Patterns of Gaze Fixation during Search for a Symbol on AAC Displays

Krista M. Wilkinson, Ph.D., Professor, The Pennsylvania State University & Adjunct Associate Scientist, Shriver Center;
William J. McIlvane, Ph.D., Director, Shriver Center of the University of Massachusetts Medical School
Tara O'Neill, Master's student, The Pennsylvania State University;
Kara Weasen, Master's student, Emerson College

• Why study visual processes in AAC?

Vision is both the input and output channel for many users of aided AAC. The effectiveness of aided displays depends in part on the efficiency with which the visual information can be processed by the user. Mismatches between the structure of visual displays and the ways in which users process information may lead to unintended barriers to effective use of these supports. Understanding visual processing is as critical to the success of aided communication interventions as understanding of auditory processing is to aural-oral language interventions.

Previous Research:

Color cues enhance the speed and accuracy of search

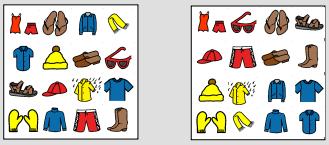
Wilkinson et al., 2008 studied the role of symbol-internal color cues in the speed and accuracy of search for a target, in nondisabled preschool children as well as older school-aged individuals with Down Syndrome. They found that when more than one symbol in an array share internal color, accuracy and speed of search for targets are facilitated if the like-colored symbols are clustered together, rather than distributed across the array:

Clustering was superior to distributing, by color

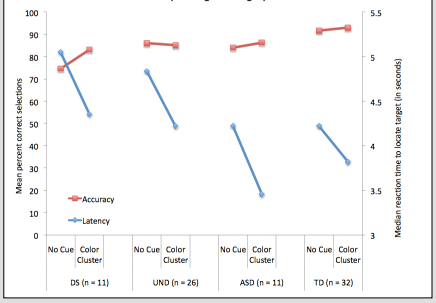
Question 1:

Do these results maintain, for different stimuli and across clinical groups?

We have examined this same effect (clustering or distributing symbols by symbol internal color) across participants in three groups of individuals with intellectual disabilities as well as nondisabled participants. Clothing stimuli were selected because we could control the internal color of the symbols, while ensuring that the color was not tied to the identity of the concept (ie, while tomatoes are oftentimes red, swimsuits and baseball caps can be any color at all). Would we still see the effect of clustering like-colored symbols together with these clothing symbols?



Average accuracy (red lines; higher = better) and latency (blue lines; lower = better) for finding like-colored targets under spatially distributed versus clustered presentation, by etiological category



Note: DS = participants with Down syndrome; UND = participants with ID of unknown origin; ASD = participants with autism spectrum disorders; TD = matches without intellectual disability; numbers in parentheses represent the number of participants within each group

Although accuracy was less affected, we saw superior reaction times in all participant groups. Individuals with autism spectrum disorder showed superiority in response time relative to the other clinical groups, a finding consistent with prior observations of response times in these populations (see, e.g., Joseph et al., 2009 for a review). However, even with the overall advantage in response time, the participants with autism still showed facilitation by the color grouping.

Question 2:

What is the reason for the facilitation by color grouping?

The research in visual cognitive science suggests that the use of color cuing works by "guiding" an individual's search. In the case of our arrays, a viewer searching for a red item would not have to search through all 16 possible choices. Instead, if color is guiding the search, the viewer would only have to search through the four red possibilities.

By this logic, the color cue operates to result in rapid search by narrowing the field of possibilities considered. However, in both the clustered and the distributed array, there are the same number of like-colored symbols (four). If the guidance was simply by the number of like-colored symbols, there should be no difference between clustered and distributed presentations.

So why are we seeing facilitation of the speed of response, above and beyond the sheer number of like-colored symbols?

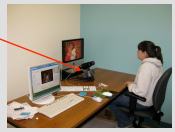
Ho #1: Perhaps viewers *spend longer* examining the symbols under distributed presentation. In this case, search would be equally exhaustive, but the amount of time spent looking at individual symbols would be longer in this condition

Ho #2: Perhaps under distributed presentation, the viewers do a *less efficient search*, that is, they look at more of the non-shared-color symbols and fewer of the like-colored symbols.

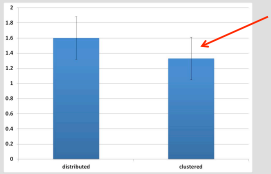
To differentiate these possibilities, participants' point-of-gaze was recorded through eye-tracking apparatus while they engaged in the visual search task. This exploratory study was conducted with typically developing individuals as a first step toward extending the work to individuals with disabilities.

Participants:
- n = 8
- Between 7 and 9 years of age
- Developing typically
- Performing at grade level in school placement
- 4 girls, 4 boys

Infrared camera; Part of ISCAN eyetracking system



Latency to find the correct target: Behavioral and eye-tracking measures



As expected, speed to respond behaviorally (choose the target symbol via mouse click) was faster when the like-colored symbols were grouped together.

This effect was statistically significant (t(7)= 3.56, p= .006).

Eye-tracking data for latency to first fixation on the correct symbol demonstrated a similar facilitation in the clustered condition. Participants took significantly less time to fixate on the target symbol in the clustered condition compared to the distributed condition, F(1, 7)= 31.4, p=0.001, effect size= .818.

Symbol Classification and Typical Scan-paths for Point of Eye Gaze

Symbols were classified in three types: correct, like-color, and non-shared color. The grids below illustrate these symbol types.

distributed

clustered

The target (correct) symbol for both conditions above was the blue jacket. There were three other blue symbols (like-colored symbols), and 12 symbols that did not share symbol internal color (non-shared) symbols within each display. In the distributed condition, the participant first fixated on the yellow hat, then the yellow raincoat, the blue t-shirt, the blue dress shirt, and finally the target blue jacket.

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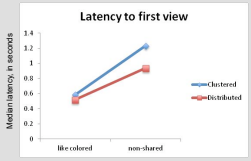
Three measures of fixation to the distracter symbols (like-colored and non-shared) were examined: latency to first view, mean fixation duration, and mean proportion of stimuli viewed.

Latency to first view

How long did it take the eyes to fixate on the like-colored and non-shared symbols in the clustered versus distributed conditions?

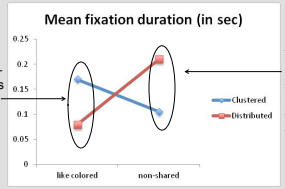


Conclusion: Fixations were significantly more rapid to like-colored symbols than to non-shared symbols under both conditions, $F(1, 7)= 77$, $p < .001$, effect size=.95. This suggests that, indeed, color is guiding search to the like-colored distracters.

Mean fixation duration: Test of Ho #1

Does the amount of time spent scrutinizing symbols vary by color condition?

Time spent scrutinizing like-colored symbols is longer in the clustered condition.



Time spent scrutinizing non-shared symbols is longer in the distributed condition.

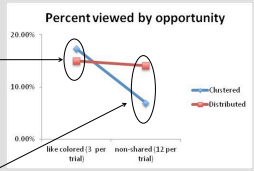
• In the clustered condition, fixations are longer to like-colored symbols and shorter to non-shared distracters, whereas in the distributed condition, fixations are longer to non-shared symbols than to like-colored symbols; this difference was significant, $F(1, 7)= 19.09$, $p= .003$, effect size= 0.85.

Conclusion: Participants are more distracted by the non-shared symbols in the distributed condition than in the clustered condition, as evidenced by longer fixations to these symbols. Hypothesis #1 was supported.

Proportion of stimuli viewed: Test of Ho #2

Is the increase in both response time and fixation to target in the distributed condition due to the fact that participants do a less efficient, more exhaustive search?

Participants looked at a similar proportion of like-colored symbols in both conditions.



Participants were more likely to look at non-shared symbols in the distributed condition than in the clustered condition. This difference was statistically significant , $F(1, 7)= 10.3$, $p= .015$, effect size = .77.

Conclusion: Participants fixate on non-relevant distracters more often in the distributed condition. Hypothesis #2 was supported.

Discussion

Facilitation of the behavioral response to a correct target under color clustering conditions corresponded to a similar facilitation of the fixation to that target as measured through eye gaze.

It would appear that the facilitation of the fixation and speed of response to the target in the clustered condition results from increased efficiency of search, in which the eye is guided to like-colored symbols and away from symbols that do not share color with the target symbol (Ho #2). Furthermore, less time is spent looking at non-relevant distracters in the clustered condition (Ho #1).

These data suggest that search can be guided not only through color cuing, but also by the spatial arrangement of like-colored symbols.