Object substitution masking reveals a competitive dynamic between levels of categorization

Jason K. Chow & Michael L. Mack

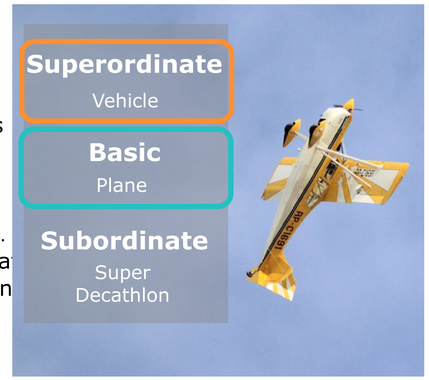
UNIVERSITY OF TORONTO

MACK LAB

Motivation

Categorization of visual objects requires significant time with different types of categorizations at different speeds.

Basic level categorizations were accepted as faster (Rosch et al., 1976). However, research has shown that superordinate categorizations can be faster in ultra-rapid exposure times (Thorpe, Fize, & Marlot, 1996).

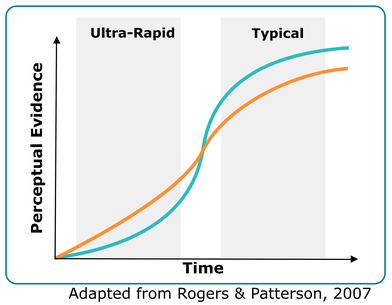


How do these levels of categorization interact in real time?

We use object substitution masking (OSM) to selectively measure levels of categorization. Behavioural and modelling data suggests a competitive dynamic in the time course of categorization.

Hypothesis

Early superordinate category advantages can be attributed to rapidly available global information (Mack & Palmeri, 2015).
Later basic category advantages can be attributed to the similarity structure of representations (Rogers & Patterson, 2007).



Adapted from Rogers & Patterson, 2007

The different temporal profiles may also be affected by a competitive dynamic between levels of categorization. Due to the time course of perceptual encoding, OSM may disrupt categorization selectively. We aim to selectively disrupt basic- and superordinate-level categorization to find possible interactions.

Superordinate- and basic-level information directly compete in categorization. If performance in one level of categorization is reduced, an increase in performance should be found in the other level.

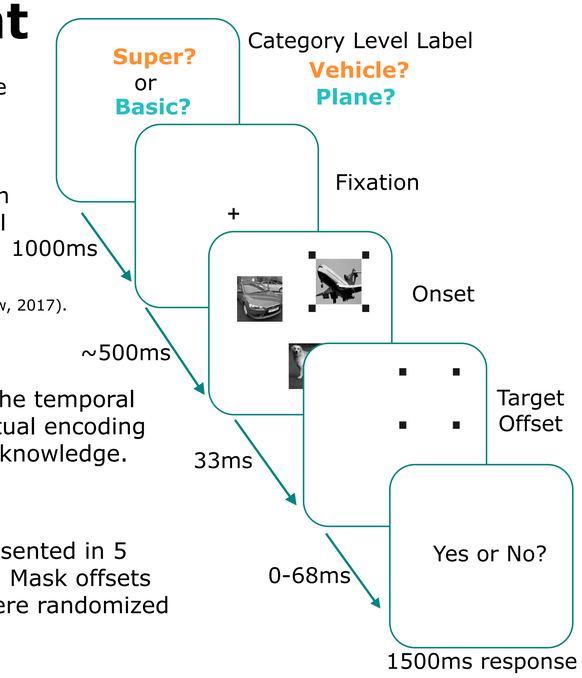
Experiment

OSM uses a trailing sparse mask to disrupt visual processing.

The trailing mask is known to selectively impair visual processing while still allowing some semantic processing to occur (Goodhew, 2017).

We used OSM to target the temporal dynamics of how perceptual encoding interfaces with category knowledge.

Category levels were presented in 5 blocks of 100 trials each. Mask offsets (0, 17, 33, 50, 68ms) were randomized between trials.

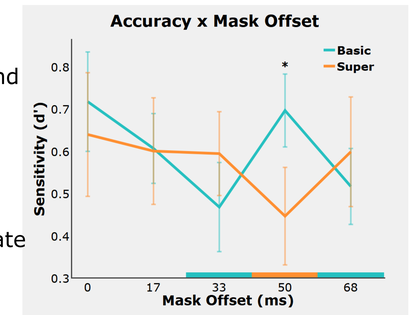


Results

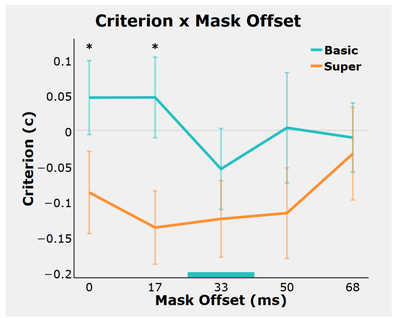
Interaction effect between mask offset and level of categorization found in d'.

Both levels of categorization are affected differentially by masking over time.

A tradeoff between basic and superordinate categorization suggests a competitive dynamic.



Error bars represent ± SEM. * indicates significance difference at p < 0.05. Coloured bars indicate significant difference from 0ms mask offset.



Error bars represent ± SEM. * indicates significance difference at p < 0.05. Coloured bars indicate significant difference from 0ms mask offset.

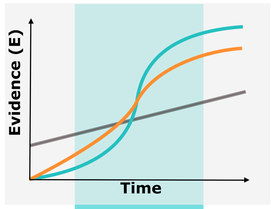
Main effect of level of categorization on response bias.

Superordinate level categorization is largely unaffected by masking and is biased towards confirming the category.

Longer mask offsets cause basic level categorization to show similar biases to superordinate categorization.

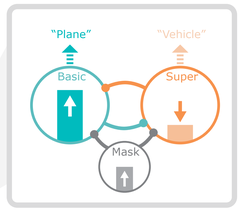
Modelling

Perceptual Encoding



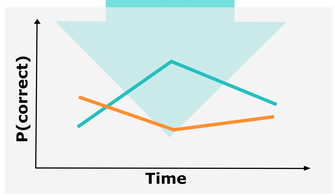
Competitive Dynamic

$$P_{basic}(t) = \frac{E_{basic}(t)}{E_{basic}(t) + E_{super}(t) + E_{mask}(t) + \epsilon_N}$$



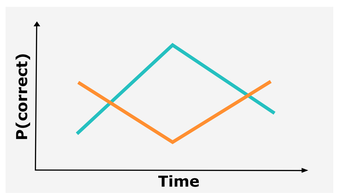
Implementing a perceptual encoding framework with the addition of mask encoding allows for a proof of concept model that reflects a competitive dynamic between levels of categorization.

Model



vs

Observed Data



Conclusions

- **OSM can selectively impair perception of category diagnostic information.**
- **Basic and superordinate categorization show a competitive dynamic which may account for previously found temporal dynamics between levels.**
- **Next steps include extending the model to drift diffusion framework to formalize mechanisms underlying the interactions between category levels.**

References

Rosch, E., Mervis, C. B., Gray, W. D., Johnson, D. M., & Boyes-Braem, P. (1976). Basic objects in natural categories. Cognitive psychology, 8(3), 382-439.
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