

Pupillary Response as an Indicator of Difficulty Levels in Perceptual Organization

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INTRODUCTION

- The pupillary dilation reflex regulates light entering the retina and also occurs during cognitive and emotional processing load (Beatty, 1982):
- A task evoked pupillary response (TEPR) is observed immediately after cognitive processing begins with changes in processing load required by the difficulty of the task. (Klingner et al., 2008).
- A fundamental process in the perception of form includes the ability to group elements in a display to represent the contour of an object.
- Kurylo et al. (2017) have developed stimuli that are composed of varying elements (color, gabor, luminance, contrast) with differing degrees of coherence that organize themselves into horizontal or vertical line orientations
- Reaction time and accuracy are found to correlate with difficulty level and are typically measured in perceptual organization studies.
- The current study uses an eye tracker to examine reaction time, accuracy and TEPR in response to difficulty levels.

Participants

- 36 healthy graduate and undergraduate students of Teachers College, Columbia University and Touro College (mean age = 23.5, $SD = 2.6$; 8 males, 28 females) have participated to the experiment for credit after providing an informed consent.
- All participants had normal or corrected-to-normal visual acuity.
- A demographic survey was given and participants were tested for visual acuity using a Snellen chart and for color blindness.
- Participants were seated at a computer and asked to complete a perceptual organization task, similar to the one utilized by Kurylo et al. (2017).
- While completing the perceptual organization task, pupillary response, reaction time and accuracy were recorded using the Gazepoint GP3 eye-tracking machine and Open Gaze Application Programming software.

METHODS

- Stimuli included patches with 70, 80, 90 or 100% coherence. Examples for 100% and 70% levels can be seen in Table 1.
- Eighty stimuli of differing difficulties (Level 1 - 4) were used for each condition. The study consisted of 6 blocks, with each block consisting of forty stimuli of each condition. The order of the blocks was randomly assigned.
- Participants viewed each patch and were instructed to press one of two keys to indicate whether they thought the orientation was horizontal or vertical

Table 1. Examples of stimulus organized both vertically and horizontally for difficulty Level 1 and Level 4.

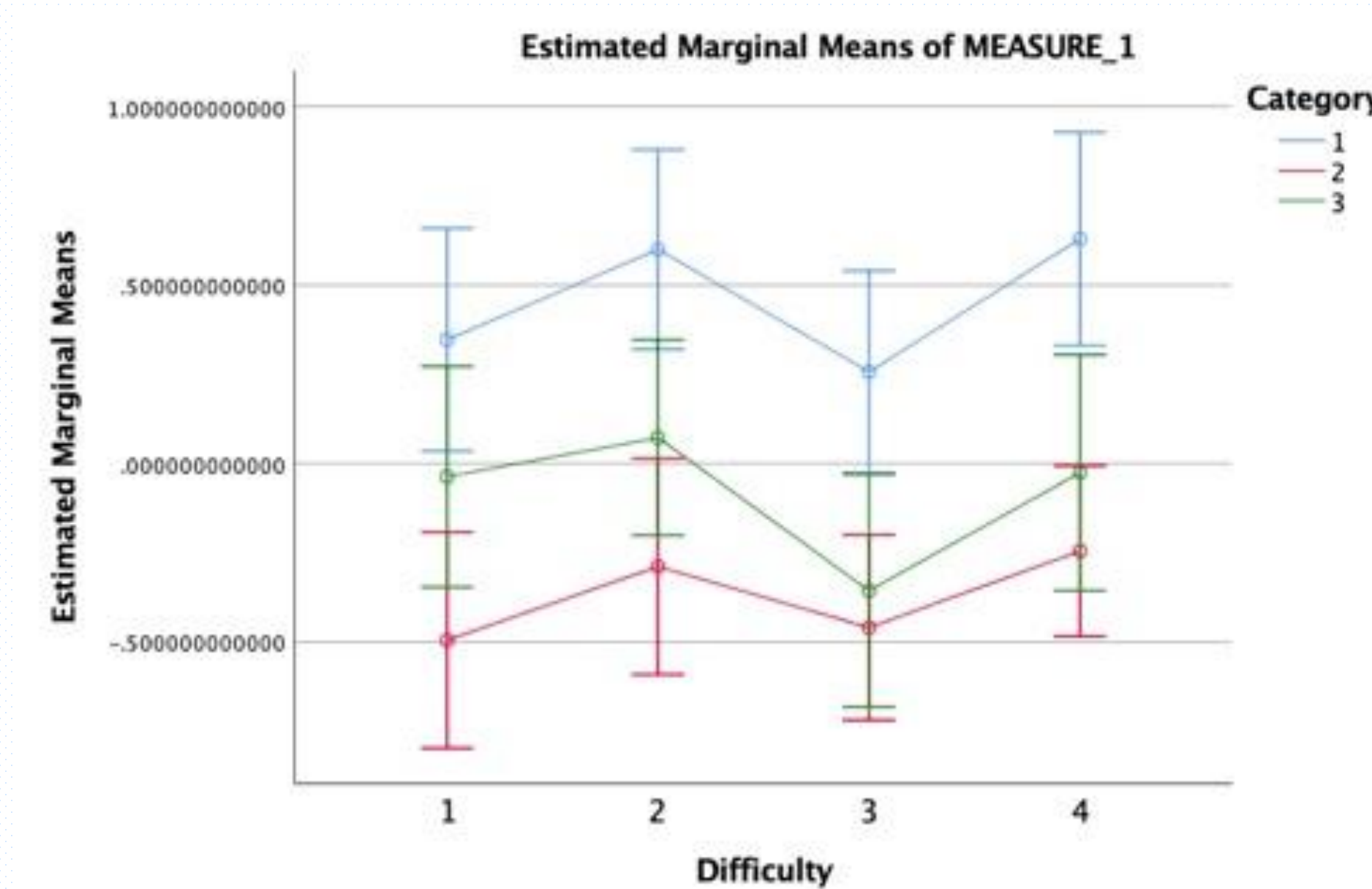
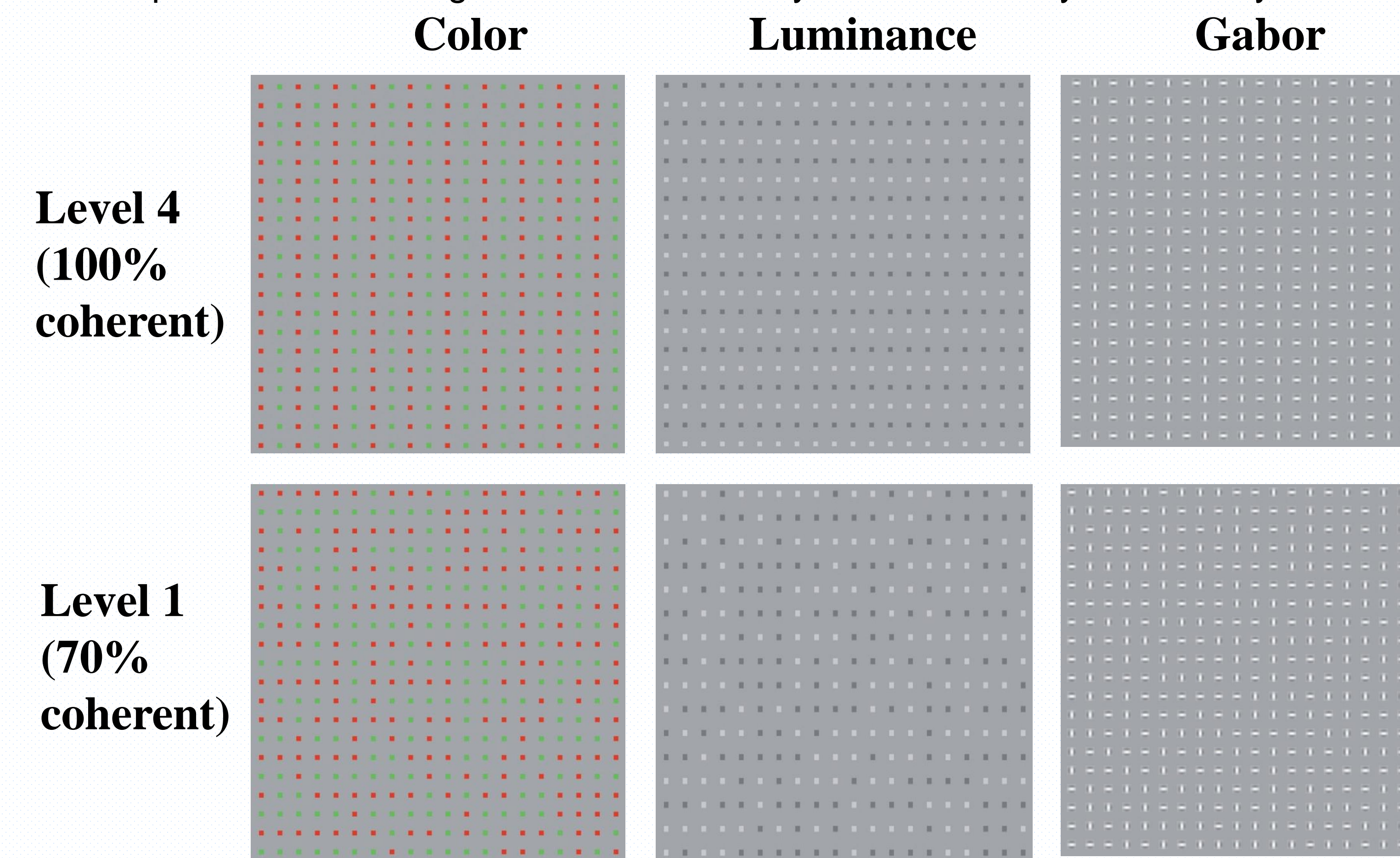


Figure 1. TEPR (mm) across difficulty levels.

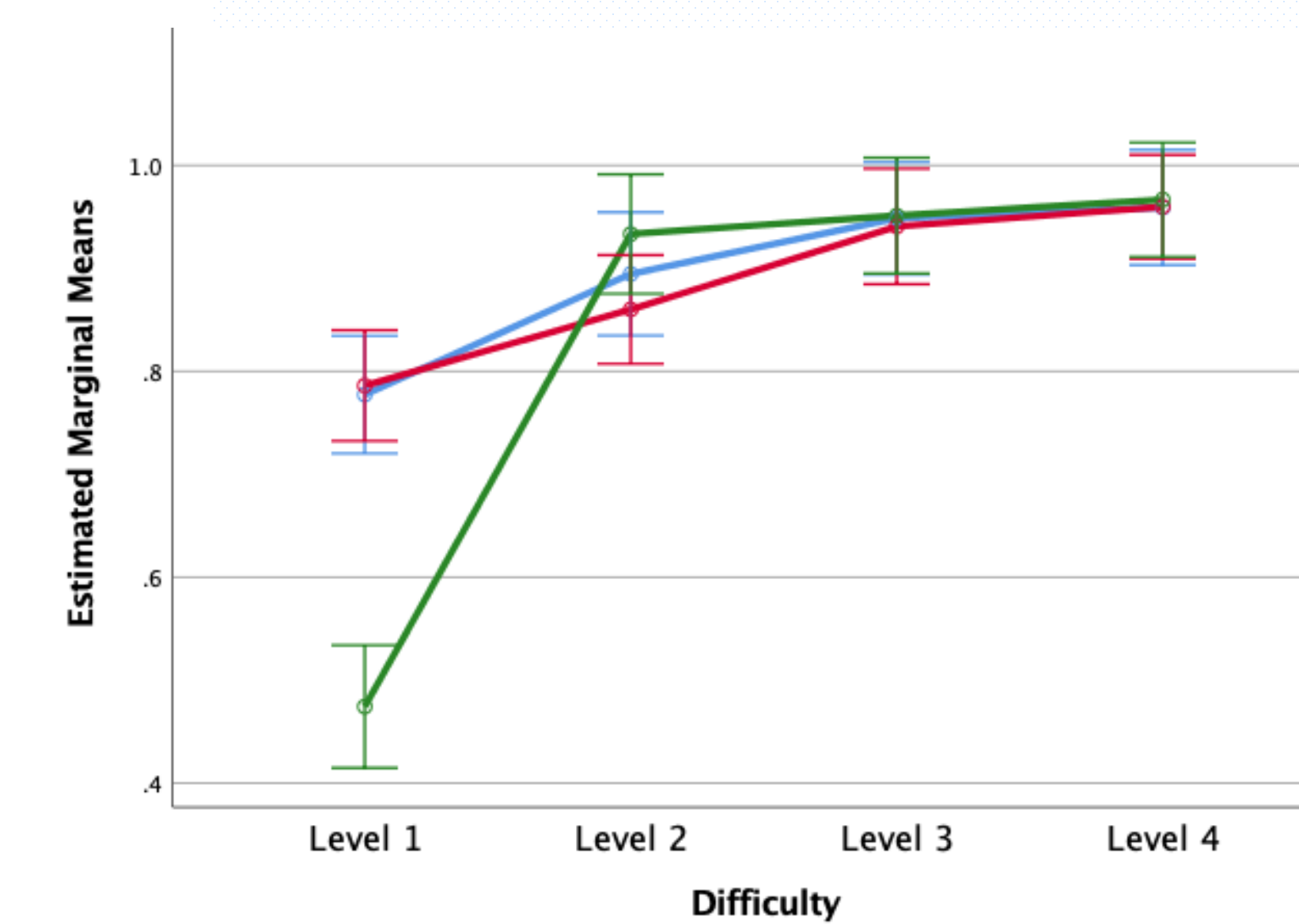


Figure 2. Accuracy across difficulty levels.

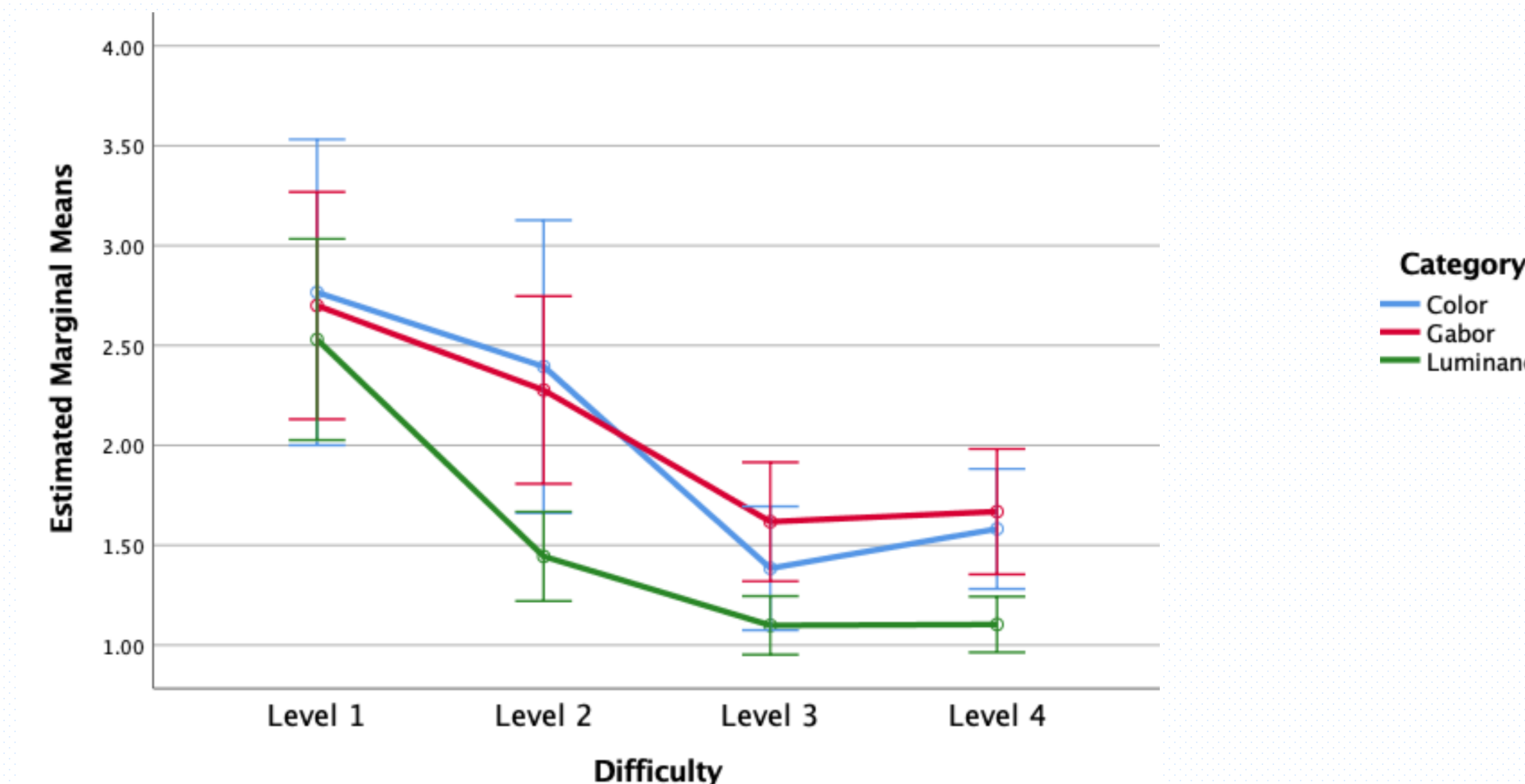


Figure 3. Reaction time across difficulty levels.

RESULTS

- For RT, Accuracy and Pupil, a repeated measures MANOVA was run with category (Color, Luminance, Gabor), orientation (horizontal, vertical) and difficulty level (1-4) as factors. Pupil size was recoded as z-scores.
- A systematic effect of difficulty was observed for accuracy and reaction time (Figure 2, Figure 3)
- Pupil dilation showed a main effect of orientation ($p = .02$) and category x orientation ($p = .02$) (Figure 1).
- Individual contrasts for difficulty were significant ($p < .05$), but difficulty itself did not show a main effect due to the non-linearity of the data
- Category x orientation x difficulty was significant for reaction time ($p < .0001$) and accuracy ($p < .0001$).
- Although there were significant effects of pupil dilation, we cannot say that pupil dilation was the result of increased load, assuming that such load is predicted by task difficulty

DISCUSSION

- Differences in pupillary responses were found in different conditions in this task suggesting some effects of experimental manipulations
- The level of pupillary response was different for each of the stimulus types, and was not linearly related to difficulty, even though differences between difficulty levels were significant
- However, difficulty levels did have a linear relationship with reaction time and accuracy as found in previous studies, suggesting that this manipulation does tap into cognitive processing at the behavioral level
- These results suggest that pupillary response might be used as a biomarker of cognitive processing in this task, but the exact nature of this relationship requires further examination

References

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