VISUAL SEGMENTATION OF SPATIALLY OVERLAPPING SUBSETS

Igor S. Utochkin1,2
National Research University Higher School of Economics, Russia
isutochkin@inbox.ru

What is subset segmentation for?
It allows to rapidly judge the global properties of relevant multiple objects without paying attention to irrelevant ones...
... even when relevant and irrelevant objects are intermixed! (e.g., Chong & Treisman, 2005, Vis.Res., 45:891-900; Halberda, Sires, & Feigenson, 2006, Psychol.Sci., 17:572-576)

However, global features of no more than two such subsets can be well extracted at one time (Halberda et al., 2006, Psychol.Sci., 17:572-576; Poltoratski & Xu, 2013, J.Vis., 13(8):6).

A PROBLEM: What happens beyond this boundary? Do we perceive just "visual stuff" or maybe something more?

An approach: The Subset enumeration task
Why such a task?
✓ It draws attention from estimating within-subset features to segmentation as it is, which is a somewhat primary ability;
✓ It forces the observer to internally report all subsets (instead of partial report), that makes it appropriate for probing the phenomenology and the time course of segmentation

What do we know about "standard" enumeration of objects?
Both small and large numbers of objects are differentiated but in different ways!
All enumeration modes require different types of attentional involvement (Chong & Evans, 2011, WIREs Cog.Sci., 2:634-638)

General Methods
Sets of dots of one to six colors

Three Set sizes

Exp. 1, 2, 3
Exp. 4

Exp. 1, 2, 4

Time course of a trial

Exp. 1, 2, 4

Exp. 3

6
12
36

Exp. 2

500 ms
50 ms
100 ms

Until response (up to 7000 ms)

Exp. 1: Enumeration of subsets at a glance

A preliminary estimate of subset subitizing capacity is two (consistent with Halberda et al., 2006, and Poltoratski & Xu, 2013)
✓ Large sets are enumerated better than small ones (see Exp. 2)
✓ Terminal subset numbers are enumerated better than intermediate ones (see Exp. 4)

Exp. 2: Large sets advantage: Exhaustive and redundant subset formation vs. Foveal sampling
(MANIPULATION: Sets of all sizes were grouped densely around the fovea)
✓ Subitizing capacity was confirmed to be no more than two
✓ Large sets advantage maintained despite foveation. So, it appears that it is provided by parallel, exhaustive and redundant subset processing

Exp. 3: Enumeration beyond subitizing capacity: Counting vs. Estimation
(MANIPULATION: Unlimited stimulus presentation time)
✓ The absolute error increased monotonously with the number of subsets
✓ The reaction time changed as in previous experiments
✓ Consequently, the terminal pattern can be explained by the combination of the "ceiling effect" and the "all-colors" memory template

Exp. 4: Terminal numbers advantage: Enumeration "ceiling effect" vs. "All colors" memory template
(MANIPULATION: The color alphabet was increased by one color)
✓ No more than two overlapping subsets can be subitized, that is, represented effortlessly and momentarily
✓ Beyond that capacity limit, subsets also can be segmented but serial attentional selection is required
✓ Subset segmentation beyond the subitizing capacity limit is the subject of top-down regulation, such as attentional strategies (towards both subsets and individuals) and memory templates

Matching Exps. 1-3:
The subitizing range was insensitive to the presentation time but subsets beyond this range were. This can be ascribed to strategic modulation of selection
Large set advantage reversed within the 4-6-subset range. It suggest that focused attention to individuals can be used for subset segmentation as well

CONCLUSION