When more is more: Multisensory stimulation enhances performance improvement by temporal expectations

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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

Multisensory Interplay (MSI) vs Temporal Expectations (TE)

Unisensory Multisensory Temporal Attention Window

Unattended Attended

Performance (e.g., d-prime)

Unisensory < Multisensory Unattended < Attended

Methods

2 Examples for one trial: unisensory and multisensory sequence

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

Stimulus sequence (11 stimuli)

Temporal Expectations (TE)

Manipulation of difficulty/level of noise (4 experiments, N = 120)

Spatial uncertainty

Target uncertainty

A V AV AV(A) AV(V)

Low: Speaker High: Headphones

Low: mixed sequences High: only multisensory sequences

Quantifying MSI

- 2 task relevant modalities: A and V
- Take unisensory maximum (max. criterion)

Results MSI & TE

Max(uni) Multisensory

Temporal performance enhancement interacts with performance enhancement by temporal expectation (F(1,116) = 4.246, p = .042).

Quantifying trial-by-trial performance

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

N-1 Mismatch N-1 Match

Unexpected (early) target

Expected (late) target

Results trial-by-trial TE

N-1 match N-1 mismatch

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).

Prediction of MSI? (n = 120)

Multisensory enhancement (AV vs. Max[A,V])

Unisensory Preference

Max[A,V] - min[A,V]

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).

Summary and 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