A note on the equality judgment experiment in Itthipuripat, et al. (2019)

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Abstract

Itthipuripat, Chang, Bong, & Serences (2019) investigated the effects of attention on appearance and decision criteria. Using a series of comparative and equality judgment tasks, they determined that most of the effects of attention could be explained as changes in decision criteria; however, their equality judgment experiment did reveal an effect of attention on appearance at low contrasts. Because their analysis reported $C_{\max}$, the contrast at which the equality judgement is maximum, and because $C_{\max}$ is not independent of potential low-contrast response biases, I decided to reanalyze their equality judgment data. Based on this reanalysis, I was not able to rule out a potential effect of attention on appearance at low contrast. But, due to the small number and asymmetric range of contrasts probed, their experiment was not well designed to test this contrast regime, and I am not confident about their result. For the higher contrasts they tested, the measured effects of attention trended in the opposite direction.

Introduction

The effects of attention upon the appearance of objects is an experimental question with roots as old as the field of experimental psychology. Carrasco, Ling, & Read (2004) used exogenous attentional cues that compel subjects to orient their attention to one of two subsequent targets and asked subjects which of the two targets had higher contrast—this task is hereafter termed a “comparative judgment”. The study reported that attention

increased the apparent contrast of the attended target. However, we showed that when using this comparative judgment, the effects of attention could not be distinguished from those of decision bias, as these two factors were degenerate in the response model. We therefore introduced the “equality judgment”, in which subjects reported whether the two targets had equal contrast or not, and showed that the effects of attention were due to changes in the decision criteria and not changes in appearance (Schneider & Bavelier, 2002; Schneider & Komlos, 2008). Anton-Erxleben, Abrams, & Carrasco (2010) attempted to replicate the equality judgment experiment, but they used significantly smaller stimuli that were much less visible, which caused the subject’s responses to be skewed towards a non-zero guessing rate asymptote at low contrasts. They mis-fit these skewed functions with symmetric functions, which pulled the central tendency toward the low-contrast end, and reported that attention altered appearance. But I showed that when taking this low-contrast skew into account, their measurements actually showed the opposite, that attention did not alter perceived contrast (Schneider, 2011). Moreover, I showed that the results reported in Anton-Erxleben, Abrams, & Carrasco (2010) were entirely due to the skew, as the magnitude of the reported effect in each subject was highly correlated with the skew. In every case in their data, the two stimuli contrasts that were most likely to be judged as equal were in fact the two stimuli that had equal contrast. Attention was not causing two equal-contrast stimuli to appear unequal, as it should if the hypothesis that attention alters appearance were true. Anton-Erxleben, Abrams, & Carrasco (2011) analyzed the $C_{\max}$ parameter, the maximum amplitude of the equality judgment psychometric function, reported in Schneider and showed that attention did alter this parameter, but we reiterated (Beck & Schneider,

2017) that $C_{\max}$ was not independent of the response criteria as a result of the low-contrast skew, as noted in Schneider (2011).

Recently, Itthipuripat, Chang, Bong, & Serences (2019) used a series of comparative and equality judgments to show that the effects of attention are mostly changes in decision criteria. However, in their equality judgment experiment, they did report an effect of attention on appearance. Since they repeated the error of Anton-Erxleben, Abrams, & Carrasco (2011) in analyzing the $C_{\max}$ parameter, which is not independent of the response criterion, I decided to reanalyze their data to verify their report.

Methods

I requested and received from Sirawaj Itthipuripat the trial-by-trial subject responses for all seven subjects in the equality judgement data reported in Itthipuripat, Chang, Bong, & Serences (2019). In each trial of their experiment, two Gabor patches were presented for 33 ms. One of the Gabors was preceded by 125 ms by an attentional cue with a duration of 58 ms in its location. Each Gabor had a spatial frequency of 3 cpd, a Gaussian envelope with a standard deviation of 2.18° , and an eccentricity of 13.74° to the left or right of fixation. The cued and uncued targets could each have a Michelson contrast of 0, 5, 10, 20, 40 or 80%. The method of constant stimuli was used with 36 repetitions of each combination of contrast pairs, for a total of 1296 trials.

Significant differences in these parameters compared to Schneider & Komlos (2008) were that the stimuli were larger, with a 2.18° vs. 1° envelope and were farther away from fixation, 13.74° vs. 4° . The larger stimulus size may be sufficient to compensate for the larger eccentricity, according to the cortical magnification factor

(Dougherty et al., 2003). More importantly, ignoring the 0% contrast stimuli, which are not relevant for the present purposes, Itthipuripat, Chang, Bong, & Serences (2019) used only five different test contrast levels for each contrast of the cued stimulus. And the test contrasts were drawn from the same contrasts used for the cued target, such that for the high and low contrast stimuli did not have a symmetric range of tests contrasts to compare against (See Figure 1). In contrast, for each level of the cued contrasts used in Schneider & Komlos (2008), the uncued test contrasts were presented at 11 different contrasts, in a range that symmetrically surrounded the cued contrast. This is important because the contrast range used in Itthipuripat, Chang, Bong, & Serences (2019) might sample only one half of the psychometric function and therefore did not permit an accurate model fit for the highest and lowest cued contrast levels tested (see the 5% and 80% contrast levels in Figure 1).

I fit the response data, omitting the 0% contrast trials, to the following response model (Schneider, 2006; Schneider & Bavelier, 2002; Schneider & Komlos, 2008), to determine the equivalent contrast of the cued targets:

$$P(c_1 = c_2) = \Phi\left(\frac{\tau - \Delta c - \alpha}{\sigma}\right) - \Phi\left(\frac{-\tau - \Delta c - \alpha}{\sigma}\right),$$

where $\Phi(x) \equiv \frac{1}{2\pi} \int_{-\infty}^x e^{-u^2/2} du$ is the cumulative normal distribution, τ is the contrast difference criterion, Δc is the actual difference in contrast between the cued target (c_1) and the uncued target (c_2), σ^2 is the variance of the contrast difference and α is the hypothesized attentional boost in perceived contrast of the cued target relative to the uncued target. Each parameter has units of logarithmic contrast. The variances of the estimates of the model parameters were derived for each subject by assuming that the likelihood function is distributed in parameter space approximately normal near the

optimal parameters (MacKay, 1992), and these variances were used to compute the weighted mean of each model parameter across subjects (Schneider, 2006). The perceived contrast was calculated from the model fit as $c' = ce^{\alpha}$ for each actual contrast level c of the cued target.

Results

The model fits for all of the individual subjects and contrasts levels tested are shown in Figure 1. As can be seen, the limited number of uncued contrast levels tested makes the model fits unreliable for the low and high cued target contrasts, because only half of the response function is sampled. Nonetheless, the α parameters in the fits were used to plot the equivalent contrast of each cued contrast level in Figure 2.

The results support the findings of Itthipuripat, Chang, Bong, & Serences (2019) of the significant effects of the cue for the cued 5 and 10% contrast targets ($p = .026$ and $p = .015$, respectively). However, it is not clear whether this is caused by attention or from the result of the sparse asymmetric sampling of the psychometric response function. The fitted model has three independent parameters, and each cued target contrast was only tested against five different contrast levels. For the 5% contrast cued target, the contrasts of all the compared uncued targets were equal or higher, resulting in only half of the psychometric function being sampled (Figure 1, leftmost column). This causes the central tendency of the fitted function to be highly unconstrained. At the higher contrasts, where the sparse sampling occurred on the opposite, high-contrast side (Figure 1, rightmost column), the trend of the equivalent contrast is in the opposite direction, as if the attentional cues had the effect of decreasing apparent contrast

(Figure 2). This trend was not significant however for the 80% contrast cued target and only marginally so ($p = .069$) for the 40% cued contrast.

Discussion

In their equality judgment experiment, Itthipuripat, Chang, Bong, & Serences (2019) reported that attention significantly increased the perceived contrast of the cued target only for low contrasts levels, contradicting the results of Carrasco, Ling, & Read (2004) who reported that attention altered appearance at higher contrasts. My reanalysis of Itthipuripat, Chang, Bong, & Serences (2019) does not contradict their low contrast findings. However, given the trends for their higher contrast cued targets, where attention tends to decrease the apparent contrast of the cued target, and given their sparse and asymmetric sampling of the psychometric response functions, further experimentation is required to confirm that their results are caused by the effects of attention and not just their experimental design. They tested a lower range of cued target contrasts than had been previously reported using Gabors. Schneider & Komlos (2008) used a range of cued target contrasts of 15–35%, whereas the reported effects in Itthipuripat, Chang, Bong, & Serences (2019) appeared for 5 and 10% contrast cued targets. Schneider (2006) used lower contrasts for solid (non-grating) stimuli and concluded that an additive stimulus-based effect boosted the detection of peri-threshold stimuli.

One effect of attention perhaps being engaged for low contrast targets is that attention could make visible otherwise invisible targets, by boosting their salience above the threshold of perception (e.g. Chica, Lasaponara, Lupiáñez, Doricchi, & Bartolomeo, 2010). If this were the case, attention might not be increasing the perceived contrast of

the stimulus, but would just be causing stimuli of a low contrast to be perceived when they otherwise would not be (Schneider, 2006). Stimuli in this range would be difficult to probe with an equality judgment, because both stimuli need to be visible for a fair comparison. For example, if two stimuli had identical perceived contrast, yet only one was noticed but the other not, then subjects would likely judge the two stimuli to have unequal contrasts. Previous studies were careful to ensure that all contrast levels tested were reliably above threshold (Schneider & Komlos, 2008). Apparent effects of attention upon appearance that are confined to a low-contrast regime are likely to reflect effects of attention upon salience (Beck & Schneider, 2017) and hence visibility, rather than changes in appearance.

Figure captions

Figure 1. The individual data for all subjects are shown. Each row is a separate subject. Each column represents the same contrast of the cued target (5, 10, 20, 40 or 80%). The filled circles show the probability the subject reported that the cued target contrast (c_1) and uncued target contrast (c_2) had equal contrasts, and the solid lines are equality judgment model fits (see Methods). The fit parameters are shown at the top of each sub-plot.

Figure 2. Equivalent contrast. The perceived contrast is plotted as a function of actual contrast, $c' = ce^{\alpha}$. Each $\times$ symbol represents a single subject. The solid line is the perceived contrast calculated from the weighted mean of the α parameters across subjects. The shaded region shows the extent of the 95% confidence interval of the weighted mean. Significant or marginally significant p -values are shown from t -tests on the weighted means.

References

- Anton-Erxleben, K., Abrams, J., & Carrasco, M. (2010). Evaluating comparative and equality judgments in contrast perception: attention alters appearance. *Journal of Vision*, 10(11), 6, 1–22. <https://doi.org/10.1167/10.11.6>
- Anton-Erxleben, K., Abrams, J., & Carrasco, M. (2011). Equality judgments cannot distinguish between attention effects on appearance and criterion: A reply to Schneider (2011). *Journal of Vision*, 11(13), 8–8. <https://doi.org/10.1167/11.13.8>
- Beck, J., & Schneider, K. A. (2017). Attention and Mental Primer. *Mind & Language*, 32(4), 463–494. <https://doi.org/10.1111/mila.12148>
- Carrasco, M., Ling, S., & Read, S. (2004). Attention alters appearance. *Nature Neuroscience*, 7(3), 308–13. <https://doi.org/10.1167/12.9.1387>
- Chica, A. B., Lasaponara, S., Lupiáñez, J., Doricchi, F., & Bartolomeo, P. (2010). Exogenous attention can capture perceptual consciousness: ERP and behavioural evidence. *NeuroImage*, 51(3), 1205–1212. <https://doi.org/10.1016/j.neuroimage.2010.03.002>
- Dougherty, R. F., Koch, V. M., Brewer, A. A., Fischer, B., Modersitzki, J., & Wandell, B. A. (2003). Visual field representations and locations of visual areas V1/2/3 in human visual cortex. *Journal of Vision*, 3(10), 586–598. <https://doi.org/10.1167/3.10.1>
- Itthipuripat, S., Chang, K.-Y., Bong, A., & Serences, J. T. (2019). Stimulus visibility and uncertainty mediate the influence of attention on response bias and visual contrast appearance. *Journal of Vision*, 19(14), 8. <https://doi.org/10.1167/19.14.8>
- MacKay, D. J. C. (1992). Bayesian interpolation. *Neural Computation*, 4(3), 415–447.
- Schneider, K. A. (2006). Does attention alter appearance? *Perception & Psychophysics*,

68(5), 800–814. <https://doi.org/10.3758/BF03193703>

Schneider, K. A. (2011). Attention alters decision criteria but not appearance: a reanalysis of Anton-Erxleben, Abrams, and Carrasco (2010). *Journal of Vision*, 11(13), 7. <https://doi.org/10.1167/11.13.7>

Schneider, K. A., & Bavelier, D. (2002). Components of visual prior entry. *Journal of Vision*, 2(7). <https://doi.org/10.1167/2.7.439>

Schneider, K. A., & Komlos, M. (2008). Attention biases decisions but does not alter appearance. *Journal of Vision*, 8(15), 3, 1–10. <https://doi.org/10.1167/8.6.1094>

Figures

Figure 1

Figure 2