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On Why Objects Appear Smaller in the Visual Periphery

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Abstract

An object appears smaller in the periphery than in the center of the visual field. In two experiments ($N = 24$), we demonstrated that visuospatial attention contributes substantially to this perceptual distortion. Participants judged the size of central and peripheral target objects after a transient, exogenous cue directed their attention to either the central or the peripheral location. Peripheral target objects were judged to be smaller following a central cue, whereas this effect disappeared completely when the peripheral target was cued. This outcome suggests that objects appear smaller in the visual periphery not only because of the structural properties of the visual system but also because of a lack of spatial attention.

Keywords

attention, visual perception

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The apparent size of one and the same object depends on the object's position in the visual field: Stimuli that fall into the visual periphery appear to be smaller than identical stimuli that occupy the center of the visual field (e.g., Anstis, 1998; Baldwin, Burleigh, Repperell, & Ruta, 2016; von Helmholtz, 1867; Newsome, 1972; Schneider, Ehrlich, Stein, Flaum, & Mangel, 1978; Thompson & Fowler, 1980). This perceptual distortion—the *size-eccentricity effect*—is commonly explained by structural properties of the visual system, such as the higher density of retinal receptive fields in the fovea compared with the periphery (for a current model, see Moutsiana et al., 2016). Thus, changes in perceived object size have been attributed to the different retinal locations at which these objects appeared, a notion we will refer to as the *retinal-eccentricity hypothesis*.

Even though the retinal-eccentricity hypothesis is intuitively plausible, several recent findings suggest an alternative, the *attentional hypothesis*. This hypothesis is motivated by increasing evidence indicating that spatial attention not only alters the efficiency of visual processing but also changes how objects appear to observers (for reviews, see Anton-Erxleben & Carrasco, 2013; Carrasco & Barbot, 2014, 2019). Crucially, attention affects the apparent size of objects: When attention is drawn toward a peripheral object by a small transient cue, this object is perceived as larger compared with a neutral cue (Anton-Erxleben, Heinrich, & Treue, 2007; Kirsch, Heitling, & Kunde, 2018; for conceptually related observations, see Cutrone, Heeger, & Carrasco, 2018; Klein, Paffen, te Pas, & Dumoulin, 2016; Suzuki & Cavanagh, 1997). Increasing the size of the transient cue and thus increasing the size of the attended area has further been shown to reduce the perceived object size (Kirsch et al., 2018).

These findings are consistent with the idea that attention alters the properties of receptive fields of cortical neurons (Anton-Erxleben & Carrasco, 2013; Baruch & Yeshurun, 2014; Carrasco & Barbot, 2014; for converging neurophysiological evidence, see Anton-Erxleben, Stephan, & Treue, 2009; Womelsdorf, Anton-Erxleben, & Treue, 2008). It has been suggested that receptive fields shrink at an attended location (i.e., reduce their size) and gravitate toward that location. Such dynamic

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changes would entail perceptual magnification of the spatial area adjacent to an attended location. Accordingly, an attended object appears larger than an unattended one because the attended object activates the receptive fields of additional neurons that code more distant locations. Because spatial attention tends to stick to the center of the visual field by default (e.g., Anstis, 1998), this mechanism would naturally predict a size-eccentricity effect (e.g., Baruch & Yeshurun, 2014). That is, an object in the center of attention would be perceptually magnified, compared with an object not in the center of attention. In other words, the attentional hypothesis holds that objects appear smaller in the periphery because they are unattended. Moreover, the retinal-eccentricity hypothesis and the attentional hypothesis are not mutually exclusive, so any potential effect of attention might be modulated by eccentricity (see, e.g., Carrasco, Williams, & Yeshurun, 2002; Megna, Rocchi, & Baldassi, 2012).

To evaluate the attentional hypothesis, we adopted a tried and tested psychophysical method from research on attention and object appearance (Carrasco, Ling, & Read, 2004; see also Carrasco & Barbot, 2019) and modified it to assess the size-eccentricity effect.

Experiment 1

Experiment 1 aimed to establish a psychophysical procedure for quantifying the size-eccentricity effect that allows for an attentional-cuing manipulation. Participants were presented with two simultaneous circular objects and had to judge which of the objects was larger (see Fig. 1a). One object always appeared in the middle of the screen, and the other was presented either to the left or to the right of the central position. The size of one object was constant (*standard object*), whereas the size of the other object varied from trial to trial (*test object*). On any given trial, either object could appear in the center of the display or at a peripheral location. The magnitude of the size-eccentricity effect was quantified as the difference in the point of subjective equality (PSE) when the test object appeared either centrally or peripherally (see Fig. 1b).

Method

Participants. The size-eccentricity effect is a robust phenomenon that can be experienced by each individual observer (Anstis, 1998; Helmholtz, 1867). The sample size was thus rather arbitrarily determined to be 12 participants (age: M = 33 years, SD = 13; two males). All participants had normal or corrected-to-normal vision. They gave their written informed consent for the procedures and received monetary compensation for their participation. The study was conducted in accordance with the ethical guidelines (2016) of the German Psychological Society (DGPs).

Apparatus. The experimental room was dimly lit, and trials were displayed on a 19-in. CRT monitor (Samsung Samtron 96B; 100 Hz refresh rate; 1,024 × 768 pixels; 1 pixel ~ 0.35×0.35 mm^2). Participants viewed the monitor at a distance of 65 cm, and their heads were supported by a combined chin and forehead rest.

Stimuli. All stimuli were displayed on a gray background (red, green, blue, or RGB, color space coordinates = 128, 128, 128). Number-sign symbols (###) and fixation crosses were light gray (RGB coordinates = 175, 175, 175) whereas targets were circles filled dark gray (RGB coordinates = 81, 81, 81). Question marks were presented in green. The number signs and the fixation cross always appeared in the center of the screen. The question mark was shown in the upper center. Stimulus presentation was controlled using E-Prime software (Version 2.0; Schneider, Eschman, & Zuccolotto, 2012).

Procedure. At the beginning of each trial, three number signs were displayed side by side for 1,000 ms. The number signs were replaced by the fixation cross (580 ms), followed by a blank screen for 60 ms. Then two targets were presented simultaneously for 100 ms. This stimulus duration was brief enough to prevent eye movements (but did not necessarily guarantee that participants were fixating in the center). The final display featured a question mark, which prompted participants to indicate which of the targets had been larger (Fig. 1a). They responded by clicking the left (for the left target) or the right (for the right target) button on a computer mouse. Participants were asked to fixate on the position of the central target throughout the experiment and to avoid eye movements.

Design. One of the two targets always appeared in the center of the screen, and the other target appeared either to the left or to the right of the central target. The intertarget distance varied between 3.1° and 12.3° in four equidistant steps (from center to center). One of the targets was always 1.97° in diameter and served as the standard object. The size of the test object (second target) varied from 75% to 125% of the standard size in nine steps, yielding 72 conditions as the factorial combinations of Test Size (9) × Test Position (2: center or periphery) × Eccentricity (4).

Participants first performed 72 practice trials and then four experimental blocks of 216 trials each (12 repetitions of each condition). All conditions were presented in random order across trials.

Data analysis. We computed the proportion of trials in which the test object was judged to be larger as a function

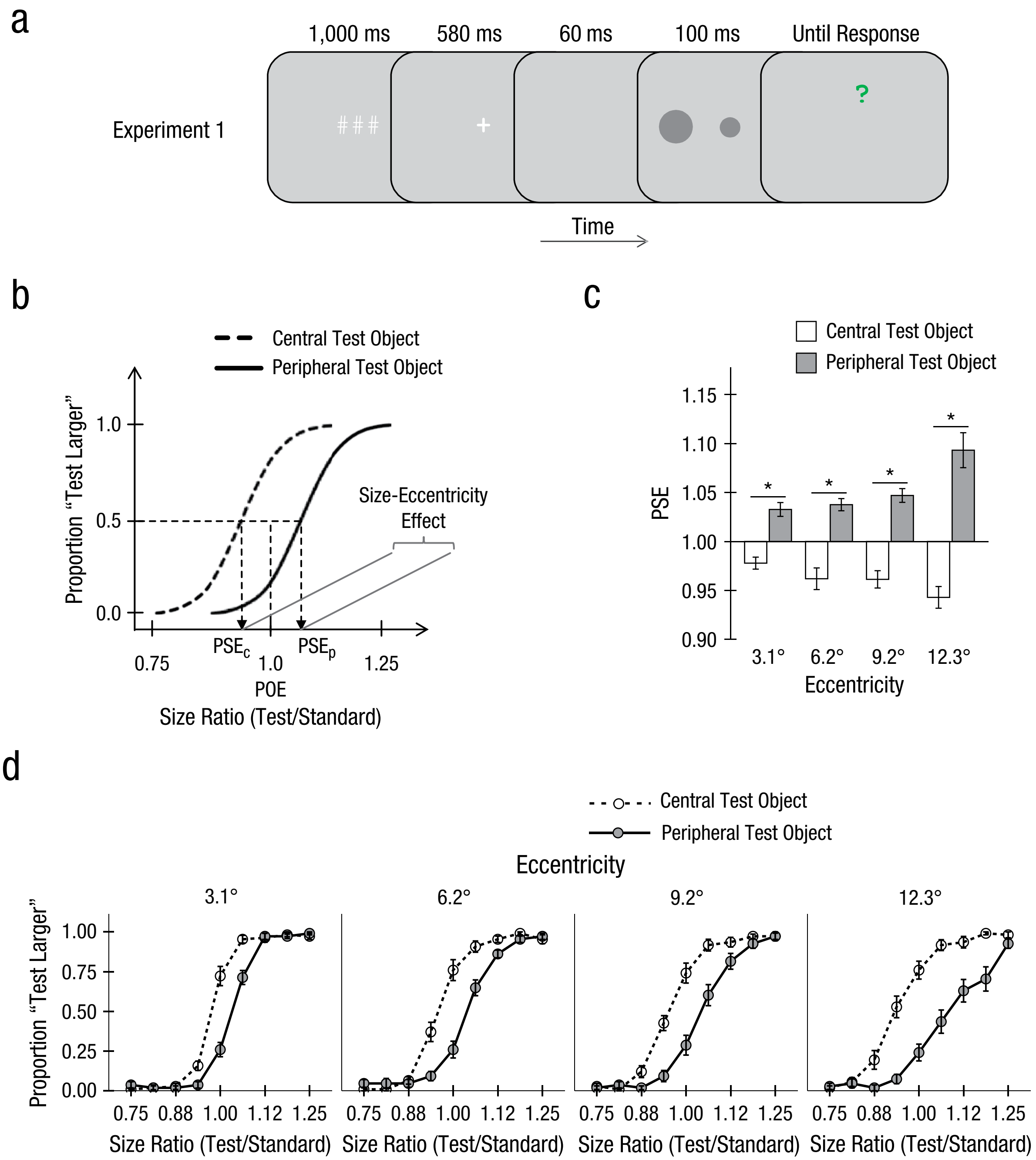

Fig. 1. Design and results of Experiment 1. On each trial (a), participants judged which of two target objects (filled circles) was larger. One target object always appeared in the center of the display, whereas the other appeared with different eccentricities either to the left or to the right. One target had a constant size (*standard object*), whereas the other varied from 0.75% to 1.25% of the standard size (*test object*). Stimuli shown here are not drawn to scale. The size-eccentricity effect (b) was quantified by first assessing the proportion of trials in which the test object was judged to be larger than the standard object as a function of the ratio between the size of the test and standard objects, separately for centrally presented and peripherally presented test objects. The points of subjective equality (PSEs) were then determined by calculating the difference between the PSE for central test objects (PSE$_c$) and the PSE for peripheral test objects (PSE$_p$). POE denotes the point of objective equality. The mean PSE (c) is shown as a function of eccentricity and the location of the test object. Error bars show within-participants standard errors computed according to the method of Cousineau (2005), and asterisks denote statistically significant differences ($p < .05$). The mean proportion of trials on which the test object was judged to be larger (d) is shown as a function of the relative size and location of the test object, separately for each of the four eccentricities. Error bars show standard errors indicating the variability across participants.

of the test size for each test position and eccentricity (see Fig. S1 in the Supplemental Material available online for individual data). These values were then fitted with a psychometric function by using a local model-free fitting procedure (Zychaluk & Foster, 2009). Three participants were excluded from further analyses because of low discrimination performance (Fig. S1) with a mean r^2 of more than 3 standard deviations below the mean of the other participants. The mean r^2 of the remaining data amounted to .97 (SD = .04).

PSEs were determined by identifying the size of the test object at which the psychometric function yielded a likelihood of 50% judgments that the test object was larger. The scale of the PSE values is in units of size ratios of the test object relative to the standard object. The magnitude of the size-eccentricity effect was determined by subtracting the PSE for the centrally presented test object from the PSE for the peripherally presented test object (see Fig. 1b). All statistical analyses were performed using SPSS software (Version 25). Raw data are publicly available on the Open Science Framework (https://osf.io/49z3d/).

Results

Figure 1 shows the mean PSE values for each condition (Fig. 1c) as well as the corresponding judgment data (Fig. 1d). As predicted, centrally presented test objects yielded smaller PSEs than peripheral test objects. This size-eccentricity effect (i.e., the difference in PSEs between centrally and peripherally presented test objects) was significant for each level of eccentricity, all ps ≤ .002, as indicated by one-sample t tests against zero. An analysis of variance (ANOVA) including eccentricity as a within-participants factor further suggested that the size-eccentricity effect increased with eccentricity, $F(3, 24) = 10.37$, $p < .001$, $\eta_p^2 = .565$.

The results of Experiment 1 confirmed that the experimental protocol was able to capture a robust size-eccentricity effect: Objects were consistently judged to be smaller when they appeared in peripheral regions of the visual field than when they appeared centrally. These results set the stage for implementing an attentional-cuing manipulation (Carrasco et al., 2004) to evaluate the attentional hypothesis.

Experiment 2

In Experiment 2, we introduced transient shifts of spatial attention by presenting a small exogenous cue at different locations right before the target objects (see Fig. 2a). In the critical conditions, the cue was presented at the location of the central object (*central-object-cued* condition) or of the peripheral object (*peripheral-object-cued* condition). The retinal-eccentricity hypothesis predicted equal size-eccentricity effects for both conditions because the conditions differed only in attentional allocation, not in terms of the retinal locations of target objects. In contrast, the attentional hypothesis predicted a size-eccentricity effect when the central object was cued but no effect when the peripheral object was cued.

In addition to this crucial dissociation, we further included two baseline conditions to test more specific predictions of the attentional hypothesis (see Fig. 2b). In one baseline condition, the cue was entirely omitted (*no-cue* condition). This condition mirrored the experimental situation of Experiment 1, in which attention was presumably focused at the location of the central object. In the second baseline condition, the cue was at the same eccentricity but at the opposite location from the peripheral target (*irrelevant-location-cued* condition). This condition resembled the neutral condition of previous studies, in which the cue captured attention at a certain location that did not correspond to the location of any target object (e.g., Anton-Erxleben et al., 2007; Carrasco et al., 2004; Gobell & Carrasco, 2005).[1]

The retinal-eccentricity hypothesis did not predict any difference in the size-eccentricity effect for the baseline conditions compared with the critical conditions because the locations of target objects remained the same. The attentional hypothesis, however, yielded two specific predictions. First, the central cue should focus attention at the center of the central target object, whereas attention should be distributed more broadly when this location was not cued. Because an increase in attentional spread decreases apparent object size (Baruch & Yeshurun, 2014; Kirsch et al., 2018), the attentional hypothesis predicted a larger size-eccentricity effect when the central object was cued than in both baseline conditions. Second, the attentional hypothesis predicted a larger size-eccentricity effect for both baseline conditions than for the peripheral-object-cued condition, because in the baseline conditions, less attention is captured at the location of the peripheral object.[2]

Method

Participants. We recruited a new sample of 12 participants (age: M = 26 years, SD = 6; five males). As in Experiment 1, this sample size was determined arbitrarily because the impact of exogenous attentional cues on size judgments proved to be very reliable in a previous related study and was clearly observable in the individual data (Kirsch et al., 2018). The effect size (d_z) for critical comparisons amounted to about 2.18 on average. This value would require 5 participants given a power of .95 and an

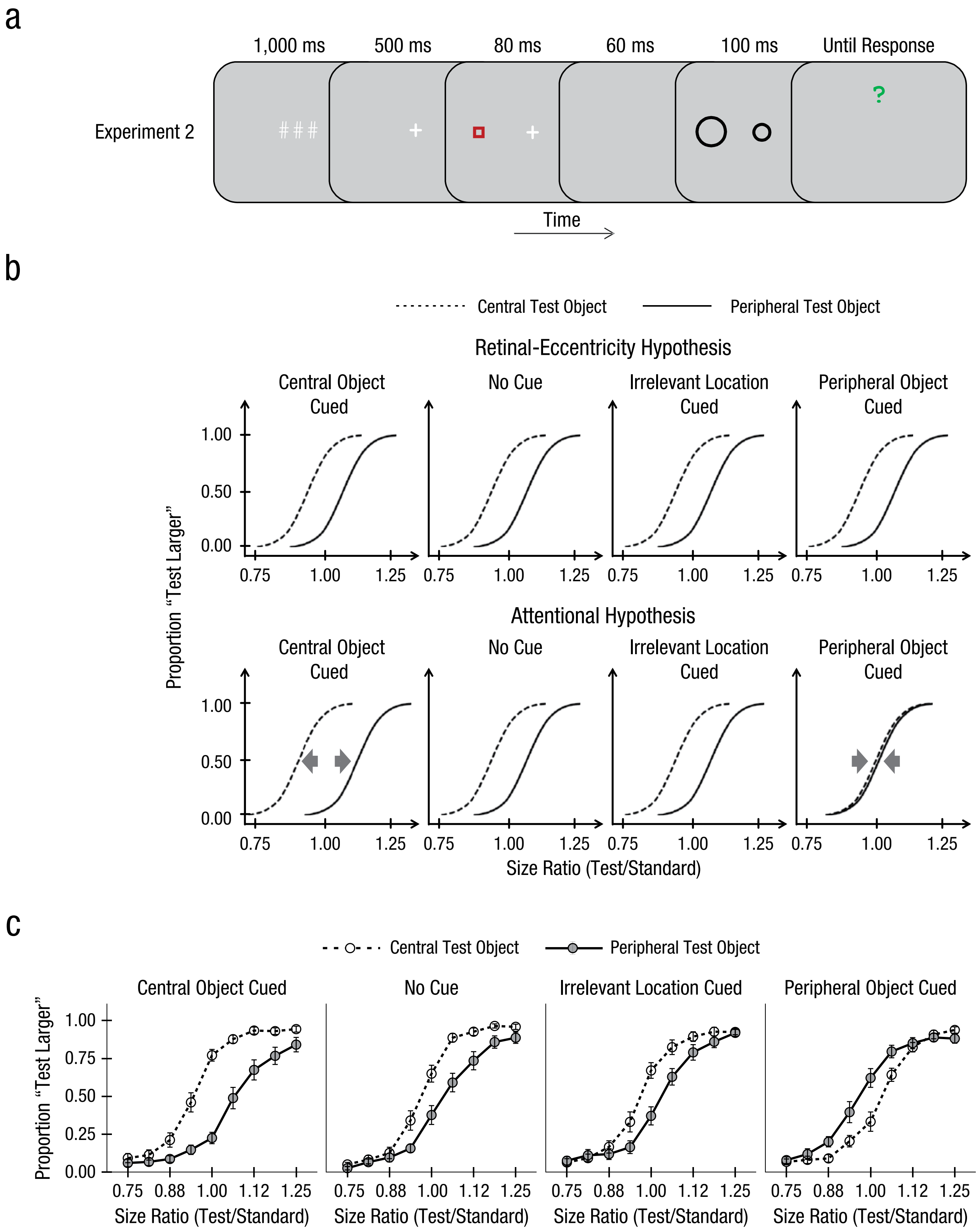

Fig. 2. *(continued on next page)*

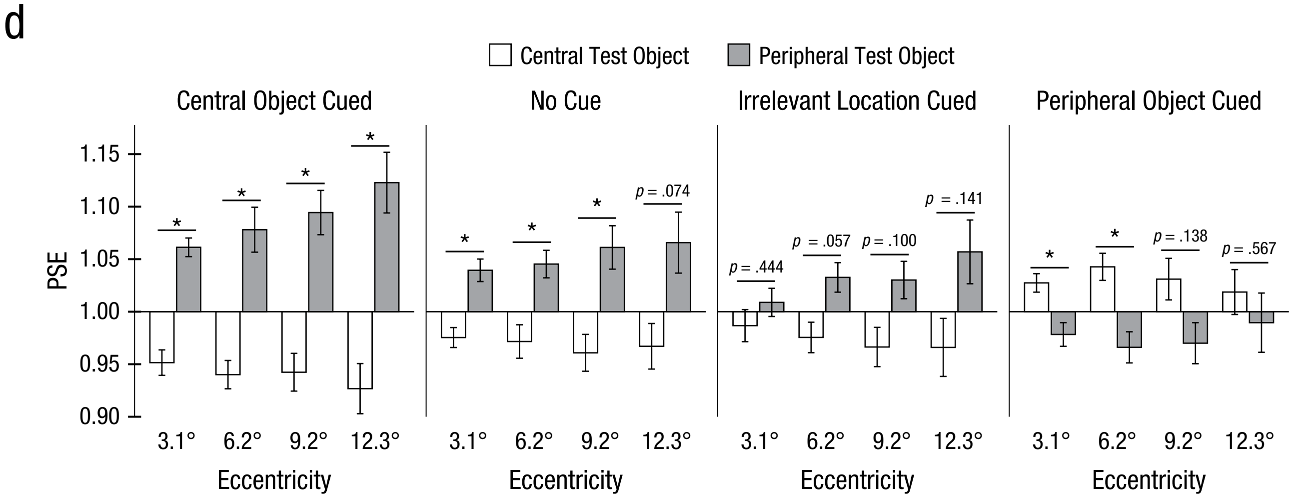

Fig. 2. Design, hypotheses, and results of Experiment 2. On each trial (a), participants judged the size of two target objects (open circles) as in Experiment 1. Crucially, on some trials, a small rectangle (cue) preceded the targets at the location of the central target (central-object-cued condition), at the location of the peripheral target (peripheral-object-cued condition), or at the same eccentricity but at the opposite location from the peripheral target (irrelevant-location-cued condition); in other trials, the cue was omitted (no-cue condition). Stimuli shown here are not drawn to scale. For each of the four cue conditions, the graphs in (b) show the impact of the cue on the size-eccentricity effect as predicted by both the retinal-eccentricity hypothesis and the attentional hypothesis. Arrows in the lower row indicate predicted increases or decreases in the size-eccentricity effect. The mean proportion of trials in which the test object was judged to be larger than the standard object (c) is shown as a function of the ratio between the size of the test and standard objects and the location of the test object, separately for each of the four cue conditions (see Fig. S3 in the Supplemental Material for the mean data of each eccentricity condition). Error bars show standard errors indicating the variability across participants. The mean point of subjective equality (PSE; d) is shown as a function of eccentricity and the location of the test object, separately for each of the four cue conditions. Error bars show within-participants standard errors computed according to Cousineau (2005), and asterisks denote statistically significant differences ($p < .05$).

alpha level of .05; the chosen sample size ensured a power of .95 for d_z greater than or equal to 1.02.

Stimuli and procedure. The methodology was the same as for Experiment 1, except for the following changes regarding stimuli and timing. Targets now were two unfilled circles with black borders, and the cue was an unfilled square with a saddle-brown border and a 5.6-mm edge length. The trial started with three number signs (1,000 ms) followed by a fixation cross (500 ms). Then the cue was flashed for 80 ms, and the targets appeared simultaneously after a delay of 60 ms. The targets remained on screen for 100 ms and were replaced by the question mark, which prompted the participants to judge which of the two stimuli had been larger (see Fig. 2a). Participants were instructed that the circles would often be preceded by rectangles and that the rectangles should be ignored.

Design. Experiment 2 featured a cue manipulation in addition to the factors used in Experiment 1 (i.e., test size, test position, and eccentricity). The cue could appear at the location of the central target (central object cued; 25% of trials), of the peripheral target (peripheral object cued; 25% of trials), and at the same eccentricity as the peripheral target but on the opposite side of the center (irrelevant location cued; 25% of trials). Additionally, in some trials, the cue was omitted (no cue; 25% of trials). In these trials, the trial timing was preserved by presenting the fixation cross for 580 ms. Except for the characteristics of the targets (filled vs. unfilled), these trials were thus identical to those of Experiment 1. The cue conditions were implemented in a trial-by-trial manner (i.e., all experimental conditions were presented in a random order, as in Experiment 1).

The main experiment included 3,456 trials (12 repetitions of each of 288 conditions), which were distributed over two separate experimental sessions on two different days. At the beginning of each session, participants performed 72 practice trials, followed by eight blocks of 216 trials each.

Data analysis. Data were analyzed in the same manner as in Experiment 1, and we excluded 1 participant for poor discrimination performance for the same criterion as in the preceding experiment (see Fig. S2 in the Supplemental Material for individual data). The mean r^2 of the remaining data was .93 (*SD* = .09). Raw data are publicly available on the Open Science Framework (https://osf.io/49z3d/).

Results

Figure 2 shows the resulting PSEs and mean judgments (see Figs. 2c and 2d). In an initial analysis, we probed whether the size-eccentricity effect (computed as in Experiment 1: PSE for peripheral test objects – PSE for central test objects) differed significantly across the cue and eccentricity conditions. A 4 × 4 ANOVA with the within-participants factors eccentricity and cue revealed a significant main effect for cue, $F(3, 30) = 30.75$, $p < .001$, $\eta_p^2 = .755$, and a significant interaction between cue and eccentricity, $F(9, 90) = 2.65$, $p = .009$, $\eta_p^2 = .209$. The main effect for eccentricity was not significant, $F(3, 30) = 1.76$, $p = .176$, $\eta_p^2 = .150$. We then followed up with planned analyses on a subset of the conditions.

An ANOVA including only the conditions in which either the central object or the peripheral object was cued revealed a significant main effect for cue, $F(1, 10) = 62.97$, $p < .001$, $\eta_p^2 = .863$, and a significant interaction between cue and eccentricity, $F(3, 30) = 3.32$, $p = .033$, $\eta_p^2 = .249$. A significant size-eccentricity effect was present for all levels of eccentricity when the central target was cued, all ps ≤ .003, and this effect increased with eccentricity, $F(3, 30) = 4.28$, $p = .013$, $\eta_p^2 = .300$. When the peripheral object was cued, the size-eccentricity effect was descriptively reversed (i.e., the peripheral target object was judged as larger than the central target object), and this reversal was significant for two of the four levels of eccentricity. Thus, the size-eccentricity effect was present when the central target was cued, and it was absent or even reversed when the peripheral target was cued.

When comparing the two baseline conditions, we found that the size-eccentricity effect did not differ between the no-cue condition and the irrelevant-location-cued condition, $F(1, 10) = 1.92$, $p = .196$, $\eta_p^2 = .161$ for the main effect of cue; $F(3, 30) = 1.65$, $p = .198$, $\eta_p^2 = .142$ for the main effect of eccentricity; and $F(3, 30) = 1.54$, $p = .225$, $\eta_p^2 = .133$ for the interaction (ps for all single comparisons ≥ .118). The irrelevant-location-cued and no-cue conditions differed significantly from the central-object-cued condition, $F(1, 10) = 13.77$, $p = .004$, $\eta_p^2 = .579$, and $F(1, 10) = 46.08$, $p < .001$, $\eta_p^2 = .822$ (main effects of cue). For the no-cue condition, these differences varied slightly across the levels of eccentricity, as indicated by a significant interaction, $F(3, 30) = 2.98$, $p = .047$, $\eta_p^2 = .229$, but each individual difference was significantly different from zero, all ps ≤ .009. The irrelevant-location-cued and no-cue conditions also differed significantly from the peripheral-object-cued condition, $F(1, 10) = 16.92$, $p = .002$, $\eta_p^2 = .628$, and $F(1, 10) = 52.42$, $p < .001$, $\eta_p^2 = .840$, respectively, for the main effects of cue. For the irrelevant-location-cued condition, these differences varied slightly across the levels of eccentricity, $F(3, 30) = 3.76$, $p = .021$, $\eta_p^2 = .273$ (interaction; all individual comparisons: ps ≤ .074). Thus, the size-eccentricity effect observed in both baseline conditions was smaller than in the central-object-cued condition and larger than in the peripheral-object-cued condition.

Moreover, the magnitude of the size-eccentricity effect observed in Experiment 1 was not significantly different from that observed in the no-cue condition of Experiment 2, $F(1, 18) = 0.039$, $p = .846$, $\eta_p^2 = .002$ (main effect of experiment), and $F(3, 54) = 1.73$, $p = .172$, $\eta_p^2 = .088$ (interaction).

In Experiment 2, we introduced a cuing manipulation to pit the retinal-eccentricity hypothesis and the attentional hypothesis directly against each other. Results confirmed the predictions of the latter hypothesis by showing large size-eccentricity effects when the central object was cued compared with reduced (and descriptively reversed) size-eccentricity effects when the peripheral object was cued. Furthermore, the size-eccentricity effects of both control conditions (irrelevant location cued and no cue) were smaller than in the central-object-cued condition and larger than in the peripheral-object-cued condition, as predicted by the attentional hypothesis.

Caution is warranted when interpreting the results of the irrelevant-location-cued condition because the size-eccentricity effect was not significantly different from zero in this case (see Fig. 2d). Note, however, that this result does not stand in conflict with the attentional hypothesis (see Note 2). The descriptive decrease of the effect here (compared with the no-cue condition) could arise because less attention was captured at this location following the peripheral cue.

Possible impact of eye movements. Note that systematic eye movements cannot account for the results of either experiment. In Experiment 1, the location of the central target was always predictable, and the location of the peripheral target was always unpredictable. Moreover, participants were instructed to fixate the central region of the display, and the targets were only briefly presented. Additionally, in Experiment 2, the cue–target interval was too short to include eye movements, and the location of the cue could not be predicted in advance.

Possible impact of response bias. Possible explanations of the results in terms of a simple response bias are also rather implausible. For example, any tendencies to prefer a certain response button in Experiment 1 would not result in the expected size-eccentricity effect because the larger object always required 50% of the left and 50% of the right button responses. In other words, because we varied the location of the peripheral target systematically, any button preferences would cancel each other out.

Furthermore, previous control experiments attested that the chosen procedure was highly valid: The cuing effects on visual appearance were present even when participants were given different types of instructions (Carrasco et al., 2004), were present with comparative as well as with equality judgments (Anton-Erxleben, Abrams, & Carrasco, 2010), were eliminated with postcues (Gobell & Carrasco, 2005), and were confirmed in settings with voluntary shifts of attention (Liu, Abrams, & Carrasco, 2009; see also Anton-Erxleben et al., 2007 and Kirsch et al., 2018, for corresponding observations in studies on attention and perceived object size; for a review of all controls that have been used with the task of Carrasco et al., 2004, see Carrasco & Barbot, 2019).

Discussion

In the present study, we explored the origin of a perceptual bias: the decrease in perceived object size when objects are located in the visual periphery compared with when identical objects are located in the central regions of the visual field. We dissociated two basic explanations of this size-eccentricity effect by experimentally manipulating the spatial locus of attention while participants judged the size of two objects. The results were clear-cut: A robust size-eccentricity effect emerged when the central object was attended and it was absent (and descriptively reversed) when attention was drawn to the location of the peripheral object. Thus, the decrease in the perceived size of an object with retinal eccentricity that has been observed in previous studies is not a direct function of retinal eccentricity. Rather, the attentional state of the observer substantially contributes to this perceptual phenomenon. This striking influence of attention on perception could be mediated by dynamic adjustments of receptive fields of cortical neurons (Anton-Erxleben & Carrasco, 2013). Such a theoretical approach explains the observed reduction of the size-eccentricity effect when a peripheral object is cued by assuming that the receptive fields shrink at and drift toward the center of attention. This, in turn, enlarges the appearance of the corresponding part of the visual field.

Consistent with previous research, our findings further suggest that the impact of attention on size perception differs across retinal locations (e.g., see Carrasco et al., 2002). If the impact of attention were the same for each retinal location, and retinal location were homogenous, the size-eccentricity effect would have been completely reversed in the peripheral-object-cued condition (i.e., the size-eccentricity effect in the peripheral-object-cued condition would have the same magnitude as in the central-object-cued condition but a negative sign, indicating larger apparent size for peripheral objects). However, only a trend in the direction of inverse size-eccentricity effect was observed when the peripheral target was cued. This observation qualifies the attentional hypothesis by indicating structural constraints of the visual system, such as the varying density and size of receptive fields across the retina. For example, it has been suggested that larger receptive fields cause the size of an object to appear smaller (Moutsiana et al., 2016). Such a relationship would increasingly counteract the influence of attention with eccentricity and would thus prevent a complete inversion of the size-eccentricity effect. Structural constraints regarding the size of receptive fields thus seem to set boundary conditions for the impact of attention on size perception. Within these boundaries, however, changes in the apparent size of objects across the visual field seem to be determined by attentional processes that modulate the functional properties of the visual system. The critical point here is that it is not a stable state of a retinal location, such as its fixed density of receptive fields that determines the perceived size of the object. Rather it is the variable attentional state of that location.

To conclude, the present results suggest that objects appear smaller in the peripheral than in the central regions of the visual field not only because of the lower density and greater size of peripheral receptive fields but also because the peripheral regions are less attended.

Action Editor

Edward S. Awh served as action editor for this article.

Author Contributions

All authors contributed to the study concept and study design. Data were collected and analyzed by W. Kirsch. All authors collaborated on writing the manuscript and approved its final version for submission.

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Declaration of Conflicting Interests

The author(s) declared that there were no conflicts of interest with respect to the authorship or the publication of this article.

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Supplemental Material

Additional supporting information can be found at http://journals.sagepub.com/doi/suppl/10.1177/0956797619892624

Open Practices

Raw data have been made publicly available via the Open Science Framework and can be accessed at https://osf.io/49z3d/. The design and analysis plans for the experiments were not preregistered.

Notes

1. In the previous studies, the neutral cue was often presented at the center of the display, whereas the target stimuli appeared in the periphery. Thus, the attentional distribution induced by this type of cue in those studies may not be the same as in the irrelevant-location-cued condition of the present experiment.
2. According to the attentional hypothesis, the size-eccentricity effect can also be expected to decrease when an irrelevant location is cued compared with when no cue is presented. The magnitude of this effect, however, can be assumed to be rather small, so we did not consider it to be crucial for the comparison between the retinal-eccentricity and attentional hypotheses.

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