Reuniting Categories, Language, and Perception

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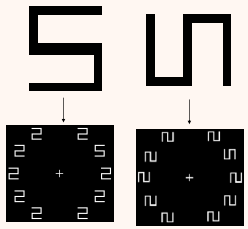
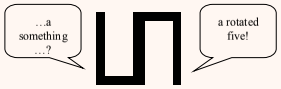


Typical search slopes are about twice as steep for the unfamiliar symbols compared to familiar numbers (e.g., Wang, Cavanagh, Green, 1994)—an effect that has been attributed to differences in perceptual familiarity.

BUT confounded with perceptual familiarity is meaningfulness.

If perceptual processing depends on meaningfulness, then placing an otherwise unfamiliar item into a meaningful category, should lead to more efficient visual processing.

What is this?



Experiment 1 uses the paradigm of visual search to study how what we know affects what we see.

The classic separation between "pure" low-level perceptual and higher-level conceptual processing has been challenged by mounting evidence for a much more interactive view (for review see Goldstone & Barsalou, 1998). Evidence from single-cell recordings have further implicated the influences of top-down, possibly conceptually-driven feedback connections (e.g., Lamme & Roelfsema, 2000). The remarkable speed at which object categorization occurs (Fabre-Thorpe, Delorme, Marlot, & Thorpe, 2001) further suggests that basic perceptual processes such as attentional selection and grouping may reflect category knowledge (Lupyan, 2007).

To what degree is visual processing shaped by conceptual knowledge?

Experiments 2a-2b

On seeing the symbol "5" we not only recognize it as a member of a familiar category (that can be perceptually instantiated using a wide variety of forms, e.g., V, **5**), but we also know its name. Because a learned category label becomes strongly associated with features that are most diagnostic (or typical) of the named category, ***using* the label can in effect make an object a "better" object by augmenting its idiosyncratic perceptual features with features typical to the named category** (Lupyan, 2007, under review). A labeled stimulus might therefore produce a perceptual representation that is more influenced by top-down conceptual information than a stimulus that is not named.

Experiments 2a-2b investigate whether hearing a category label (e.g., "find the *two*") alters visual processing when the label adds no additional information (i.e., people already know they're searching for a 2). A further aim is to investigate interactions between item typicality and the effect of labels.

Acknowledgments

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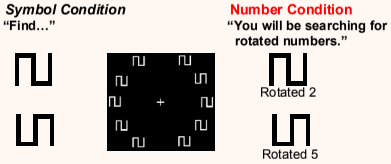
A PDF copy of this poster is available at www.cnbc.cmu.edu/~glupyan/lupyan-CogSci2007.pdf

Experiment 1

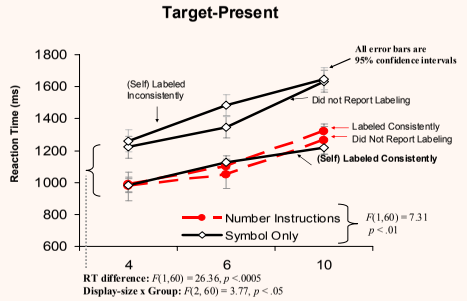
Question: What is the role of meaningfulness in visual processing?

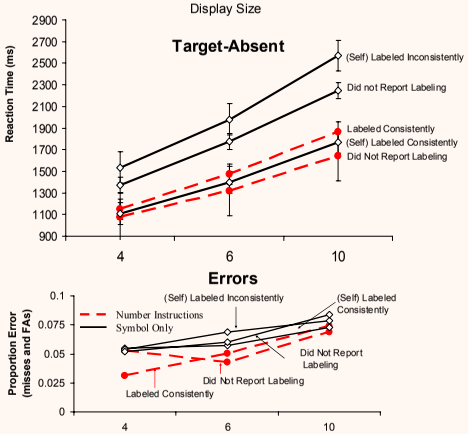
Participants: 61 Carnegie Mellon Undergraduates were run in a standard visual search task, divided between a *symbol* and a *number* condition.

Two identical conditions, except for instructions:



Procedure:
The rotated 2 and 5 characters were white on a black background and had a visual-angle size of .7° x .8°. The characters were arranged along the circumference of an imaginary circle having a diameter of 7° around a fixation cross (.5° diameter). Following the search, participants filled out a questionnaire primarily used to assess whether participants in the *symbol* group self-labeled the stimuli. For the *symbol* group, the responses fell into three categories. First, participants who consistently self-labeled the stimuli, either as rotated 2s/5s, or thought of them as other (often creative) symbols/symbol combinations (N=14). Second, participants who labeled the stimuli inconsistently (i.e., only part of the time) (N=11). Third, participants who did not report labeling the stimuli (N=16). Participants in the *number* condition fell into two categories: those who reported consistently labeling the stimuli as rotated 2s and 5s, as instructed (N=15), and those who although instructed to do so, did not report labeling the stimuli (N=5).





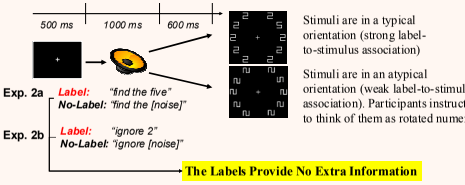
The mean proportion of misses was 8% and did not differ among conditions, $F(1,60)<1$. The false alarm rate was greater in the *symbol* condition ($M = .05$) than the *number* condition ($M = .01$), $F(1,60) = 4.74$, $p < .05$.

Experiments 2a-2b

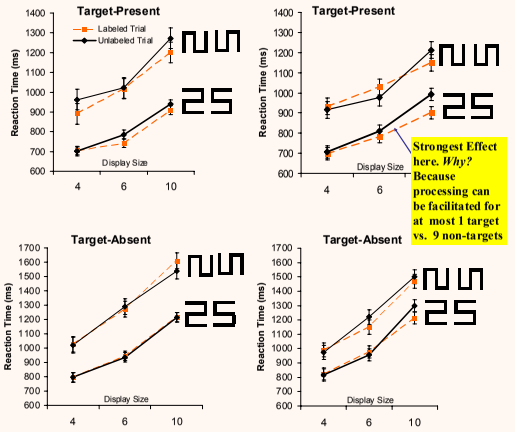
Question: Does hearing a a verbal label for the target (Exp 2a) or non-targets (Exp 2b) further speed visual processing?

Participants: 48 Carnegie Mellon undergraduates participated for course credit (24 in Exp. 2a and 24 in Exp. 2b).

Procedure: Participants completed 2 blocks of 240 trials – searching for a 2 among 5s and searching for a 5 among 2s (counterbalanced). On half the trials, participants heard "find the two [five]" (Exp. 2a), "ignore five [two]" (Exp 2b)—the *label* condition. On half, they heard "find the.." or "ignore.." followed by white noise—the *no-label* condition. Both auditory cues were of equal length and amplitude. Because participants knew ahead of time the identity of the target and non-targets on each trial, the labels communicated no additional information.



Target Labeled - "find the…" Non-Targets Labeled - ignore…"



Search on **rotated trials** was performed more slowly than on upright trials, $F(1, 23) = 64.43$, $p < .0005$, but **not less efficiently**, $(2, 23) = 2.14$, $p > .12$. For Experiment 2b, this interaction was also nonexistent, $F(1, 23) < 1$ (cf. Wang, Cavanagh, Green, 1994).

Labels had an overall effect of speeding search RTs, $F(1, 24) = 5.15$, $p < .05$, but this **effect was limited to the upright trials**, $F(1, 23) = 5.59$, $p < .05$. Labels did not reliably affect performance on rotated trials, $F(1, 23) = 2.49$, $p > .13$.

Search slopes were reduced for labeled trials as revealed by a highly significant labeling × display-size interaction, $F(2, 23) = 5.76$, $p < .01$. There was also a significant orientation × labeling interaction, $F(1, 23) = 6.52$, $p < .025$: **the effect of labels was mediated by orientation**:

For the upright trials, labeling the non-targets resulted in both **faster overall search**, $F(1, 23) = 8.1$, $p < .01$, **and shallower slopes**, $F(2, 23) = 3.27$, $p < .05$. On rotated trials, labels did not reduce overall search RTs $F(1, 23) < 1$, but again produced shallower slopes, $F(2, 23) = 4.07$, $p < .025$

Findings

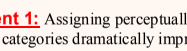
Experiment 1: Assigning perceptually novel stimuli into meaningful categories dramatically improved visual processing (as measured by a visual search task).

Experiments 2a-2b: Hearing uninformative verbal labels produced shorter RTs and shallower slopes during search, particularly speeding up responses to more typical category exemplars. Naming non-targets facilitated search even more than naming targets, suggesting that rather than simply drawing attention to the named category, labels facilitate grouping together multiple items from the named category.

Insofar as labels become associated with category-typical visual features, actually hearing the label may facilitate responses of object-selective regions of cortex which in turn can guide attention to the members of the named category, possibly in parallel and throughout the visual scene (Lupyan, 2007). Facilitation depends on stimulus typicality because labels have stronger associations with more typical exemplars.

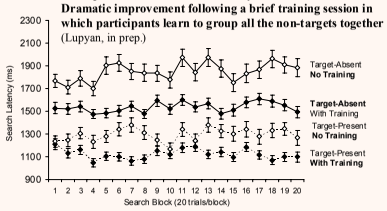
Further Examples of Interaction Between Categories, Labels, and Visual Processing

Target Non-Targets

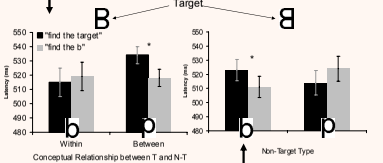


Comparison of visual search task only (400 trials ≈ 40 minutes) and search following a training session (180 trials ≈ 5 minutes).

No improvement on visual search by itself. Dramatic improvement following a brief training session in which participants learn to group all the non-targets together (Lupyan, in prep.)



Labels improve between-category, but not within-category search



Facilitation occurs only for typical items (as in Exps 2a-2b). The automatic nature of the effect is evident here – hearing the non-targets (b's) labeled, even in an inappropriate sentence frame ("*find* the b") facilitates search (Lupyan, 2007).

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Wang, Q. Q., Cavanagh, P., & Green, M. (1994). Familiarity and Pop-Out in Visual-Search. *Perception & Psychophysics, 56*, 495-500.