

Orientation priming during continuous flash suppression

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Overview

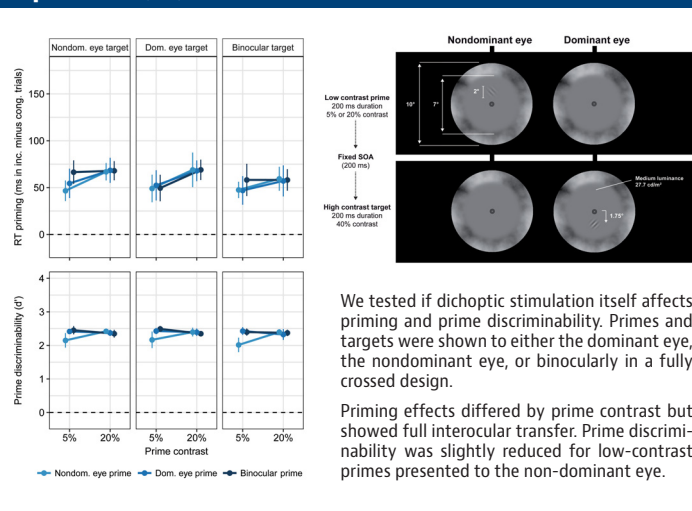
Continuous flash suppression (CFS) is a powerful method to suppress awareness of visual stimuli [1]. Some studies suggested that CFS allows priming despite complete unawareness of primes [2, 3]. However, the robustness and reliability of priming during CFS is disputed [4, 5].

The present project aims to establish a benchmark for priming during CFS using tested and easily tweakable stimuli, a large number of trials per condition, and high sensitivity in measuring direct and indirect effects of primes [6].

Primes and targets were Gabor patches, oriented 45° to the left or 45° to the right of the vertical meridian. Participants gave rapid manual responses to the orientation (left, right) of the target. In separate sessions, the same participants discriminated the prime's orientation. Prime discriminability was impeded by contrast reduction respectively CFS.

Responses to targets were considerably faster and less error-prone in trials where prime and target had a congruent rather than an incongruent orientation (i.e., priming/indirect effect) when primes were presented without CFS (Experiments 1 and 2). However, these priming effects were strongly reduced (Experiment 3) or even completely abolished (Experiment 4) during CFS, which can not only be explained by the reduced visibility of the primes.

Experiment 2 (N=16)



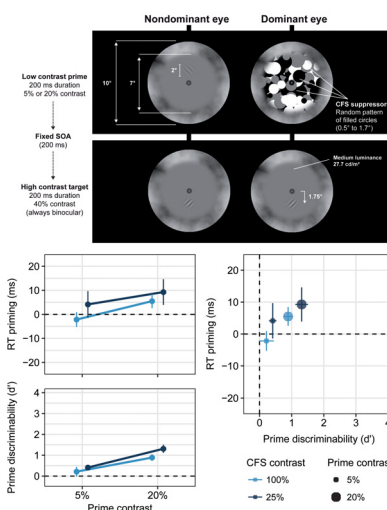
Experiment 3 (N=16)

We tested if priming persists when primes are shown to the nondominant eye while CFS suppressors are shown to the dominant eye (at a 10Hz rate).

To allow all participants a certain degree of prime discriminability, the CFS suppressors were shown at a reduced contrast in half of all trials.

As intended, prime discriminability was strongly lowered thanks to CFS. The suppression strength varied as a function of both prime contrast, and CFS suppressor contrast.

Compared to the non-CFS experiments, priming effects were drastically reduced under CFS. With low prime contrast and high CFS contrast, discriminability was at chance level. On average, priming effects in this strongest suppression condition were not different from zero.



Summary and conclusions

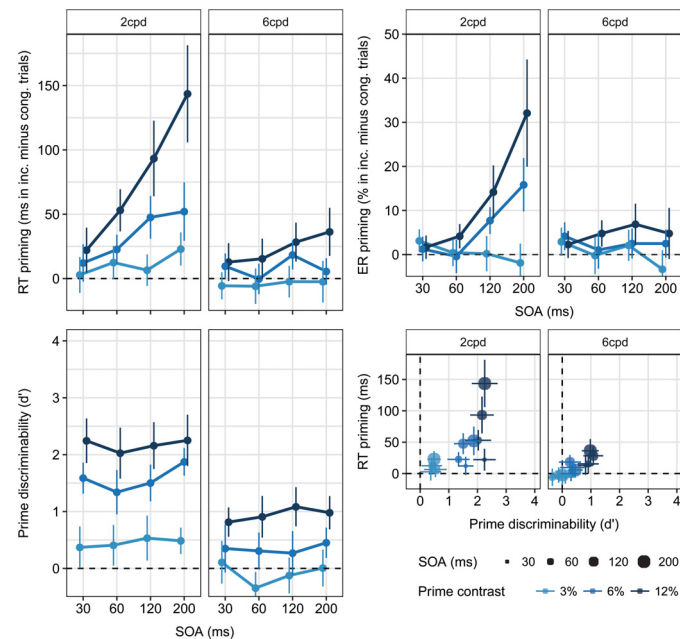
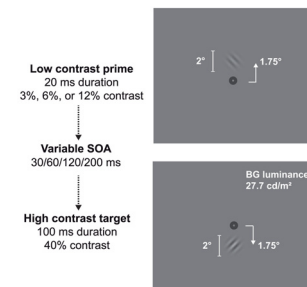
Our findings suggest that CFS is not only effective in reducing the visibility of a stimulus but also strongly impairs the stimulus' potential to prime a behavioral response to a subsequent target. In this regard, CFS behaves profoundly differently compared other techniques for rendering stimuli invisible such as metacontrast and backward masking [4, 7], where priming is reduced during masking but usually does not trend towards zero.

The bottom-up stimulus strength of a prime is key to perception and priming during CFS. If relative prime strength is too low, neural signals elicited by the prime at early stages of processing might drown in the visual noise generated by the mask. Consequently, the neural representation of the prime might not propagate to higher processing levels where it could pre-activate a response [6, 7]. This interpretation is in line with recent neuroimaging evidence showing that CFS reduces hemodynamic activity [8] and decodability of stimulus category [9] in early visual areas and beyond. Using our standardized stimuli, we are currently searching for stimulus configurations which would spare the prime's signal such that priming is restored.

Experiment 1 (N=12)

We tested different versions of the prime and target gratings under binocular conditions. We manipulated the spatial frequency (SF) of the prime and the target (2cpd vs. 6cpd), the stimulus onset asynchrony (SOA), and the prime's contrast level.

For studying priming under dichoptic conditions (and during CFS), the most potent condition was a relatively low spatial frequency grating (2cpd) and an SOA of 200 ms.

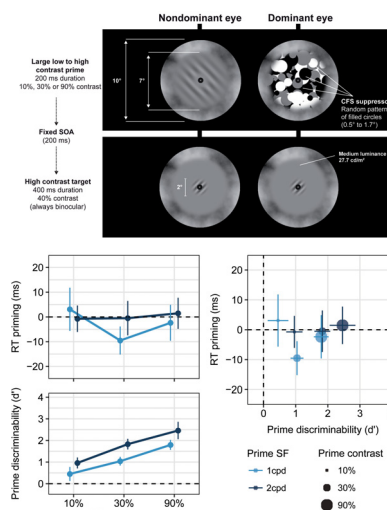


Experiment 4 (N=16)

We tested if priming during CFS could occur automatically, provided a sufficient stimulus strength of the prime. Primes now covered the larger peripheral area of the annuli. Targets were presented at fixation.

To test if possible priming effects would generalize across SF, the primes had a lower SF (1cpd) than the targets in half of the trials and had the same SF as the target (2cpd) in the other half of trials.

Although participants were able to discriminate primes (even at the lowest contrast level), the primes' high signal strength was insufficient to warrant priming during CFS. Instead, a strong visual resemblance of prime and target and the co-occupation of the same relevant locations seem likely premises for eliciting even some traces of priming during CFS.



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TeaP 60th Conference of Experimental Psychologists
Discussed at TeaP 2018, March 11-14, Marburg, Germany

Design details

Experiment 1. Participants came in for three sessions (sessions 1+2: target report, session 3: prime discrimination). Each session consisted of 960 trials. Error and outlier trials were excluded from the RT analysis (12.3% of all trials).

Experiment 2. Participants completed 864 target discrimination trials and 288 prime discrimination trials in one session. Error and outlier trials were excluded from the RT analysis (7% of all trials).

Experiment 3. Participants came in for two sessions (sessions 1: target report, session 2: prime discrimination). Each session consisted of 960 trials. Error and outlier trials were excluded from the RT analysis (7.9% of all trials).

Experiment 4. Participants came in for two sessions (sessions 1: target report, session 2: prime discrimination). Each session consisted of 968 trials. Error and outlier trials were excluded from the RT analysis (6.8% of all trials).

References

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