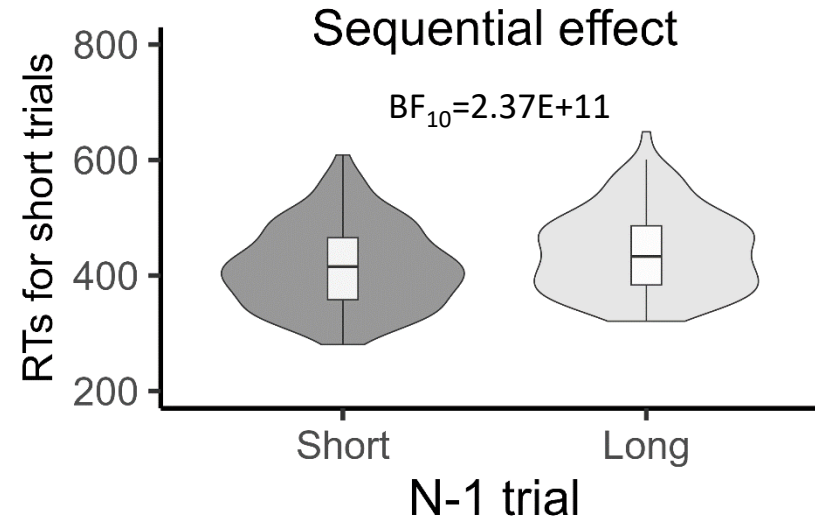
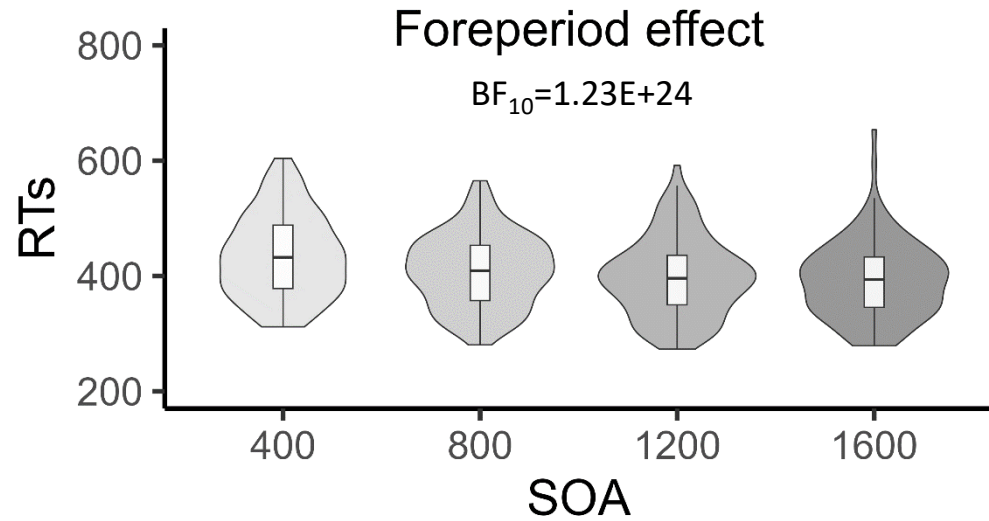
Cue for short SOA

Cue for long SOA

(c) Cues for the rhythmic temporal orienting effect at a regular or irregular pace



XP 1: Results



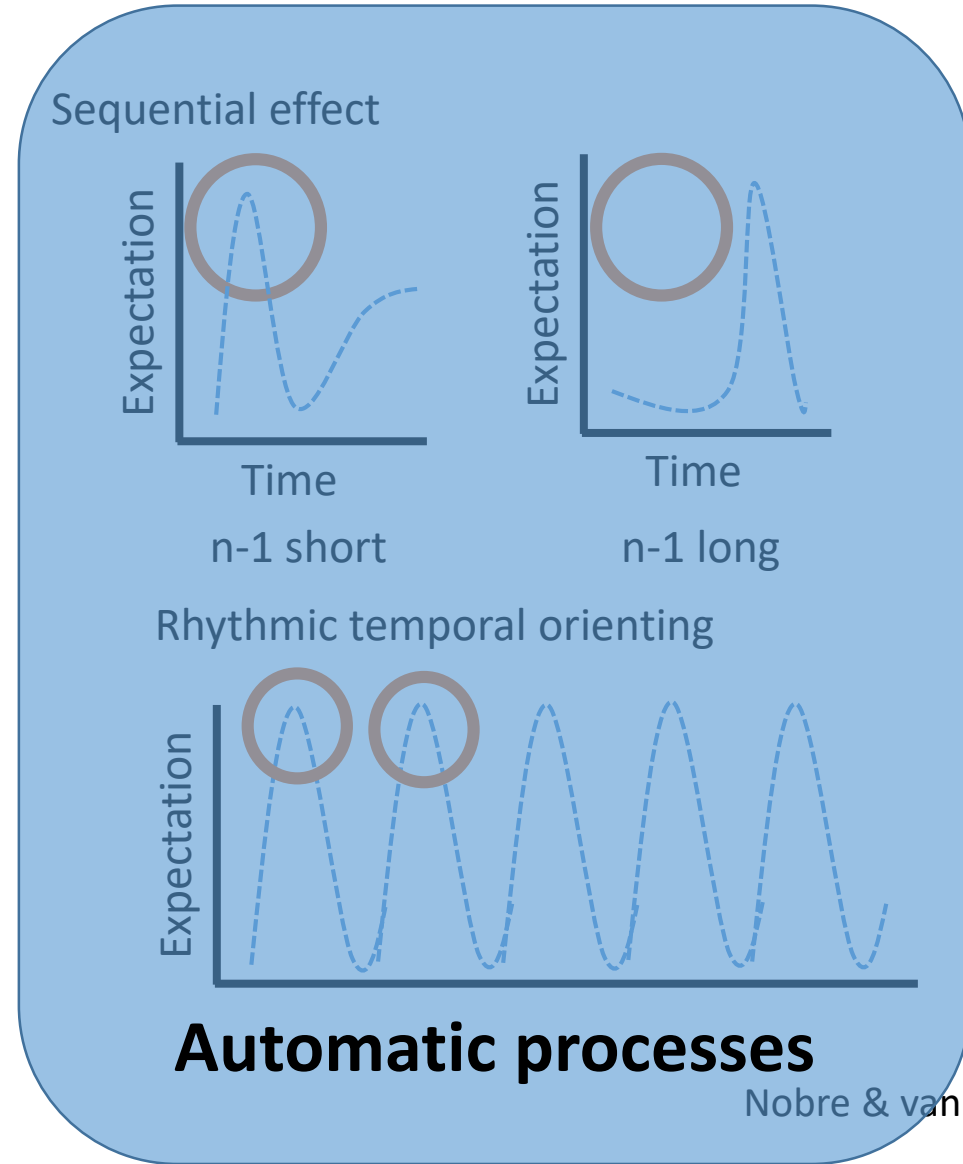
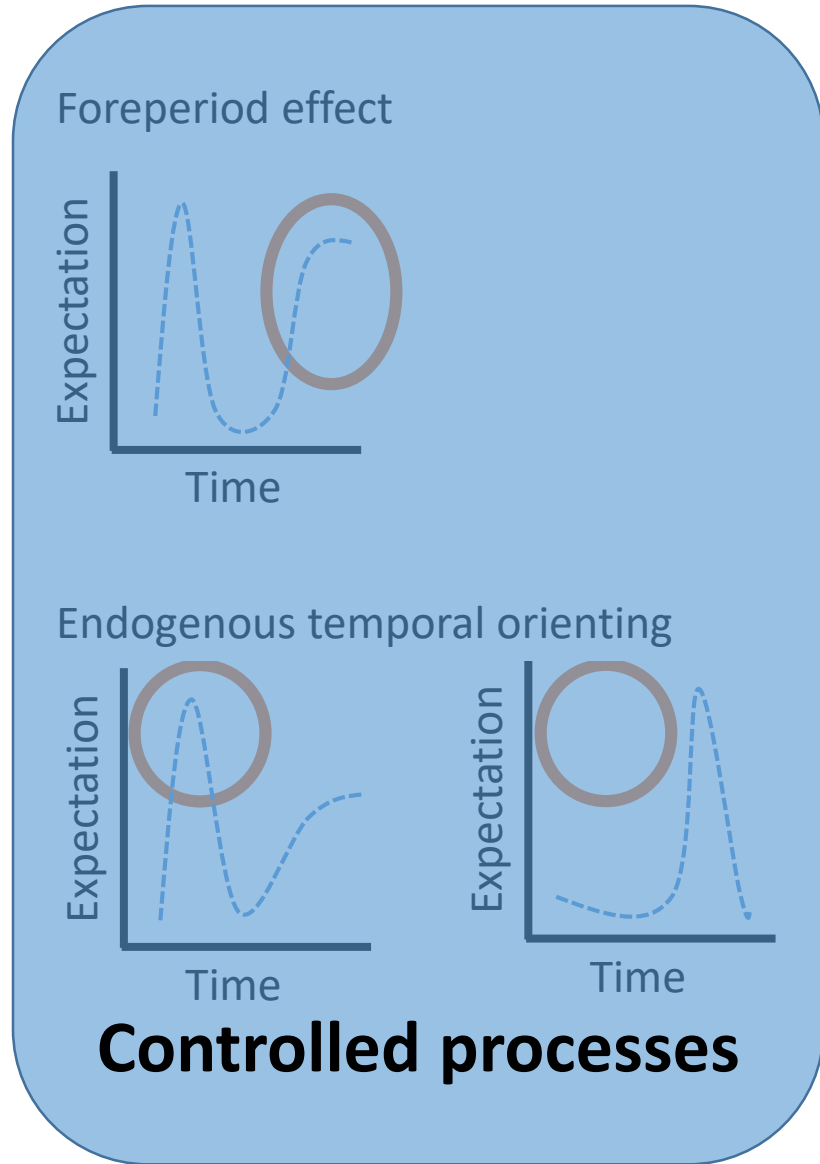
XP 1: Results

Temporal effects	RT mean	Foreperiod	Sequential	Endogenous TO
Foreperiod	$r=-.07$ $BF_{10}=0.15$			
Sequential	$r=-.18$ $BF_{10}=0.74$	$r=-.02$ $BF_{10}=0.12$		
Endogenous TO	$r=-.09$ $BF_{10}=0.18$	$r=-.06$ $BF_{10}=0.14$	$r=.21$ $BF_{10}=1.53$	
Rhythmic TO	$r=-.11$ $BF_{10}=0.24$	$r=.04$ $BF_{10}=0.13$	$r=-.01$ $BF_{10}=0.12$	$r=.15$ $BF_{10}=0.41$

Temporal effects not related to the general RTs

Temporal effects not related between them



Temporal preparation : 4 components



Temporal preparation : aging

- **Age-related changes in temporal processing** (Droit-Volet, 2016; Friedman & Janssen, 2010; Janssen, Naka, & Friedman, 2013; Lamotte & Droit-Volet, 2017; Maaß, Wolbers, van Rijn, & Riemer, 2021; Wearden, 2005; Wittmann & Lehnhoff, 2005)
- **Explicit** vs. **Implicit** temporal judgement processes (Mioni et al., 2020; Droit-Volet et al., 2019; Capizzi et al., 2022)
- **Working memory; attention** (Baudouin, Isingrini, & Vanneste, 2018; Mioni, Capizzi, & Stablum, 2020)
- **Age or cognitive decline ? Both but differentially** (Capizzi et al., 2022):
 - Explicit: decreases with age and cognitive decline
 - Implicit: increases with age BUT decreases with cognitive decline

Temporal preparation : aging



Temporal effects	Results  vs. 	References
Foreperiod	=	Chauvin et al., 2016; Zanto et al., 2011; BUT impaired for Variable Foreperiod : Vallesi et al 2009
	>	Zanto et al., 2011
Endogenous TOE	=	Chauvin et al., 2016
	<	Heideman et al., 2018
Sequential effect	=	Chauvin et al., 2016
Rhythmic TOE	=	Turgeon et al., 2016; Hiroyasu & Yotsumoto, 2020

Endogenous TOE more controlled processing?

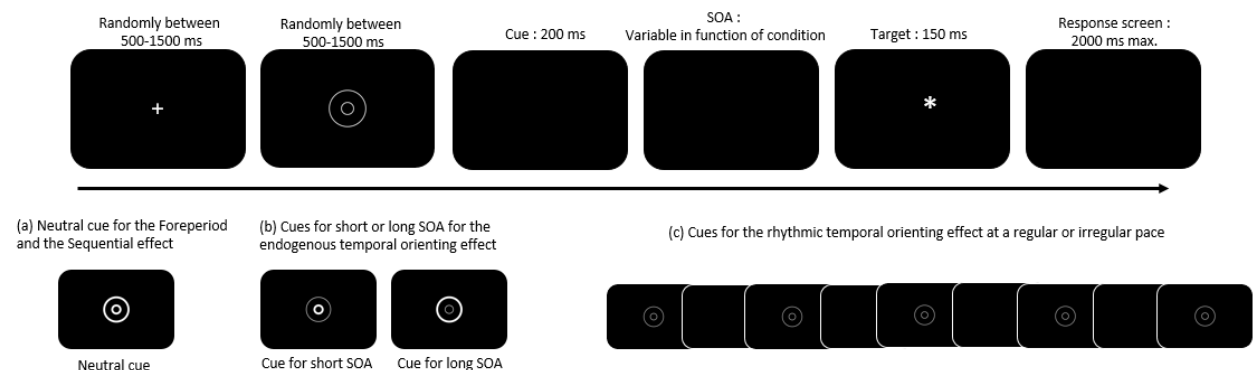
Experiment 2

Temporal preparation in aging

XP 2 : Method

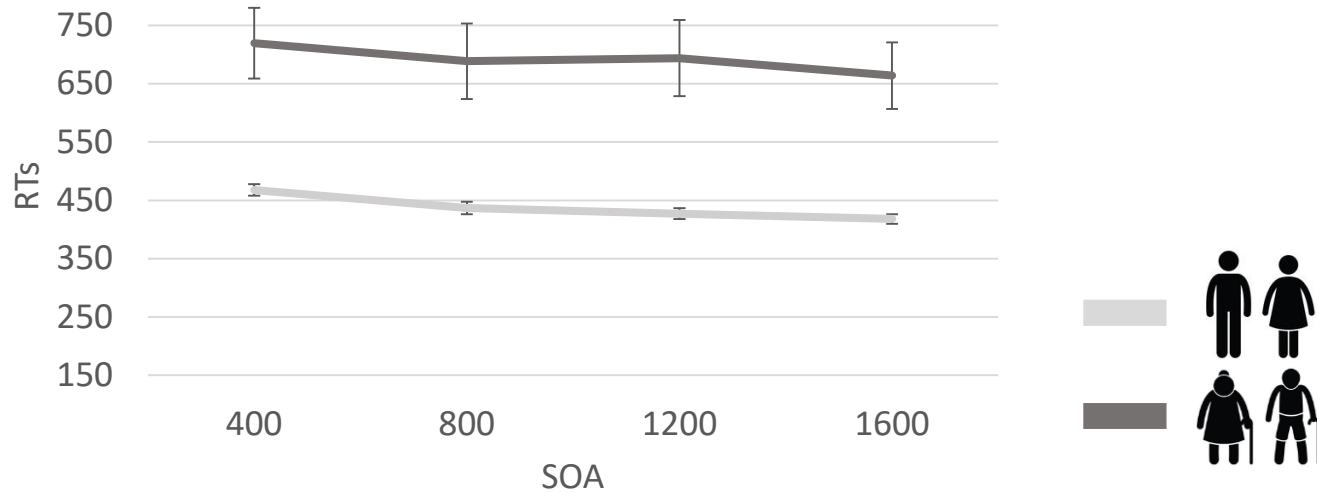
	Young adults 	Old adults 
N	30	30
Age	20.40 +- 1.81 (18-25)	79.43 +- 8.94 (64-94)
Sex	22 women	22 women
Education (school years)		10.23 +- 3.45 (5-17)
MoCA		P55 +- 28 (12-98) (exclusion if <P10)
Working memory (direct span)		7.83 +- 2.15 (6-16) → span length: 5

Same Unique paradigm :
Foreperiod; Sequential;
Endogenous TOE; Rhythmic TOE

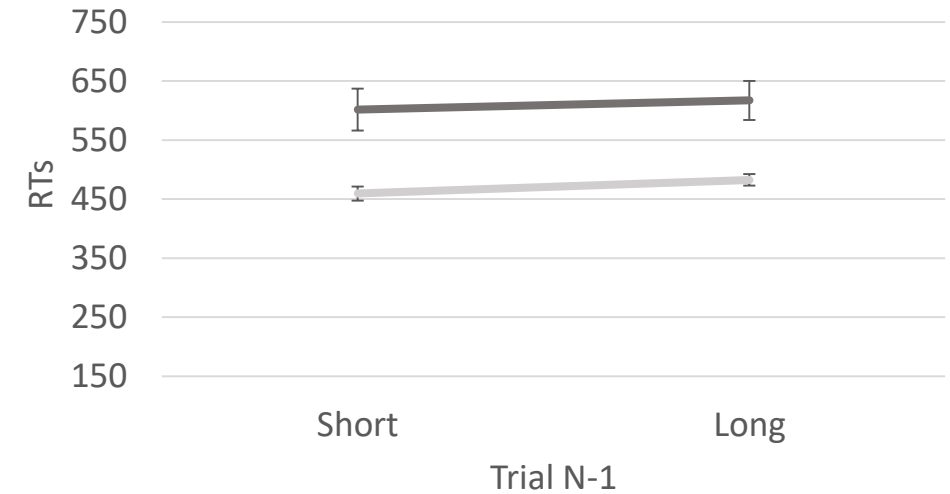


XP 2 : Results

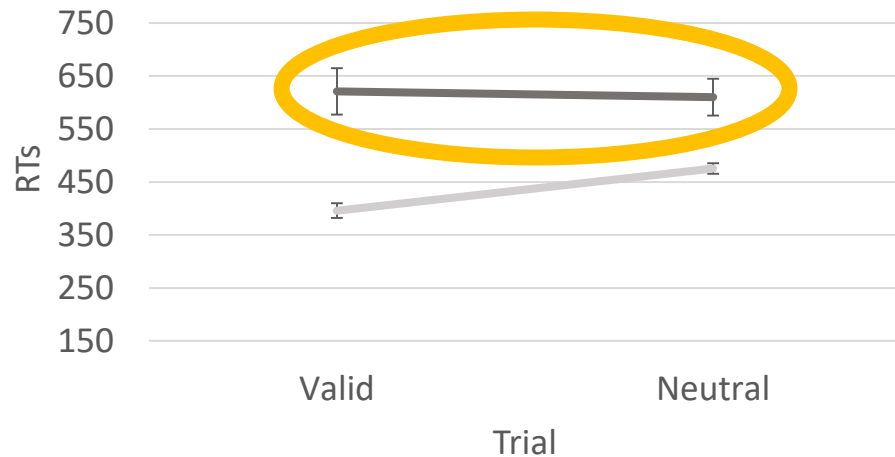
Foreperiod

 Interaction : $BF_{Inc}=0.06$ 

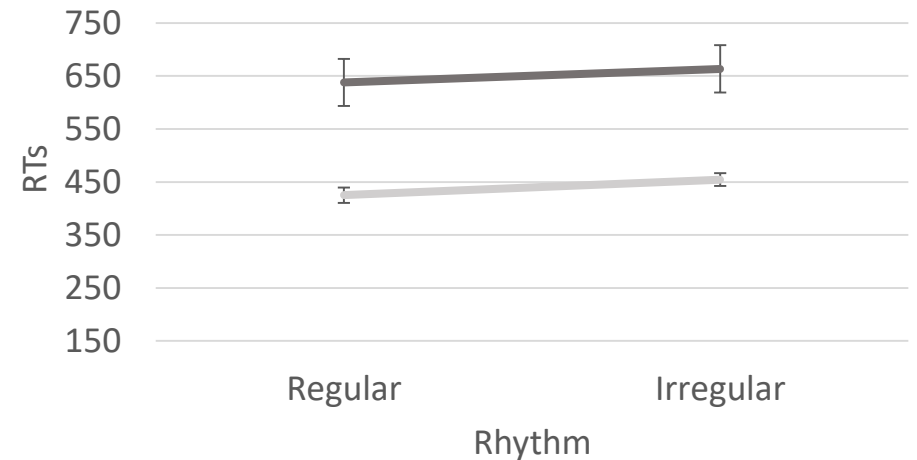
Sequential (short trials)

 Interaction : $BF_{Inc}=0.29$ 

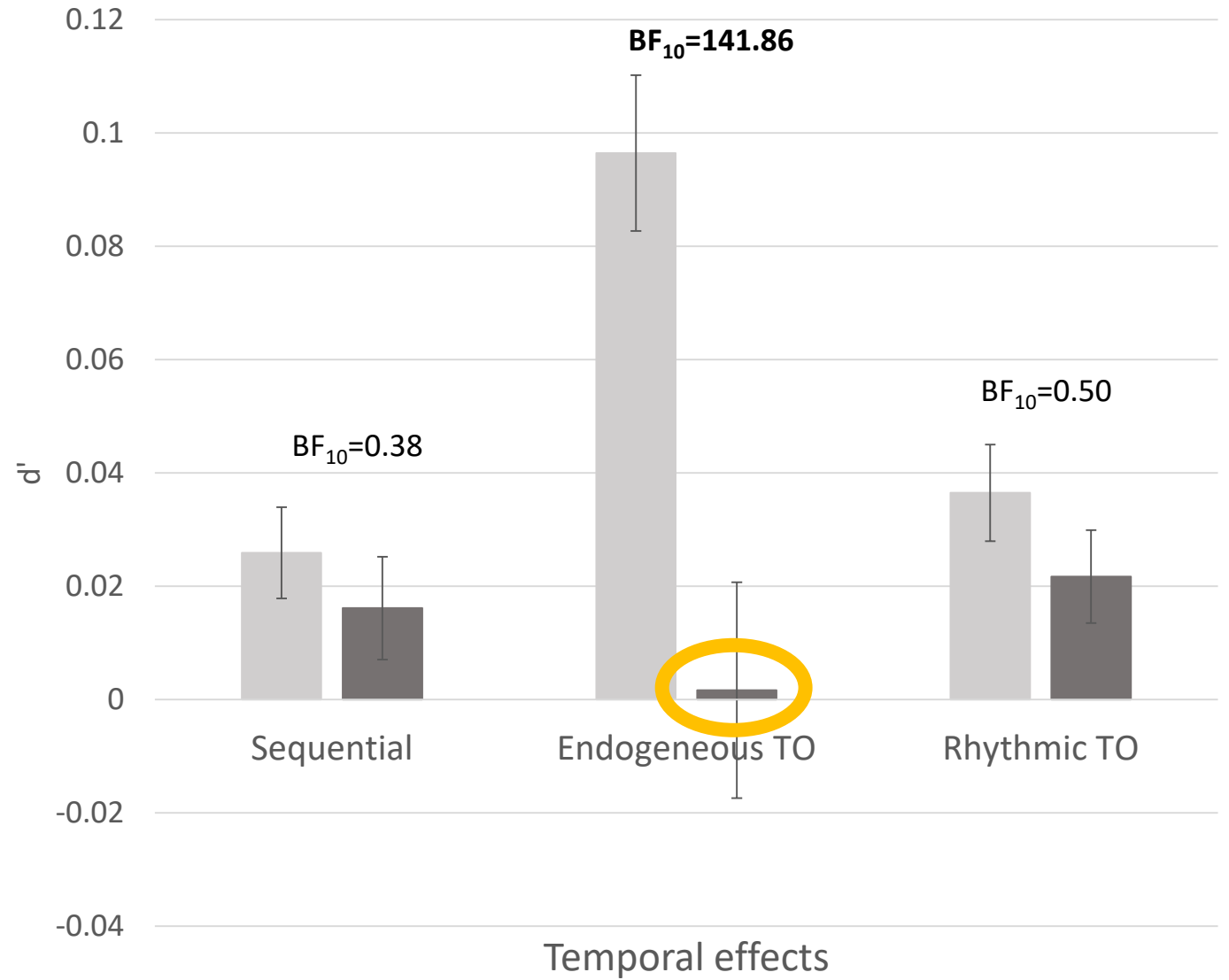
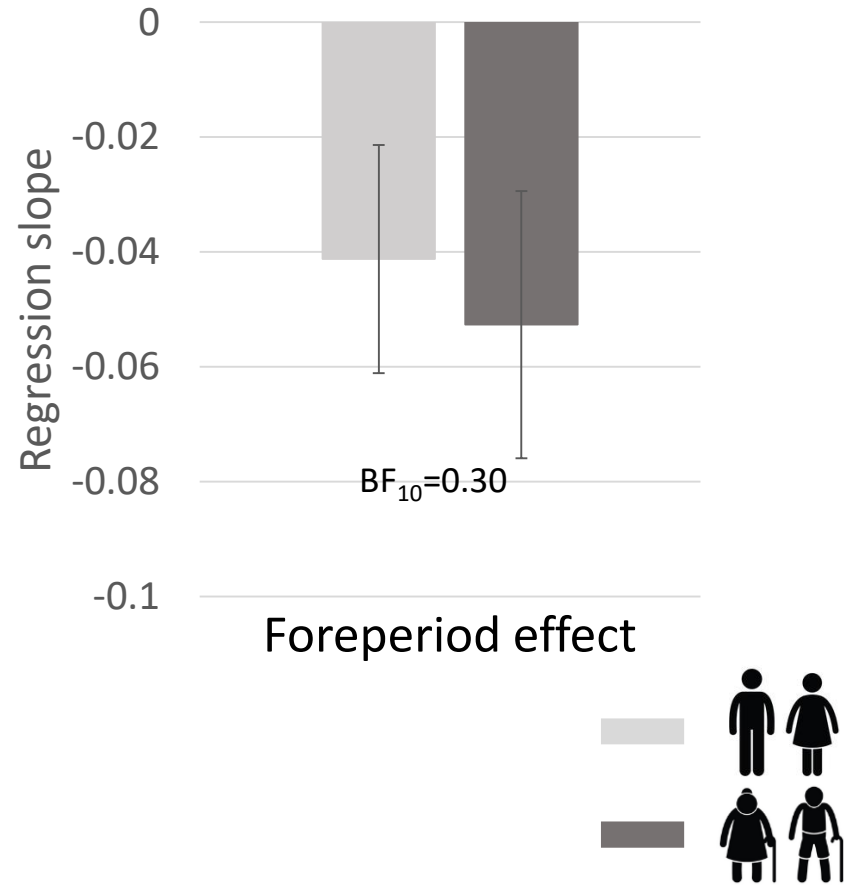
Endogenous TOE (short trials)

 Interaction : $BF_{Inc}=8.23$ 

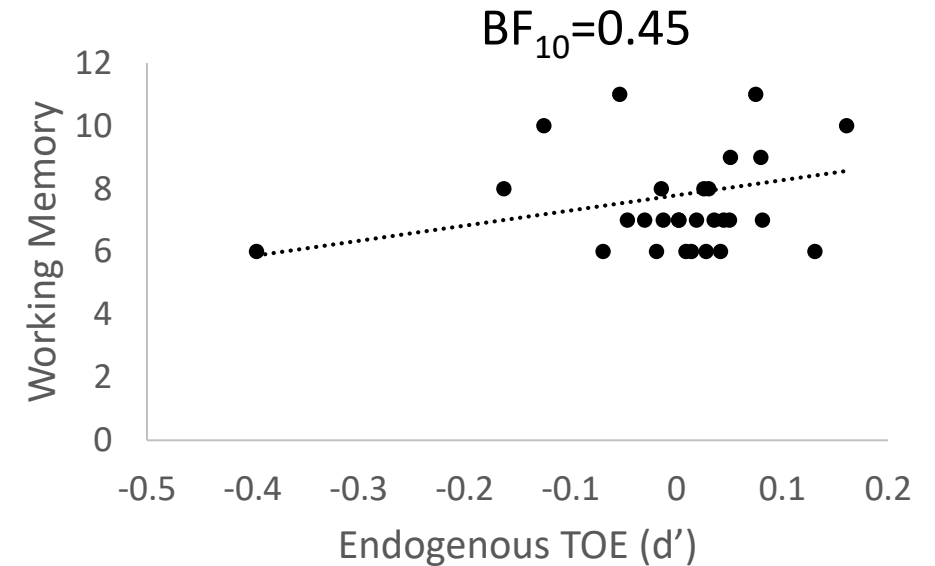
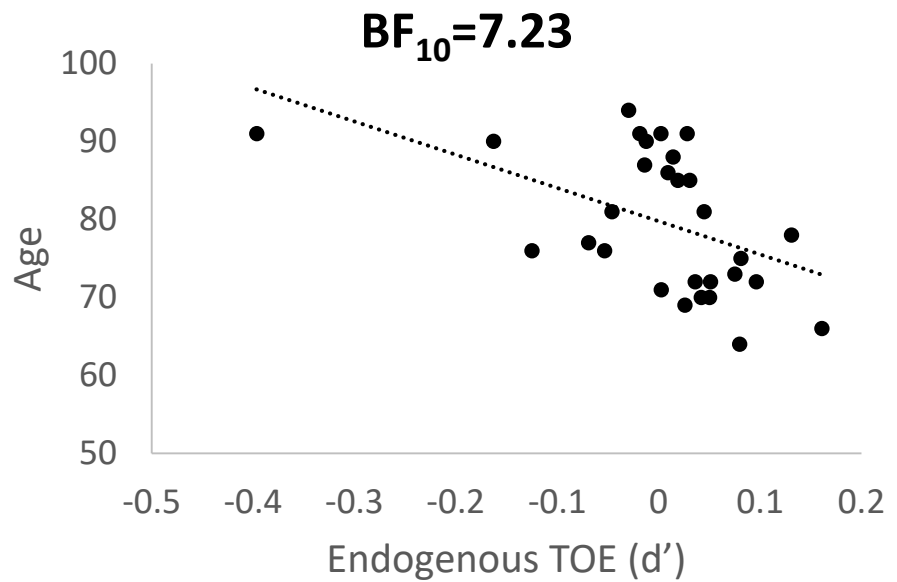
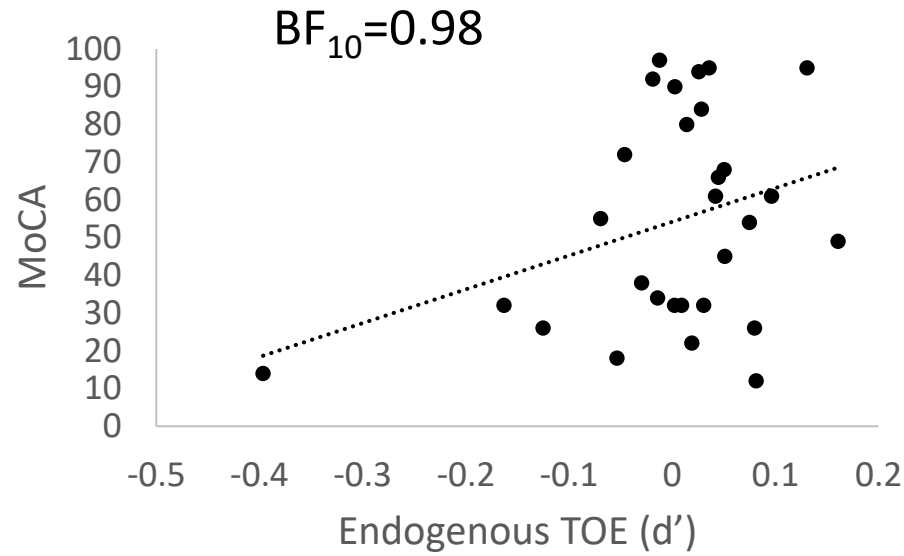
Rhythmic TOE

 Interaction : $BF_{Inc}=0.27$ 

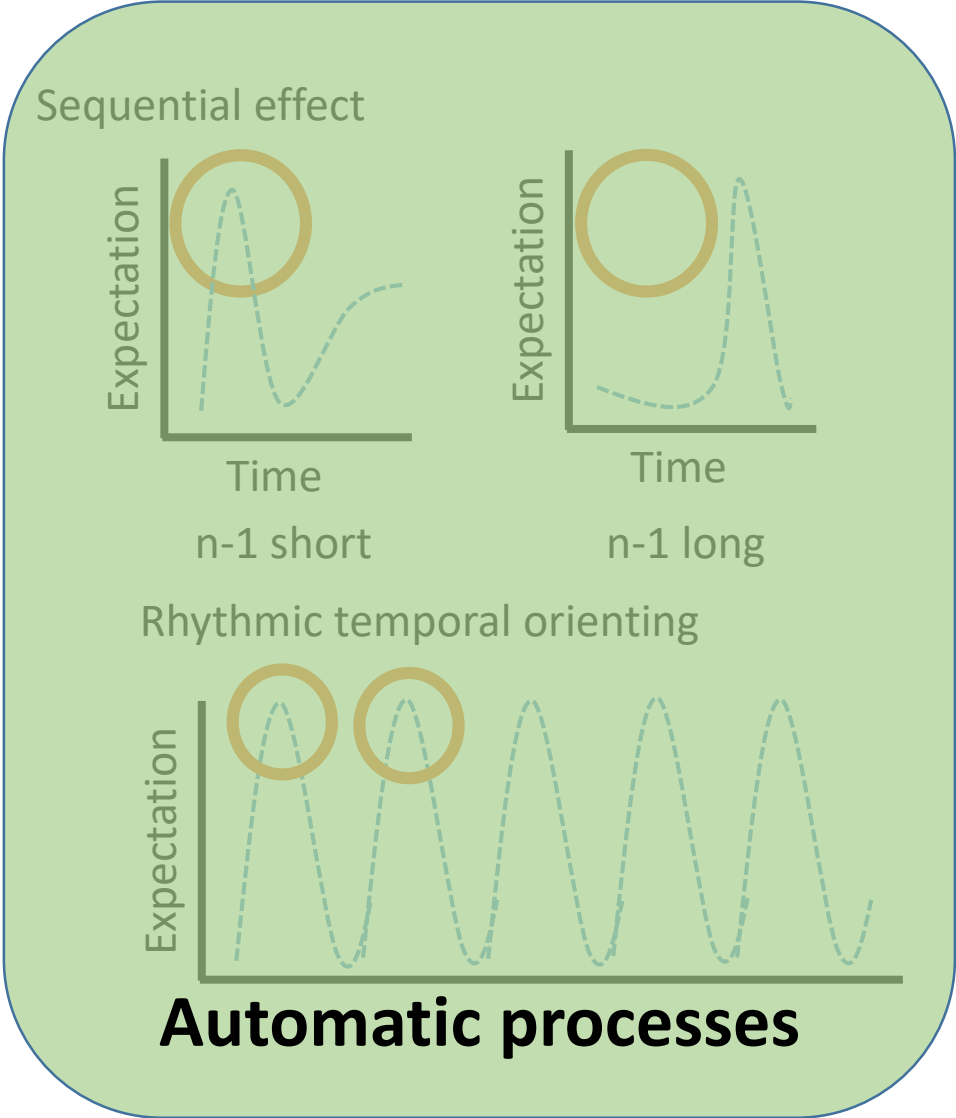
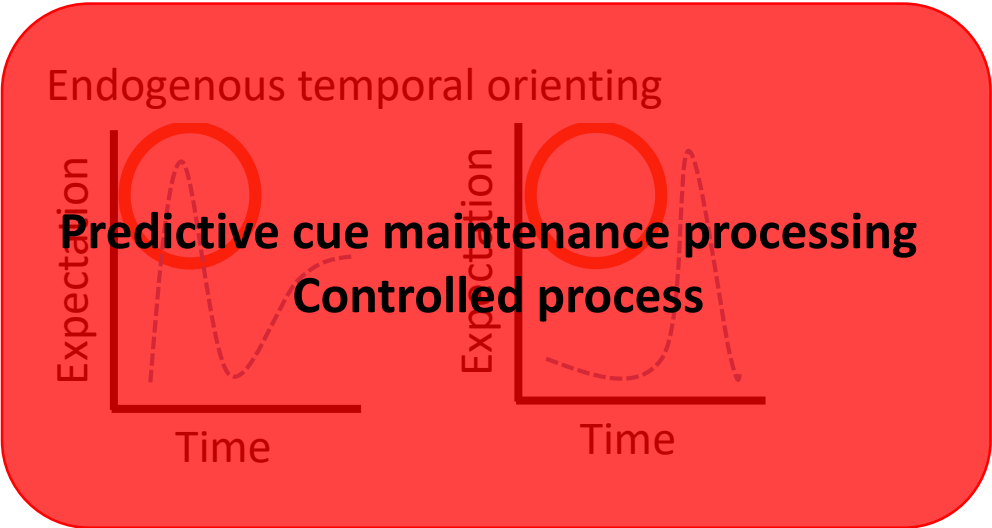
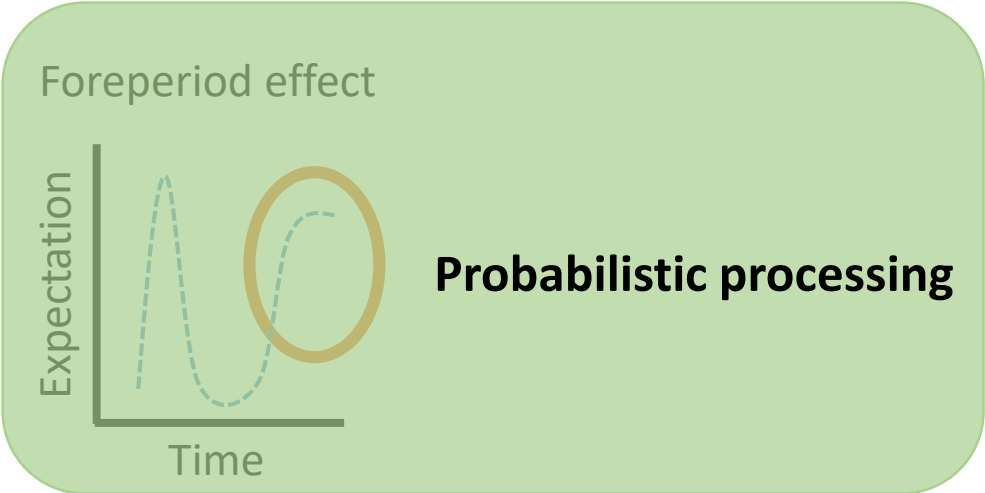
XP 2 : Results



XP 2 : Results - correlation Endogenous TOE



Discussion



Discussion

= ≠

Variable	Our study	Zanto et al. (2011)	Chauvin et al. (2016)
Age	Older (± 80 y.o.)	Younger (± 69 y.o.)	Younger (± 66 y.o.)
Education	± 10	< 12	± 18
Contrast	100% Valid vs. Neutral	100% Valid vs. Neutral	100% Valid vs. Neutral
Design	Blocked	Trial-by-trial	Blocked
Modality Cue	Visual	Visual	Auditory

→ Continuum of age, cognitive abilities and educational level?

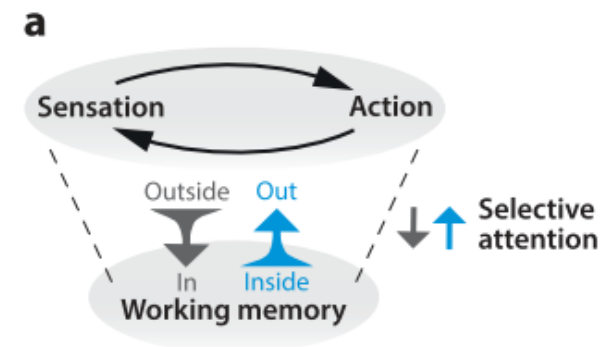
Conclusion

- Suitable design to study all temporal preparation components at the same time
- More controlled temporal preparation impaired in aging: no facilitation from the cueing for valid condition.
- Disappear under WM load
- In line with an involvement of the left and right DLPFC (Correa et al., 2016)
 - Age-related changes in prefrontal cortex activity are associated with both temporal and spatial context memory retrieval deficits in older adults (Rajah et al., 2010)
- Linked to age (not necessarily to cognitive abilities : MoCA or WM) → // explicit processes (Capizzi et al., 2022)
- Very easy task and very short of maintenance → WM or flexibility in the anticipation ko?
- For implicit ? No increase with age but preserved

Perspectives



- What about a life span perspective?
- In children : dissociation between more implicit temporal effects and endogenous TOE ?
- Endogeneous TOE : requires more control than the other temporal preparation effects BUT not necessarily linked to WM or cognitive abilities
 - early developement?
 - controlled but rather outside – in process



van Ede & Nobre, 2023

Thank you for your attention

Thanks to my collaborators:

Pom Charras

MG Capizzi

Giovianna Mioni

Appendix

Test-Retest (N=46)

- Bayesian repeated measure ANOVAs 2 (time: test-retest) X 2 (measures of interest in function of the subtest) on each subtest
 - For all measures : main effect of time (T2<T1)
 - Foreperiod: no interaction ($BF_{incl}=0.65$)
 - Sequential: no interaction ($BF_{incl}=0.94$)
 - Endogenous TOE: no interaction ($BF_{incl}=0.21$)
 - Rhythm TOE Auditory: no interaction ($BF_{incl}=0.24$)
 - Rhythm TOE Visual: no interaction ($BF_{incl}=0.33$)
- Same temporal effect in T1 and T2 → robustness of measures

Results

- FPED

Model Comparison

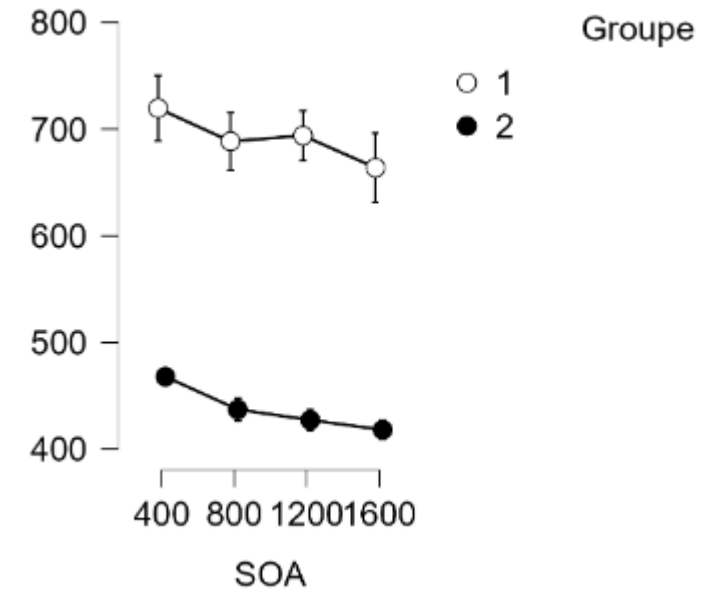
Models	P(M)	P(M data)	BF _M	BF ₁₀	error %
Null model (incl. subject and random slopes)	0.200	8.666×10^{-6}	3.466×10^{-5}	1.000	
SOA + Groupe	0.200	0.937	59.817	108162.541	14.718
SOA + Groupe + SOA * Groupe	0.200	0.052	0.221	6032.162	1.612
SOA	0.200	0.010	0.039	1109.910	0.534
Groupe	0.200	7.786×10^{-4}	0.003	89.842	4.511

Note. All models include subject, and random slopes for all repeated measures factors.

Analysis of Effects

Effects	P(incl)	P(excl)	P(incl data)	P(excl data)	BF _{incl}
SOA	0.400	0.400	0.947	7.872×10^{-4}	1202.885
Groupe	0.400	0.400	0.938	0.010	97.445
SOA * Groupe	0.200	0.200	0.052	0.937	0.056

Note. Compares models that contain the effect to equivalent models stripped of the effect. Higher-order interactions are excluded. Analysis suggested by Sebastiaan Mathôt.



Results

- SQED

Model Comparison ▼

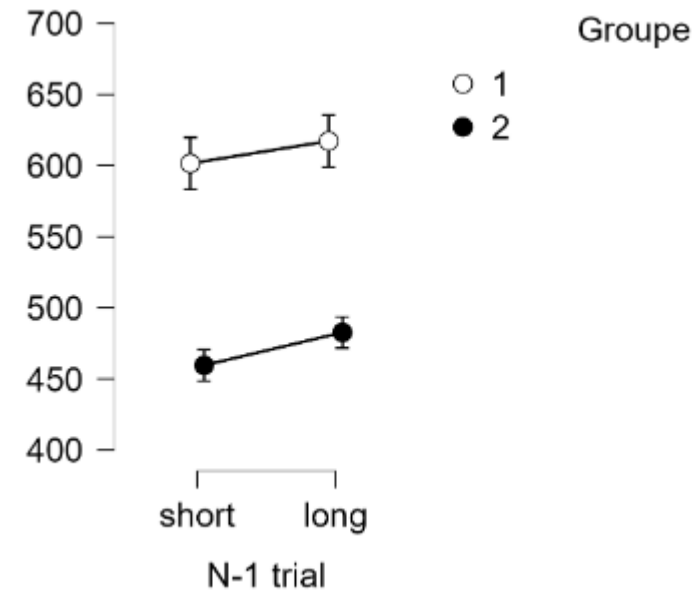
Models	P(M)	P(M data)	BF _M	BF ₁₀	error %
Null model (incl. subject and random slopes)	0.200	0.003	0.011	1.000	
N-1 trial + Groupe	0.200	0.624	6.646	222.803	2.837
Groupe	0.200	0.184	0.900	65.571	7.211
N-1 trial + Groupe + N-1 trial * Groupe	0.200	0.178	0.869	63.691	2.991
N-1 trial	0.200	0.011	0.043	3.831	0.939

Note. All models include subject, and random slopes for all repeated measures factors.

Analysis of Effects

Effects	P(incl)	P(excl)	P(incl data)	P(excl data)	BF _{incl}
N-1 trial	0.400	0.400	0.635	0.187	3.404
Groupe	0.400	0.400	0.808	0.014	59.689
N-1 trial * Groupe	0.200	0.200	0.178	0.624	0.286

Note. Compares models that contain the effect to equivalent models stripped of the effect. Higher-order interactions are excluded. Analysis suggested by Sebastiaan Mathôt.



• TOED

Model Comparison

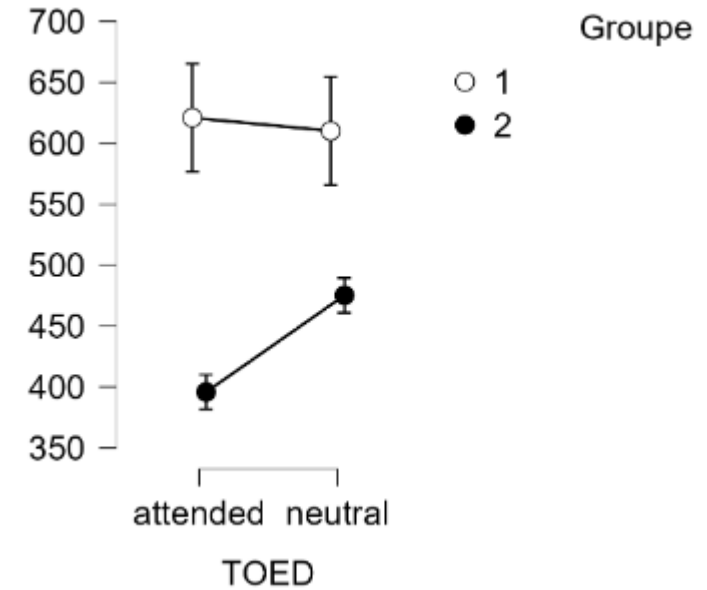
Models	P(M)	P(M data)	BF _M	BF ₁₀	error %
Null model (incl. subject and random slopes)	0.200	8.671×10^{-5}	3.469×10^{-4}	1.000	
TOED + Groupe + TOED * Groupe	0.200	0.812	17.237	9360.438	28.496
TOED + Groupe	0.200	0.099	0.438	1137.283	1.218
Groupe	0.200	0.090	0.393	1032.794	0.955
TOED	0.200	9.871×10^{-5}	3.949×10^{-4}	1.138	1.087

Note. All models include subject, and random slopes for all repeated measures factors.

Analysis of Effects ▼

Effects	P(incl)	P(excl)	P(incl data)	P(excl data)	BF _{incl}
TOED	0.400	0.400	0.099	0.090	1.101
Groupe	0.400	0.400	0.188	1.854×10^{-4}	1014.817
TOED * Groupe	0.200	0.200	0.812	0.099	8.231

Note. Compares models that contain the effect to equivalent models stripped of the effect. Higher-order interactions are excluded. Analysis suggested by Sebastiaan Mathôt.



Results

- TOEX VIS

Model Comparison

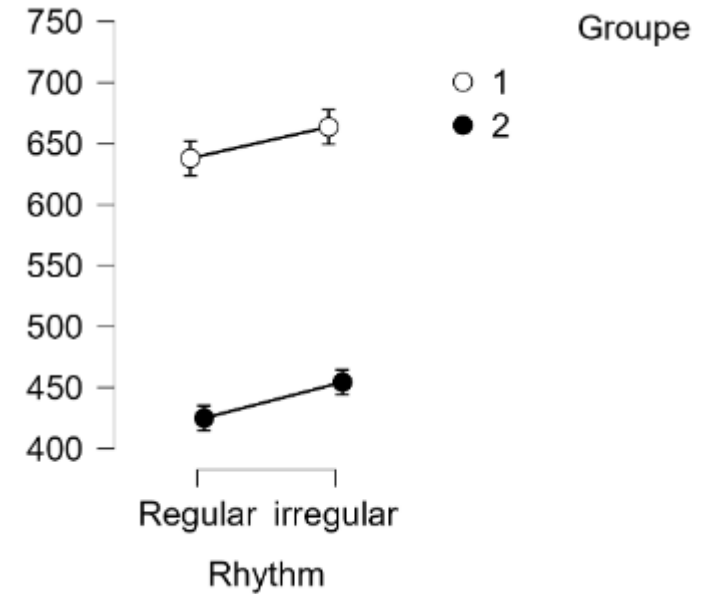
Models	P(M)	P(M data)	BF _M	BF ₁₀	error %
Null model (incl. subject and random slopes)	0.200	4.312×10^{-6}	1.725×10^{-5}	1.000	
Rhythm + Groupe	0.200	0.785	14.579	18192.827	2.159
Rhythm + Groupe + Rhythm * Groupe	0.200	0.211	1.070	48933.382	3.651
Rhythm	0.200	0.003	0.012	716.779	1.259
Groupe	0.200	0.001	0.005	281.881	1.157

Note. All models include subject, and random slopes for all repeated measures factors.

Analysis of Effects

Effects	P(incl)	P(excl)	P(incl data)	P(excl data)	BF _{incl}
Rhythm	0.400	0.400	0.788	0.001	645.888
Groupe	0.400	0.400	0.786	0.003	253.943
Rhythm * Groupe	0.200	0.200	0.211	0.785	0.269

Note. Compares models that contain the effect to equivalent models stripped of the effect. Higher-order interactions are excluded. Analysis suggested by Sebastiaan Mathôt



Result

- No cor

Bayesian Pearson Correlations

Variable		FPED_Pente_regression	d_SQED_short	d_TOED_short	d_TOEX_AUD	d_TOEX_VIS
1. FPED_Pente_regression	Pearson's r	—				
	BF ₁₀	—				
2. d_SQED_short	Pearson's r	0.446	—			
	BF ₁₀	4.157	—			
3. d_TOED_short	Pearson's r	0.359	0.054	—		
	BF ₁₀	1.315	0.239	—		
4. d_TOEX_AUD	Pearson's r	0.003	-0.053	-0.090	—	
	BF ₁₀	0.227	0.236	0.256	—	
5. d_TOEX_VIS	Pearson's r	0.315	0.068	-0.148	0.173	—
	BF ₁₀	0.892	0.241	0.306	0.338	—
6. score MOCA	Pearson's r	0.246	0.131	0.368	0.029	0.040
	BF ₁₀	0.515	0.285	1.447	0.229	0.232
7. Moca_adjusted_Z_score	Pearson's r	0.238	0.219	0.228	-0.096	0.083
	BF ₁₀	0.487	0.433	0.453	0.256	0.249
8. temps cloches	Pearson's r	-0.444	-0.513*	-0.246	-0.290	-0.199
	BF ₁₀	4.044	12.475	0.508	0.719	0.386
9. empan endroit	Pearson's r	0.151	0.113	0.227	0.273	-0.292
	BF ₁₀	0.307	0.269	0.450	0.628	0.729
10. empan envers	Pearson's r	4.651×10 ⁻⁴	0.271	0.143	-0.233	-0.279
	BF ₁₀	0.227	0.620	0.299	0.471	0.659
11. Mill Hill	Pearson's r	0.231	0.172	0.111	0.225	0.171
	BF ₁₀	0.465	0.336	0.270	0.448	0.335
12. cl.ches	Pearson's r	0.047	0.021	-0.055	0.027	-0.297
	BF ₁₀	0.234	0.228	0.240	0.229	0.762
13. Cloches_scores_RT	Pearson's r	0.170	0.101	0.161	0.061	-0.063
	BF ₁₀	0.334	0.260	0.322	0.238	0.239

* BF₁₀ > 10, ** BF₁₀ > 30, *** BF₁₀ > 100

Results

- Evidence in favor of an association between Age and the Endogeneous Temporal effects ($r=.49$; $BF_{10}=7.23$) but not the other temporal effects (all $r<.39$, $BF_{10}<1.99$)
- No correlation between any temporal effect and WM measures in old Adults (all $r<-.23$, $BF_{10}<0.73$)
- No correlation between any temporal effect and MoCA in old Adults (all $r<.37$, $BF_{10}<1.45$)
- Evidence in favor of an association between the RT for the Bell test (Selective attention) and the Foreperiod and the Sequential effects (resp., $r=.44$, $BF_{10}=4.04$; $r=.51$, $BF_{10}=12.48$).