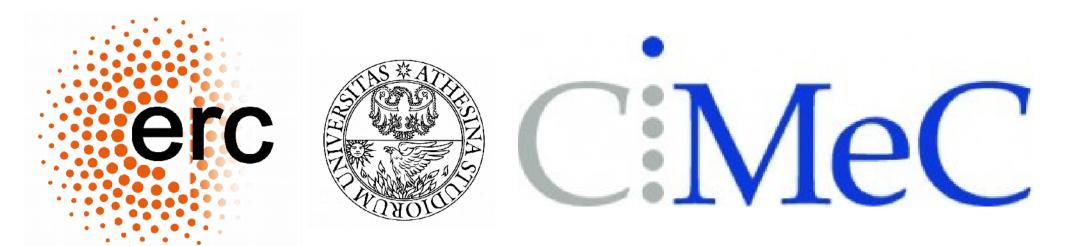# Temporal integration in rapidly presented natural scenes

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Animals Vehicles

Neutral

Introduction and Methods

The human visual system has the capability to extract information about scene context and contained objects at blazing speeds. It is an open question whether rapid categorization primarily involves **feed-forward** processes or whether **feedback** loops also contribute [1,2,3].
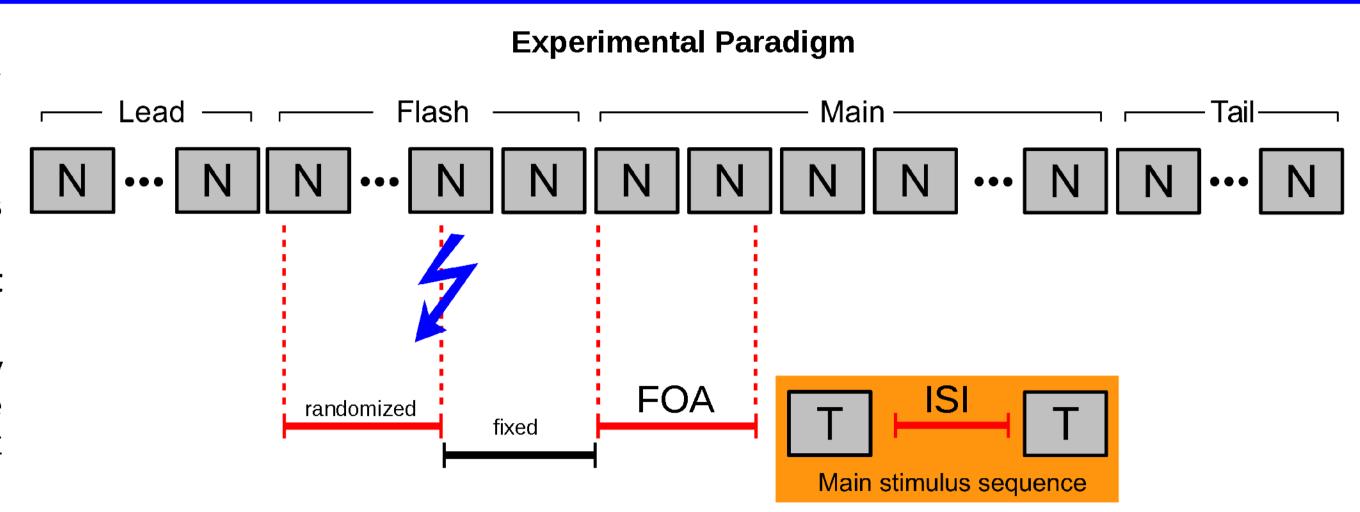We employed an **RSVP paradigm** to probe the temporal dynamics of visual object discrimination.

To test the temporal integration of information for rapid categorization, **three classes of images** were prepared for the experiment. The **"neutral"** class contained many types of natural scenes, but did not contain any objects from either of the two target object categories. The **target object categories** were natural scenes containing either **animals** or **vehicles**, but not both.

We presented a **rapid stream of "neutral" images** at a presentation rate of **50Hz**. Randomly embedded in this image sequence were either **one ore two presentations** of one image from one of the **target object** categories, adapted in contrast to each subject to achieve 57% object classification accuracy for single presentations.

The **ISI between presentations** was systematically varied from **0 to 600ms** to measure the temporal integration window.

Additionally, the background of the screen flashed at a random time (**FOA**), with the intention to induce a phase reset in the visual system.
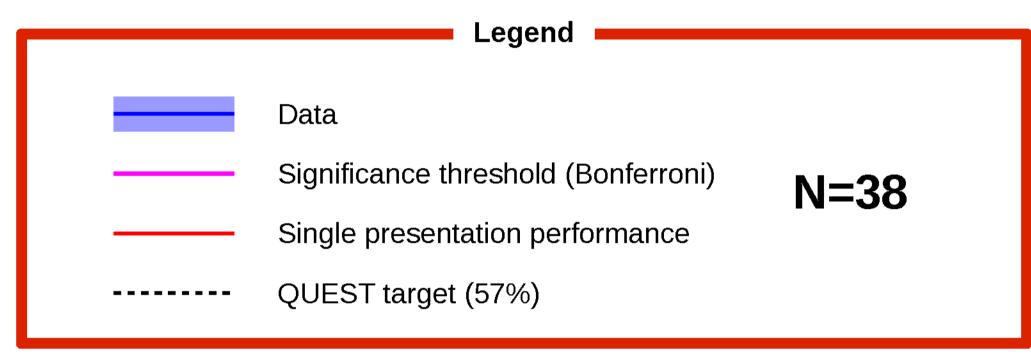
Experimental Paradigm

Lead — Flash — Main — Tail

randomized   fixed   FOA   ISI
Main stimulus sequence

Results

Flash-Induced Oscillatory Dynamics (FOA)

Trials were sorted by **distance from flash** (**FOA,** single-presentation trials only).
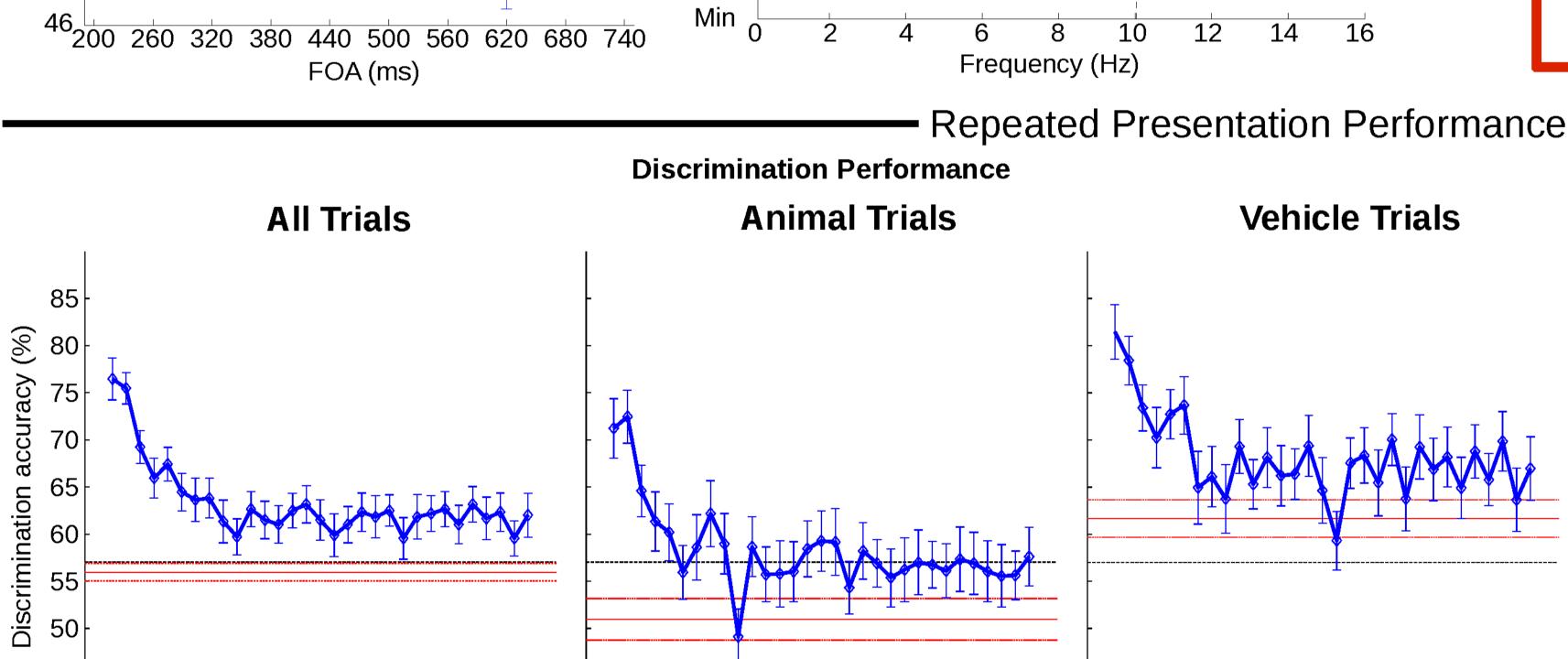**Fourier power spectra** were computed individually **per subject, then averaged.**
Random permutation analysis (N=100k) revealed a **significant oscillatory component** at **10Hz**.

Legend

Data	
Significance threshold (Bonferroni)	**N=38**
Single presentation performance	
QUEST target (57%)	

Repeated Presentation Performance (ISI)

Discrimination Performance

All Trials   **Animal Trials**   **Vehicle Trials**

Trials were sorted by **distance between stimulus presentations** (**ISI**).

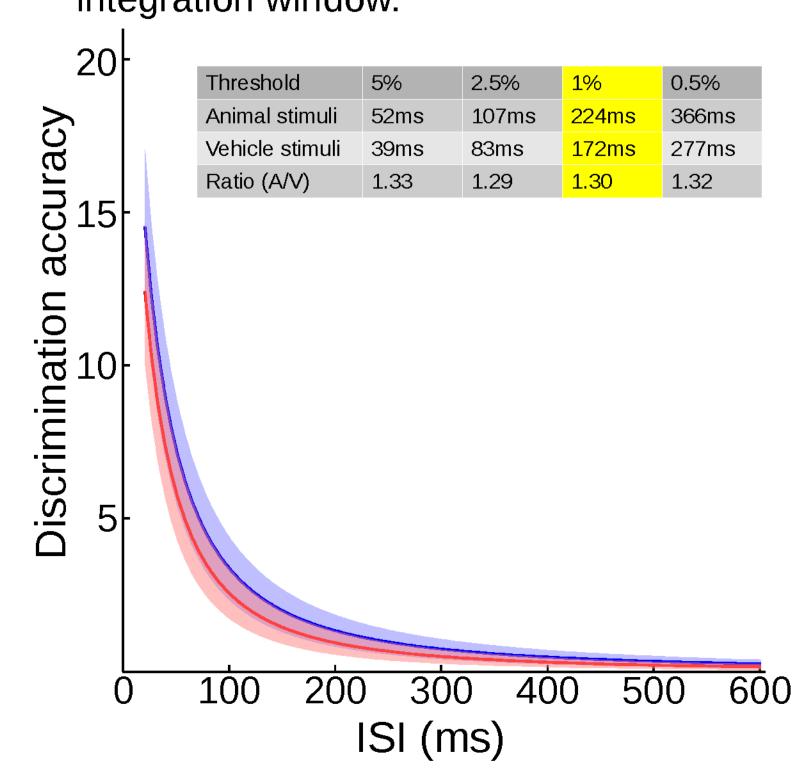**Double-presentation trials** showed a **clear performance improvement** over single presentation trials.

The **performance of animal** trials is **significantly less** than the **performance of vehicle** trials, suggesting a **bias**.
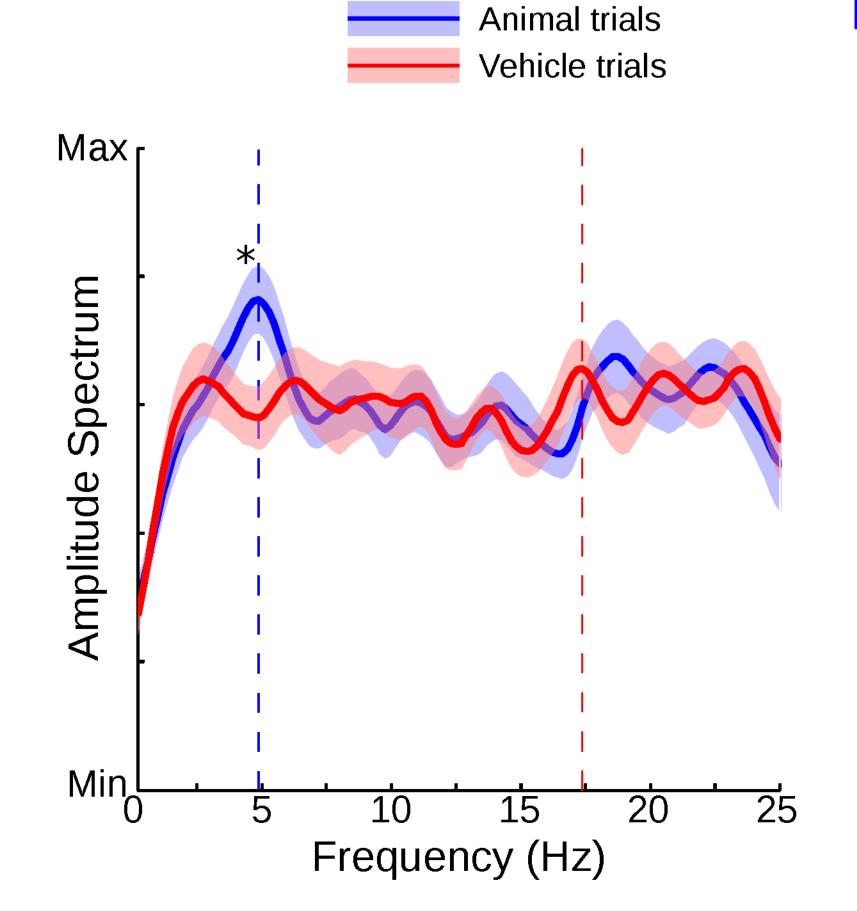
Sample Subjects

S1   S2

Temporal window of integration

Data was first **centered over [400..600ms]**. Groups of subjects were then **randomly sampled** from all (N=1000), and an exponential **decay function** was then fitted to the average of each re-sampled group. Analysis reveals a **significant difference** between animal and vehicle trials, with a **30% slower decay with the animal stimuli,** suggesting that information about animals is combined over a longer temporal integration window.

Threshold	5%	2.5%	1%	0.5%
Animal stimuli	52ms	107ms	224ms	366ms
Vehicle stimuli	39ms	83ms	172ms	277ms
Ratio (A/V)	1.33	1.29	1.30	1.32

Recurrent processing

Fourier power spectra were computed per subject, then averaged, for pooled and separated target stimulus classes. Permutation analysis (N=100k) revealed a **significant oscillatory component**, only with the animal stimuli, at approx. **5Hz** (4.88).

Animal trials
Vehicle trials

Conclusions

Classification **accuracy** was significantly **higher** in the **double-presentation** condition.

Sorting trials by **FOA**, an **oscillatory pattern** emerged at **10Hz**.

Sorting trials by **ISI**, an **oscillatory pattern** emerged at **5Hz**, only with the animal stimuli. Estimating the principal temporal integration window revealed **30% longer integration** for animal stimuli.

Our findings indicate the presence of **recurrent processes** in visual perception. Oscillatory activity and estimated temporal integration windows suggest **differential processing** for animal and vehicle stimuli. These findings are consistent with suggestions that **animals are special** stimuli for the visual system.

1 Koivisto et al., "Recurrent Processing in V1/V2 Contributes to Categorization of Natural Scenes." J Neurosci 2011
2 Thorpe et al., "Speed of Processing in the Human Visual System." Nature 1996
3 Serre et al., "A Feedforward Architecture Accounts for Rapid Categorization." PNAS 2007