The temporal profile of visual encoding in the recognition of familiar objects

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Introduction

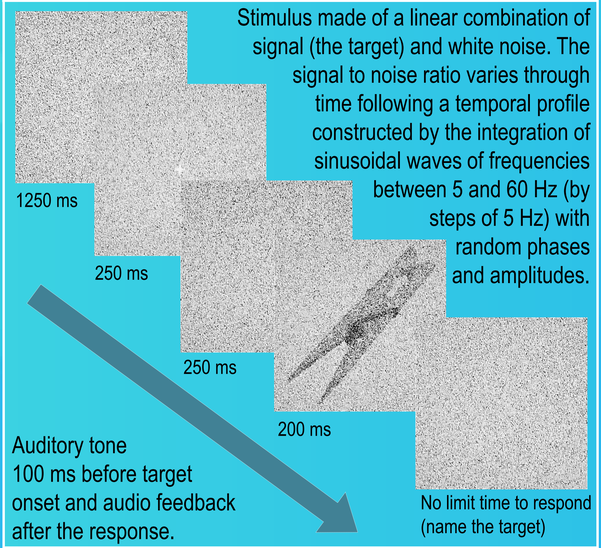
Several studies have shown temporal variations in visual processing capacity in humans. Using the method of temporal sampling, studies carried out in our laboratory on the recognition of faces (Blais, Arguin & Gosselin, 2013), words (Achouline et al., 2019; Arguin, 2018; Fortier-St-Pierre & Arguin, 2019) and unfamiliar objects (Arguin & Massé, 2019) suggest that, within the initial 200 ms of target display, encoding effectiveness varies substantially following a pattern that is unique according to stimulus class. Moreover, the results show patterns in the progression of temporal frequencies through time of the signal-to-noise ratio of the stimulus that are particularly favorable to efficient target processing and which also vary according to stimulus class.

The present study aims to determine the temporal features of processing effectiveness in a familiar object identification task.

Methods

Participants	12 young adults (7 women) aged from 19 to 35 years old
Stimuli	330 familiar object images from the ‘‘Bank of Standardized Stimuli’’ (Brodeur and al., 2012) 
Material	Screen ASUSVG248QR with a 120 Hz refresh rate Program written in MatLab with ‘‘Psychophysics Toolbox’’ extensions (Kleiner and al., 2007)
Procedure	2 sessions of 1h10 each / 1 practice bloc (30 trials) + 4 experimental blocs (1200 trials)

Experimental task



Stimulus made of a linear combination of signal (the target) and white noise. The signal to noise ratio varies through time following a temporal profile constructed by the integration of sinusoidal waves of frequencies between 5 and 60 Hz (by steps of 5 Hz) with random phases and amplitudes.

Data analysis

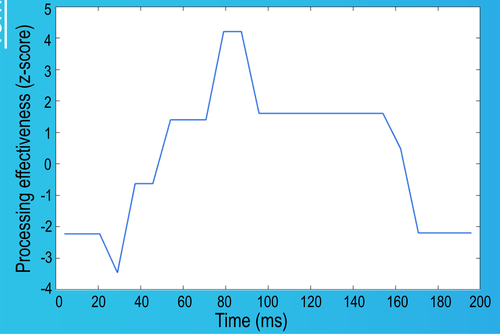
For each participant, a classification image was constructed by subtracting the weighted sum of temporal sampling profiles (or of the outcome of their time-frequency analysis or of the phase x amplitude values from which they were made) associated with errors from that associated with correct responses. These were z-scored prior to averaging. Mean classification images were then smoothed and the Pixel test (Chauvin et al., 2005) was used to determine the statistical significance of z-score differences. All distinct consecutive values in the classification images illustrated below are significantly different from one another ($p < .05$).

Results

Phase-Amplitude domain: The classification image obtained from data analysis was perfectly uniform, thus indicating that no Phase x Amplitude feature impacted performance.

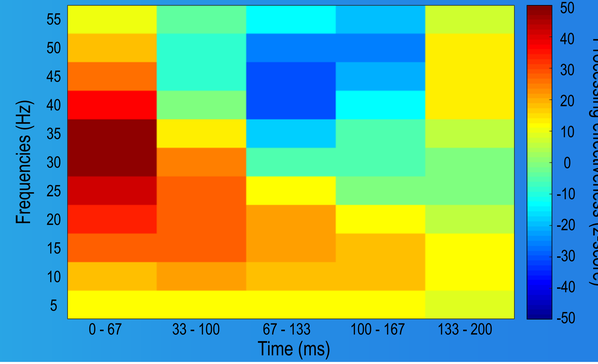
Temporal domain

Processing effectiveness is lowest at target onset, then rises to a peak at 79-88 ms to then gradually decline to about its initial level until 200 ms. There is a large between subject variability (mean of inter-subject correlations = 0.0087).



Time-frequency domain

The highest effectiveness peak is in the 0-67 ms time window for 25-35 Hz stimulus oscillations. This peak then declines trough time and shifts towards lower frequencies. The lowest effectiveness is in the 35-55 Hz range between 67 and 167 ms, while some of these frequencies (40-50 Hz) show a high effectiveness at 133-200 ms. Mean of inter-subject correlations = 0.9274.



Discussion

The present results indicate rapid variations of visual encoding effectiveness in the initial 200 ms of stimulus exposure and suggest that the time-frequency classification images tap a highly fundamental aspect of visual processing given its remarkable stability trough participants. The uniform Phase x Amplitude classification image suggests that this code is inappropriate to capture how visual processing effectiveness unfolds through time. The temporal patterns demonstrated may originate from the particular set of cerebral oscillators that underly task performance.

References

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