

The fate of temporal expectations in noisy environments: Robust extraction of temporal regularities is limited to multisensory events



Felix Ball^{1,2,3}, Lara E. Michels¹, & Tömme Noesselt^{1,3}

¹Institute of Biological Psychology, Otto-von-Guericke University, Magdeburg, Germany
²University Clinic for Neurology, Otto-von-Guericke University, Magdeburg, Germany
³Center for Behavioral Brain Research, Magdeburg, Germany



Reprint: Felix.Ball@ovgu.de | Visit also www.Noesseltlab.org

Background

- natural environment is continuous stream of multisensory information
- information integration to generate reliable mental model of our world
- two optimization mechanisms to integrate incoming information
 → multisensory interplay (MSI) and temporal expectations (TE)
- However, how these mechanisms interact is currently unknown**

Performance (e.g. d-prime) is higher for multisensory targets and targets presented at expected moments in time:

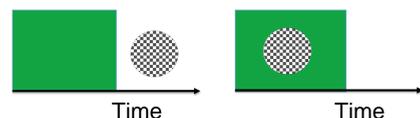
Multisensory Interplay (MSI)^{1,2,3,4}

Unisensory < Multisensory
Maximum



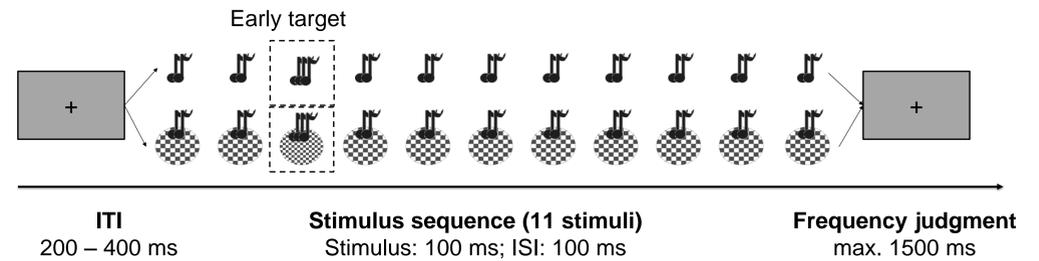
Temporal Expectations (TE)⁵

Unattended < Attended



Methods

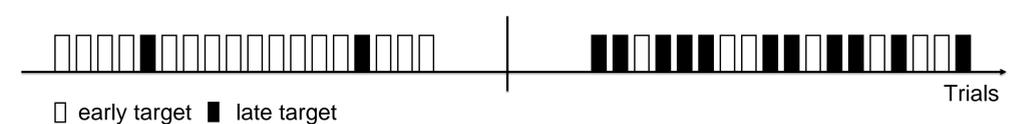
2 Examples for one trial: unisensory and multisensory sequence



Manipulation of TE through ratio of early to late targets within run

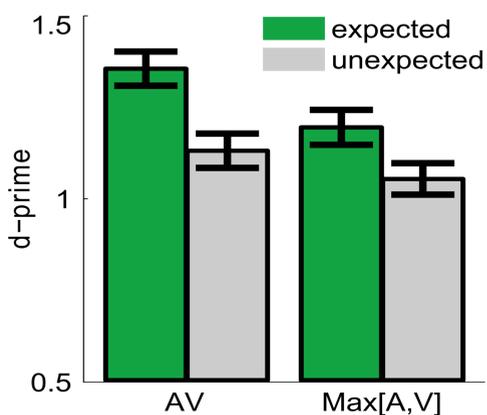
'Expected Early' Run (85 % Early)

'Expected Late' Run (42 % Early)



MSI x TE interaction

Results MSI & TE (n=120)

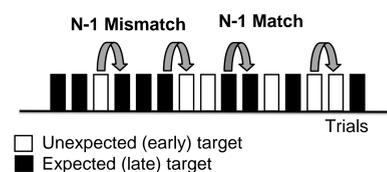


Multisensory performance enhancement interacts with performance enhancement by TE ($F(1,116) = 4.246, p = .042$).

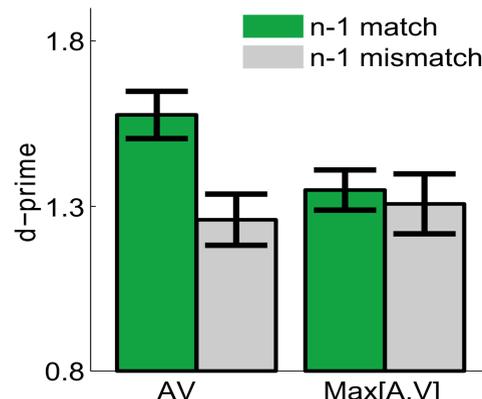
Trial-by-trial extraction of temporal information

Quantifying trial-by-trial performance

Match vs. mismatch between target expectations in current (N) and previous trial (N-1)



Results trial-by-trial TE (n=120)

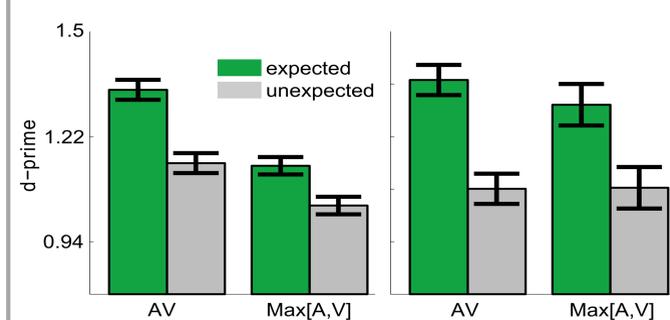


Benefit of multisensory interplay for extraction of temporal regularities is already present on a trial by trial level. Whenever successive trials match in their expectation level, performance increases for multisensory stimuli ($F(1,116) = 5.047, p = .027$).

Dependency on knowledge type?

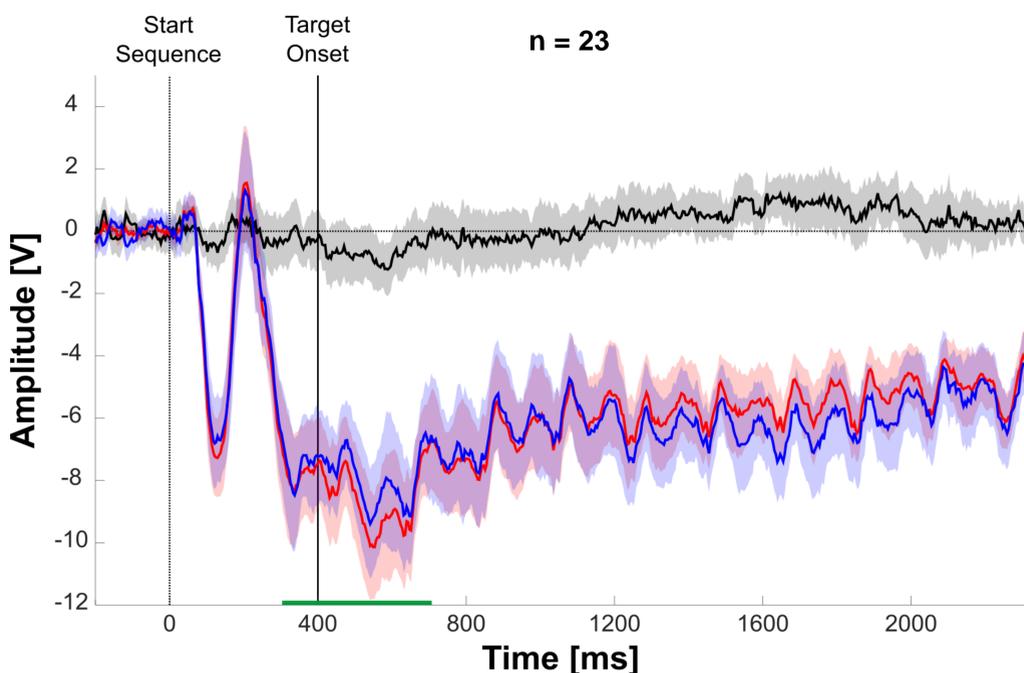
Implicit TE (n = 83)

Explicit TE (n = 37)

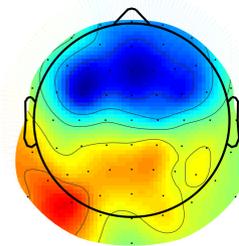


Interaction of TE and MSI does not depend on explicit knowledge of temporal regularities ($F(1,118) = .54, p = .816, BF = .216$).

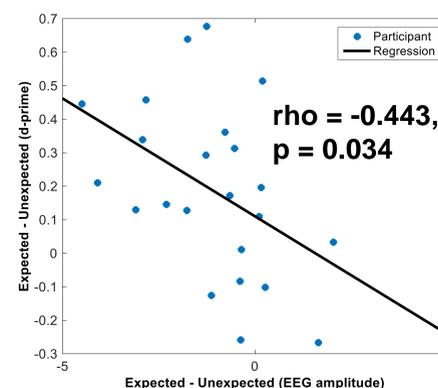
Multisensory (AV) neural correlates of temporal expectations



CI Difference
 CI Expected
 CI Unexpected
 Difference
 Expected
 Unexpected



ROI:
 Fz, F1/2,
 FCz, FC1/2



Frontal multisensory CNV peaks roughly around target presentation (expected > unexpected). CNV amplitude correlates with the behavioural TE benefit. CNV can be an index of implicit, automatic extraction of temporal regularities.

Summary & Conclusion

- TE effects enhanced for multisensory relative to unisensory stimulation
- MSI interacts with TE trial-by-trial
- Effects are independent of explicit temporal knowledge

Together, the pattern of results indicates that multisensory stimulation has a protective and enhancing effect on the generation and usage of temporal expectations, highlighting the need for multisensory paradigms in future studies investigating temporal expectations.

References

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