Effects of object-based predictions and predictions robustness on subjective visual perception

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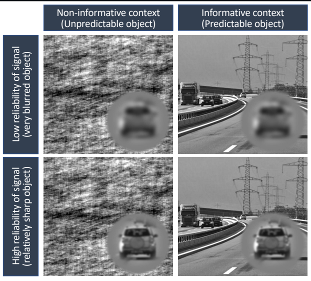
CONTEXT

- Visual perception is not only determined by the intrinsic characteristic of **sensory inputs** but also by the **predictions** we have about them[1].
- Previous studies on scene perception have for example shown that **context-based predictions** influence object categorization speed[2] and accuracy[3] but also their **subjective appearance, in particular when visual inputs are noisy**[4].
- For example, our previous studies showed that **blurred objects than can be predicted based on their contextual information are perceived as sharper than the exact same blurred object that cannot** (i.e., embedded in a meaningless, non-informative context)[4].
- This effect was shown to be **modulated by the quality (i.e., reliability) of visual signals** and was stronger as visual inputs were noisy (i.e., blurred)[1,4,5].
- However, current predictive processing theories suggest that **the influence of predictions on visual perception may also depend on the robustness of predictions**[1].
- Additionally, there is **neuroimaging evidence suggesting that object-based predictions can reciprocally influence the processing of scene context**[6].



Is the influence of context-based predictions on subjective perception of objects also modulated by the robustness of predictions? → Experiment 1

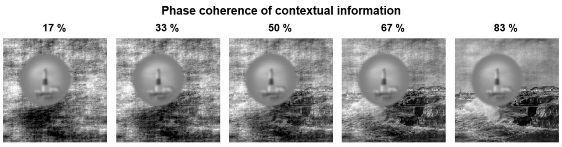
Can object-based predictions sharpen the visual perception of scene contextual information? → Experiment 2

METHOD: PERCEPTUAL BLUR MATCHING TASK

Experiment 1

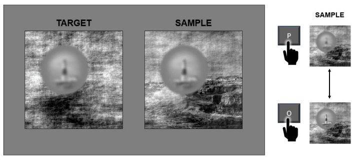
Participants: N = 65 (19.86 ± 2.87 years, 54 F)

Stimuli: 20 real-world scenes (10 indoors/10 outdoors scenes), containing a main object, resized to 350 x 350 pixels and converted to 256-level gray-scale images. For each scene, the main object was blurred with 31 blur levels. We created five versions of each scene in which the contextual information around the object was phase-scrambled with different phase-coherence levels : 17% - 33% - 50% - 67 % - 83%.



Procedure:

- 2 images (Target and Sample) appear simultaneously on the screen.
- **Different blur level** for each object → **Participant had to adjust the blur level of the Sample object to match it with the Target one.**



- For each trial, the **Target-Sample pair always contained one object embedded in a context with the lowest phase coherence** (i.e., a phase coherence of 17%) while the other was embedded in a context with a higher phase-coherence (i.e., a phase coherence of 33%, 50%, 67% or 83) → **Manipulation of the predictability of the Sample object**
- **Target-Sample pairs also varied in terms of difference in phase coherences between the Target and Sample contexts** → **Manipulation of predictions robustness**

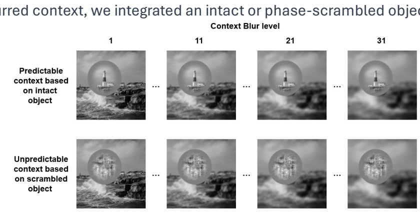
Measure:

Matched Blur level (MBL) = Blur level attributed to the Sample object when matched to the Target one

Experiment 2

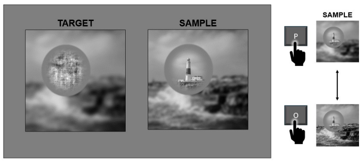
Participants: N = 30 (21.35 ± 3.61 years, 16 F)

Stimuli: 20 real-world scenes (10 indoors/10 outdoors scenes), containing a main object, resized to 350 x 350 pixels and converted to 256-level gray-scale images. For each scene, contextual information was blurred with 31 blur levels. On each blurred context, we integrated an intact or phase-scrambled object.



Procedure:

- 2 images (Target and Sample) appear simultaneously on the screen.
- **Different blur level** for each context → **Participant had to adjust the blur level of the Sample context to match it with the Target one.**



- For each trial, object in the **Target-Sample pair could be either different** (one intact, the other scrambled) **or identical** (both intact or both scrambled → **Control condition**)
- **Target contextual information could be either very blurred** (blur level greater than 16) **or less blurred** (blur level below 16) → **Manipulation of the reliability of the signal**

Measure:

Matched Blur level (MBL) = Blur level attributed to the Sample context when matched to the Target one

HYPOTHESES

Experiment 1

Context-based predictions should sharpen the subjective perception of blurred objects[4].

→ When the Target and Sample **objects within a pair are objectively equally blurred,** participants **should subjectively perceive the more predictable object as sharper than the less predictable object.** Hence, they should compensate this perceived difference by attributing a higher blur level to the more predictable object than the less predictable one.

→ **The difference in perceived sharpness between more and less predictable objects should increase as the robustness of predictions for the more predictable object increases.**

Experiment 2

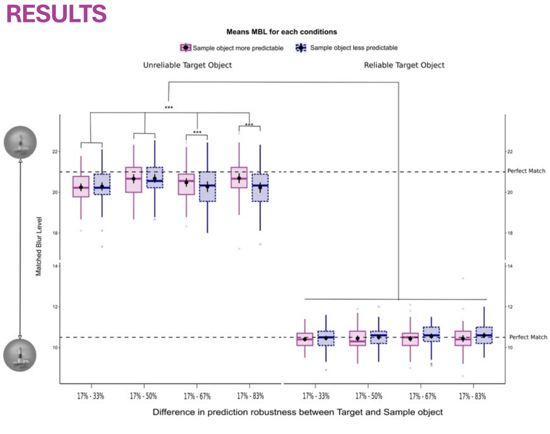
Based on Experiment 1, in the Different Target/Sample Pair condition:

→ At an objectively equal blur level, **scene contexts that can be predicted based on object information** (containing an intact object) **should be subjectively perceived as sharper than contexts that cannot** (containing a scrambled object). Participants should compensate this perceived difference between contexts by attributing a higher blur level to the Sample context when it contains an intact object than when it contains a scrambled object.

→ **This difference in perceived sharpness should be more pronounced when the Target context is unreliable (very blurred).**

RESULTS

Experiment 1

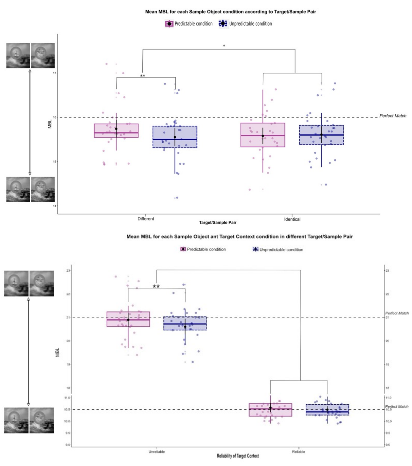


Our main analysis revealed no significant influence of contextual information on the perceived sharpness of objects.

→ **Our post-hoc analyses taking into account the reliability of the Target object** (more or less blurred than the Sample one) **did reveal a significatively higher MBL attributed to the Sample object when it can be robustly predicted based on contextual information than when it cannot,** and this **effect increased with the relative robustness of predictions.**

→ When the visual signal of the Target object is unreliable, **robustly-predicted objects were subjectively perceived as sharper than objectively similar objects benefiting from weaker predictions.**

Experiment 2



→ **Interaction between Target/Sample Pair type and Predictability of Context :** The MBL attributed to the context of the Sample is significatively higher when the object present in the context is intact (predictable) than when the object is scrambled (unpredictable).

→ Therefore, in Different Target/Sample pair condition, **at an objectively equal level of blur, participants perceive the context containing an intact object as sharper than a context containing a scrambled object.**

→ **This effect is significatively more pronounced when the Target Context is unreliable** (i.e., blurrier than the Sample context)

→ This perceptual **sharpening effect of predictions increases as the signal reliability decreases.**

CONCLUSION

The influence of predictions on visual perception is weighted by the robustness of predictions, as suggested by the predictive processing framework[1]. **Furthermore, predictions tend to weigh more as visual signals become unreliable** while they have little to no influence when visual signals are clear and reliable.

Object-based predictions can also sharpen the perception of scene contextual information, especially when the signal reliability is low. Our findings are in line with recent neuroimaging findings[6], **demonstrating the reciprocal influence between context and object-based expectations in shaping the visual perception of scenes.**

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