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Analysis of the Experimental Setup in "Does Isolating a Visual Element Call Attention to It?: Results of an Eye-tracking Investigation on the Effects of Isolation on Emphasis"

In their study, Williams et al. question whether isolation, when used apart from any other visual dominance factors (e.g. color, size, position, etc.), is a significant factor in emphasizing a visual element. To answer this question, the experimenters utilize eye tracking software to study eye fixation data from human test subjects. Williams et al. constructed a within-subjects experiment with seventeen university undergraduate students as participants. The single-level independent variable was the exposure of all the participants to three "target" slides. The dependant variable, attention[1], is measured by three metrics which are defined by the authors: number of fixations in the target look zone, amount of time spent fixated in the target look zone, and the time until a fixation in the target look zone occurred (24).

Overall, the experimenters do an excellent job of isolating the independent variable, preventing possible confounds, and explaining their results in a cautious way, so as not to overemphasize the implications of their findings; however, the experimenters fail to discuss their rationale for why they test only one level of the independent variable and how they arrive at a reliable baseline, or control, to compare their measurements of the dependant variable against. In this review, I will show how the experimenters accounted for error variance and confounding variables, examine the single-level independent variable (including target slide design), and

[1] It is worth noting that the authors justify the link between eye fixations and attention on page 22 by citing past research which validates this connection.

propose an alternate 2x1 within-subjects experimental design that fits the data collected by the experimenters.

Williams et al. take several measures to control for error variance and eliminate confounds in their study. All of the participants were shown three different "target" slides, with visual elements arranged so that one element was isolated from the rest. In order to prevent other types of visual dominance factors (color, size, etc.) from becoming a confounding variable, the slides were composed of colorless geometric shapes of equal size. Between target slides, distracter slides were used to prevent participants from "induc[ing] a pattern in the stimulus materials" (24). Additionally, a "black field" slide was shown in between each of the slides to prevent the influence of "the [subjects'] final fixation position in one slide" form "influenc[ing] the [subjects'] initial fixation position in the subsequent slide" (24). Three target slides and five distracter slides were shown in a different, random order to each participant; each participant viewed every slide.

Before critiquing the experimental setup, we must examine how Williams et al. constructed the target slides. All of the slides were divided into six "look zones," two rows of three quadrants (page 23, see figure 4). Each of the three target slides had one isolated element in a different location: "upper left-hand corner" (zone 1), "upper right-hand corner" (zone 3), or "lower right-hand corner" (zone 4, as in the example target slide in figures 3 and 4 of the article) (23). Initially, it seems reasonable to question the number of target slides (why only three in an eight slide set, especially when four corners would seem to suggest the use of four target slides?) and placement of the isolated elements (why those particular zones?). Despite their careful attention to detail when eliminating sources or error, the authors do not address these questions in their study. I will return to the issue of the placement of the isolated elements on the target

slides later, but first let us examine the measurements taken in order to better understand the independent variable.

The only measurements reported in the results section of the experiment are subjects' fixations on the target slides[2], meaning these measurements will be compared to a baseline or control. The experiment was designed as a single group within-subjects study, with all subjects being shown the slide set only once; as such, there is only one level of the independent variable in this experiment: exposure to the slide set. The only data that Williams et al. present as the dependant variable are the combined *mean* fixation results of *all* the target slides; the use of mean numbers rules out the possibility of the location of the isolated element being an independent variable, and the use of data from target slides only rules out fixation data from the distracter slides being factored into the reported results. If only the mean data from a one-level independent variable are gathered, what then is the value held constant that the experimenters will compare the measurements of the dependant variable against?

The control value for this experiment is an ideal "symmetry" of fixations model that the experimenters determine through under-explained reasoning. The experimenters use a one-sample *t* test to determine whether the results are statistically significant. Since the participants are only exposed to one level of the independent variable (i.e. the experiment is not set up where participants first view "control" slides, then view "experimental" slides and the results of the two exposures are compared), a control must be modeled from existing data on the subject of eye fixation.

Returning to the subject of the construction of the target slides, the researchers indicate in their introduction that eye tracking was a relatively new way of examining issues related to

[2] Some of the results reported are derived (proportions), but they are directly based off of fixation data from the target slides.

visual dominance factors; therefore, it is reasonable to infer that there are few prior experimental models on which to base their own. The authors chose Brandt's 1945 *The Psychology of Seeing*, a prior eye tracking study, to provide guidance in normalizing their results. The authors interpret Brandt's findings as follows: "a person's first fixation on a target slide tends naturally to occur just above and to the left of the geometric center of the visual field" (24). Williams et al. interpret the natural fixation area in their target slides to be zone 2 (24). Their interpretation of Brandt's study, combined with the fact that the experimenters notice in their results a "tendency to fixate [on zone 2] more often and for greater periods of time, regardless of the presence or absence or location of a dominant element" leads the researchers to omit fixation data from zone 2 in the reporting of their results. A survey of Brandt, however, shows that his fixation slides are organized differently from the target slides in Williams et al. (Brandt's slides have 25 equal quadrants as opposed to six look zones), and Brandt's conclusions on the natural tendencies of eye fixations determined that the upper left *quadrant of the entire slide* was most fixated on (Brandt 35). This is problematic, as the experimenters' slides are divided into sixths, and they chose to wholly omit zone 2 (top center), but not omit data from zone 1 (top left). Likewise, when describing where they place the isolated visual elements on the target slides, the authors do not explain how they account for Brandt's conclusion that fixations on left-hand quadrants were far more likely than right-hand quadrants, and upper half fixations were far more likely than lower half fixations (Brandt 27-38). While these factors potentially impacted the experimenters' decision on where to place isolated visual elements on the target slides and how to exclude data that is the result of, as Brandt terms it "basic eye movement laws and tendencies," the experimenters do not reveal, to my satisfaction, the exact linkages between Brandt's research and their decisions (Brandt 27). If their entire rationale for placement of isolated elements on target slides and exclusion of data in the control model is based on this one study, their decision to

place visual elements only in zones 1, 3, and 4 is left open to scrutiny. This is especially true of the zone 1 element, which is in, the area identified as most fixated on by Brandt, the upper left quadrant.

When determining the control model, essentially a slide devoid of visual dominance elements, Williams et al. conclude "by symmetry considerations alone" that one would "expect one-fifth of the fixations and one fifth of the time spent fixated to be spent in each [of the remaining five] look [zones]" (24). A serious question is raised as to the researchers meaning of "symmetry considerations." What, if any, evidence suggests that subjects will have an equal number or equal duration of fixations on every look zone in a slide where no visual dominance elements are present? The data they present from Brandt's *The Psychology of Seeing* seems to suggest that there is an inherent tendency for subjects to have unequal fixation on different areas of a slide, regardless of what content it contains, and the data Brandt supplies for unequal fixation is not limited to one particular quadrant that can be discarded[3]. I fail to see a natural justification that would suggest that the tendency to fixate on a particular area is a matter that can be determined by simple probability, and the authors offer no explanation as to how natural fixation patterns outside of zone 2 could potentially influence the outcome of the experiment.

For an experiment to prove causation, one variable must be held constant while another variable is manipulated. What is really at stake is the baseline fixation patters of the subject viewing a slide devoid of visual dominance elements as opposed to their fixation patterns when presented with an isolated visual element. In order to demonstrate that an isolated visual element *causes* a disproportionate fixation pattern, one must establish a baseline fixation pattern that is

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[3] Brandt supplies the "relative time spent [fixated] in each of the four quarters" of a slide filled with meaningless geometric shapes (similar to the distracter slide in the Williams et al. experiment), as 41% upper left, 25% lower left, 20% upper right, and 14% lower right.

more robust than the model the experimenters invoked to justify discarding zone 2 fixation results. An individual comparison of the results of fixation on hypothetical "control" slides versus slides with an isolated visual element would seem to provide such a comparison, yet the authors do not provide an explanation as to why there was no control level of their independent variable.

In my estimation, a within-subjects experiment such as the one the hypothetical setup I described (where subjects view "control" slides and "experimental" slides and the results are compared) would be more appropriate to answering the research question posed: does isolation of a visual element cause a proportional increase in the attention a subject pays to it? Since the visual field used by Brandt to establish the control model is very similar to the distracter slide used by Williams et al., one possibility would be to compare the fixation results from the distracter slides to the fixation results of the target slides. In discussing the elimination of zone 2, Williams et al. contended that the subjects tended to disproportionately fixate on zone 2 "regardless of presence or *absence* or location of a dominant element" (24, my emphasis). Hence, we know that they collected fixation data when dominant elements were absent, i.e. when subjects were viewing distracter slides.

To conclude, I am not suggesting that the experimenters did not consider the above factors when designing their experiment, but the authors do not address these problems in the paper. Williams et al. could have discussed how they specifically applied the Brandt piece to the construction of their target slides and normalization their data. Additionally, greater justification was called for in determining why a one-sample *t* test was more qualified to test causation in this experiment over a within-subjects study with a two-level independent variable, an experiment type that would seem to fit the data that they collected in the course of their experiment.