Ensemble size perception as a case study of the bounds of adaptation

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Abstract: Repulsive adaptation effects are widely assumed to obtain for all perceptually represented dimensions. However, the ubiquity of adaptation effects within perception remains untested. We examined ensemble size adaptation as a case study to probe whether adaptation occurs for all perceptually encoded properties. Across three experiments, we investigated whether observers adapt to average size and/or cumulative size of dot arrays. In Experiments 1a and 1b, participants adapted to displays varying in cumulative and/or average dot size, then judged either the average dot size (1a) or cumulative dot size (1b) of paired test displays. Results revealed robust adaptation to cumulative size but not average size, regardless of task instructions. Experiment 2 tested "reverse" adaptation to displays containing smaller average and/or cumulative dots size and found adaptation effects for cumulative size only. These findings force a reinterpretation of previous results investigating size adaptation and blunt the force of arguments which assume adaptation to be universal within perception, given a large body of work that finds average size to be perceptually encoded.

Keywords: visual adaptation, ensemble perception, size perception, average size, cumulative size, perceptual representation

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The visual system 'adapts' to a wide range of features. You have probably experienced at least one form of visual adaptation yourself: If you stare at a bright red square for twenty seconds, then shift your gaze to a white wall, you will visually experience a green square in the retinotopic location of the original item. The green aftereffect that you experience is an example of *color* adaptation, a repulsive visual aftereffect that occurs following prolonged exposure to its opponent color. You may have also experienced repulsive visual aftereffects to things like motion: If you stare at a waterfall and then avert your gaze, you will vividly experience motion, even in stationary stimuli. In fact, adaptation of this sort is not limited to visual perception. Such aftereffects are common to all perceptual systems (see, e.g., Calzolari et al., 2017; Dalton, 2000; McBurney & Pfafmann, 1963; McBurney et al., 1972). If you rest your hand on your arm for a minute or two, you'll notice that you stop having the sensation of your hand resting there. As with visual color adaptation, this experience reflects a decreased sensitivity to the experienced dimension (in this case, the press of the hand).

How pervasive are these adaptation effects? In recent work, considerable attention has been paid to the issue of whether adaptation effects are uniquely perceptual. This is prompted by many prominent researchers assuming as much (c.f. Clarke & Yousif 2025; Helton 2016; Phillips & Firestone 2023). For instance, it has been argued that since number adaptation exists, number must be a "primary visual attribute"; represented in vision, much like color and shape, and not merely encoded at the level of post-perceptual thought (Anobile et al. 2016; c.f. Yousif & Clarke forthcoming). Similar arguments have been made with respect to other, contested visual properties that adapt including causality (Rolfs et al., 2013), gender, emotion, race (Webster et al., 2015) and variance (Maule & Franklin, 2020).

In the present treatment, we consider the inverse of this claim. Instead of asking whether adaptation can and does occur outside of perception, we ask: Is adaptation *ubiquitous* within perception, applying to *all* perceptually represented properties? In other words, are there perceptually represented dimensions that fail to adapt?

This question has received much less attention than the first. However, a common suggestion seems to be 'No', with researchers routinely assuming that all perceived dimensions adapt. For instance, Block (2014) argues that since we don't adapt to learnt or enculturated properties (but see Clarke & Yousif, 2025) these properties must not feature in the contents of perception and perceptual experience, *pace* salient arguments to the contrary (Siegel 2010). Likewise, Burr et al. (2025) assume as much when defending their claim that humans adapt to number against recent critiques (Yousif et al. 2024; 2025). According to them we should expect that number adaptation is real, for the simple reason that "If [number] did not adapt it would be unique amongst perceptual attributes, worthy of very special attention" (p. 5).

But what, exactly, justifies this assumption that adaptation is ubiquitous in perception, applying to all or virtually all perceptually represented dimensions? One motivation seems to be the simple observation that readily appreciable and phenomenologically striking adaptation effects obtain for many canonical visual and perceptible properties – including color, orientation, brightness, motion, temperature and weight. But while this much is consistent with the ubiquity of perceptual adaptation, it is non-obvious that this ubiquity really stands up to scrutiny. For instance, Phillips and Firestone (2023) note that it is questionable whether people adapt to properties like symmetricity/ asymmetricity and to-the-left vs. to-the-right, even though these properties plausibly feature in the contents of human vision. Thus, a question arises: Is adaptation ubiquitous in perceptual representation? Or are there perceptual contents that *fail* to exhibit adaptation?

To answer this question, we take size adaptation as a case study. More specifically, we focus on *ensemble* size adaptation. One reason for our interest in size adaptation is that, while size exhibits perceptual adaptation (see, e.g., Kreutzer et al., 2015; Pooresmaeili et al., 2013; Yousif & Clarke, 2024; Zeng et al., 2017), it is not yet clear what *kind(s)* of size adaptation occur. Most prior studies on the phenomenon focus entirely on adaptation to the size of individual objects, though one prior study has reported finding that people adapt to *average* size (i.e., of a collection of dots) as well (Corbett et al., 2012). Given the received view that adaptation is pervasive in perception, it is natural to expect that adaptation would obtain for ensemble properties like average size, since many ensemble properties are taken to be perceptually represented (for review, see Whitney & Yamanashi Leib, 2018). This is particularly true of average size, which has been studied in this context extensively (Albrecht & Scholl, 2010; Ariely, 2001; Marchant et al., 2013; Sweeney et al., 2015).

There is, however, an important complication: Given the long history of work finding evidence of average size perception, prior work on ensemble adaptation has failed to tease apart adaptation to average size from adaptation to cumulative size (Corbett et al., 2012). Given the available evidence, it may then be that people adapt to average size, or cumulative size, or both. This distinction matters if we are interested in understanding the nature and scope of perceptual adaptation. Suppose, for instance, that people adapt to cumulative size but not average size. Would that mean, as per the logic employed by those hypothesizing that adaptation is diagnostic of perception (see Block, 2023; Burr et al., 2025), that cumulative size but not average size is perceived? And if that is the case, what should be made of the typical and widely supported assertion that ensemble features like average size are canonical perceptual attributes? At the very least, this result would complicate arguments that are premised on the assumption that adaptation is ubiquitous in perception and found among all perceived dimensions.

Current study: The bounds of adaptation

The present study asks whether ensemble representations of average size and/or cumulative size exhibit perceptual adaptation. We focus on size adaptation because (a) it is a relatively uncontroversial form of higher-level visual adaptation, and (b) it provides a natural means of teasing apart different ensemble properties. We view this as a critical test of the claim that adaptation is, or might be, ubiquitous in perception. However, a further aim of our study is simply to understand the phenomenon of size adaptation itself, and to better understand when and where the visual system adapts to ensemble properties. For this reason, we will additionally test, for any dimension that does exhibit such adaptation, whether that dimension also exhibits 'reverse' adaptation (wherein a smaller value exerts upward pressure on a larger value), since this has been a point of contention in many recently reported instances of perceptual adaptation to ensembles (Yousif et al. 2024; Yousif & Clarke 2024).

We can imagine three possible outcomes from our experiments. One outcome is that people adapt to both average and cumulative size. Such a pattern may support the view that any visual property is or can be prone to adaptation, and that both average and cumulative size feature in the contents of human vision. Another possible outcome is that people adapt to average size but not cumulative size. Such a pattern of results might be expected insofar as average size has been studied extensively as a perceptual property, while cumulative size has not. However, a final possibility is that people adapt to cumulative size but not average size. This pattern might be the most surprising, since prior work has assumed that average size is perceived (and thus should, given claims of perceptual adaptation's ubiquity, exhibit adaptation) where less attention has been paid the perceptual encodability of cumulative size. We have no clear reason for expecting one of these outcomes over the other; all patterns would shed light on the nature of both visual adaptation to size and to ensembles.

Experiments 1a and 1b:

Intro

To evaluate ensemble size adaptation, we had participants adapt to displays that varied in cumulative size and average size (see Figure 2A). We tested whether they adapted to one or both of these dimensions. Critically, we ran two different versions of the experiment: In Experiment 1a, participants were asked to evaluate average size, while in Experiment 1b, participants were asked to evaluate cumulative size. In both cases, they saw the same displays; all that changed was the instructions. This design allowed us to independently assess (a) whether people adapt to cumulative vs. average size and also (b) whether this adaptation depends on the explicit instructions they are given.

Methods

The design, sample size, and analysis plan were all pre-registered in advance. The pre-registration as well as raw data for both experiments can be found on our OSF page: https://osf.io/k2qm6/?view_only=6a29b95671e0493fad0510739c66a3f9

Participants. Forty undergraduate students (20 per experiment) participated through a volunteer participant pool in exchange for course credit. All participants were adults, aged 18 years or older, who were proficient speakers of English. There were no exclusions. The study was approved by the relevant IRB.

Stimuli. Stimuli were black dot arrays presented on a white background, positioned to the left and right of a central fixation cross. For both cumulative and average size, we manipulated cumulative/average diameter rather than true size. This is because a wide range of work has demonstrated that perceived size is roughly equivalent to diameter size rather than true area (Yousif & Keil, 2019, 2021). This choice is also consistent with prior work on size adaptation (Corbett et al., 2012). All subsequent units mentioned reflect pixels of diameter length.

The parameters of the adaptors and targets were designed to dissociate effects of cumulative size and average size within a single stimulus set. To simplify the experiment, all target stimuli had exactly 20 dots. Most target stimuli had a total size of 400 units. 40% of the time, one of the target stimuli had a total size of 480 units (equally often on the left and right side). This allowed us to assess whether participants were properly sensitive to true differences in size. Individual dots could be as small as 10 pixels in diameter or as large as 50 pixels in diameter. Locations of dots were randomized with the constraint that they could not appear within 20 pixels of another dot (from edge to edge).

There were four possible configurations for the adaptor stimuli. Relative to the corresponding target stimulus, it could have had: (a) The same total area, but a higher average dot area, (b) a higher total area, but the same average dot area, (c) a higher total area and a higher average dot area, or (d) the same total area and the same average dot area. The adaptor appeared on the left and right sides equally often. Therefore, there were: 4 possible adaptor configurations, 2 possible adaptor sides (left, right), and 5 possible target area combinations. In practice, this meant that the number of dots in the adaptor stimuli could be either 10, 20, or 40. This setup resulted in a total of 40 trials. The order of trials was fully randomized for each participant. Participants completed a single representative practice trial before starting the main task.

Procedure & Design. Prior to beginning the task, participants were given basic instructions about the task. They were explicitly told whether they were to judge average vs. cumulative size (depending on which condition they were assigned to; see below). They were shown some example displays as well as one example of a full adaptation trial (the data from which were not recorded). Throughout the instructions, participants were able to ask clarification questions as needed. They began the task once they indicated that they fully understood what they were meant to do. All participants viewed the same trials in a unique random order, each beginning with a 25-second adaptation phase, followed by a 750 ms test display, after which the screen would remain blank until a participant indicated a response. They were instructed to press the "Q" key if they thought the left side was greater in average/cumulative size; they were instructed to press the "P" key if they thought the right side was greater in average/cumulative size.

Participants were randomly assigned to one of two conditions: In Experiment 1a, they were asked to indicate which side had greater *average* dot size; In Experiment 1b, they were asked to indicate which side had greater *cumulative* dot size. Note that in both experiments, however, they experienced trials in which the adaptor varied with respect to both cumulative and average size. Stimulus presentation, randomization, and the debriefing protocol were identical across both groups; the only difference was whether they were told to evaluate cumulative or average size.

Results & Discussion

The results of Experiment 1 can be seen in Figure 2. As is evident from the figure, when participants were asked to assess *average* size (Experiment 1a), we found an adaptive effect of cumulative size ($t(19)=4.34$, $p<0.001$, $d=0.97$), but not average size ($t(19)=1.60$, $p=0.13$, $d=0.36$), (difference: $t(19)=2.82$, $p=0.01$, $d=0.63$). The same was true when participants were asked to assess *cumulative* size (Experiment 1b): we found a clear adaptation effect on cumulative size ($t(19)=2.80$, $p=.012$, $d=0.63$), but not average size ($t(19)=0.43$, $p=0.67$, $d=0.10$; difference: $t(19)=3.74$, $p=0.001$, $d=0.84$). In other words, regardless of the dimension participants were asked to evaluate, they only exhibited a repulsive aftereffect (i.e., chose the opposite side of the display) when the adaptor had a larger cumulative size than the corresponding target.

A careful reader might notice that, because dissociating average size from cumulative size requires varying *number*, these results could plausibly be explained as a kind of number adaptation rather than a kind of size adaptation. We think this is unlikely to be the case, for several reasons. First, we believe that number adaptation is unlikely to be genuine (Yousif et al., 2024, 2025). Second, it is not clear why adaptation to number would influence judgments of size, since proponents of number adaptation are committed to the view that while observers experience a reduced sense of number following number adaptation, "no particular dots seem to be missing" (Burr & Ross, 2008; p. 426; but see Cicchini et al., 2016 and Yousif & Keil, 2020 for the possibility that this occurs via a congruency effect). Finally, and most importantly, we believe that the complete data straightforwardly contradicts this concern: On trials where the adaptor has a greater average value *and* a greater cumulative value (but no difference in number), there is still a robust adaptation effect (Experiment 1a: $t(19)=3.38$, $p=0.003$, $d=0.76$; Experiment 1b:

$t(19)=4.49$, $p<0.001$, $d=1.00$). This effect cannot be explained by number (because number does not differ across these conditions) and seems unlikely to be explained by average value (since we failed to find evidence of such adaptation). The most parsimonious interpretation of the full data set is that people adapt to cumulative size, but not average size, regardless of number.

This work extends prior work on size adaptation (e.g., Pooresmaeili et al., 2013; Yousif & Clarke, 2024; Zeng et al., 2017) by demonstrating that observers adapt to some, but not all, ensemble representations of size. These results contradict the conclusions of prior work purporting to show adaptation to average size (Corbett et al., 2012). However, that prior work held the number of items constant, such that adaptation to average size was conflated with adaptation to cumulative size. The present data suggest that cumulative size rather than average size may have driven those prior effects. This is supported by the fact that we observed the same kind of repulsive aftereffect to cumulative but not average size in both experiments. After all, if ensemble size adaptation was fragile or easily disrupted, such that different experiments produced genuinely conflicting results on this matter, we might expect that it be easily influenced by differences in task instructions.

Together, these results suggest that while people may adapt to certain ensemble representations of size, they seem not to adapt ubiquitously to *all* perceptual size representations.

Experiment 2

In Experiments 1a and 1b, we found that adaptation to cumulative size produced a repulsive effect: participants were more likely to judge the collection on the side opposite to that of the adaptor to be larger. However, in those experiments the adaptor was always larger than the target stimuli. In Experiment 2, we tested whether "reverse" adaptation, adaptation to a smaller array, would produce a comparable repulsive (this time: upward) aftereffect.

If cumulative size is represented at a perceptual level, one might expect adaptation to be bidirectional, with both larger and smaller adaptors producing perceptual shifts. However, prior work suggests that size adaptation is often asymmetric: larger adaptors tend to induce stronger perceptual biases than smaller ones (Pooresmaeili et al., 2013; Zeng et al., 2017; but see Yousif & Clarke 2024).

While Experiment 2 mirrors the structure of Experiments 1a and 1b, it provides an exploratory test of whether adaptation to smaller cumulative sizes can produce reliable upward-directed perceptual biases, given that prior studies often report weaker or absent effects in this context.

Methods

This experiment was identical to Experiments 1a and 1b except as noted below.

The parameters of the adaptors and targets were designed to dissociate effects of cumulative size and average size within a single stimulus set, as in Experiments 1a and 1b. To simplify the experiment, all target stimuli had either 20 or 40 dots. Most target stimuli had a total size of 800 units. 40% of the time, one of the target stimuli had a total size of 960 units (equally often on the left and right side). This allowed us to assess whether participants were properly sensitive to true differences in size. Individual dots could be as small as 10 pixels in diameter or as large as 50 pixels in diameter. Locations of dots were randomized with the constraint that they could not appear within 20 pixels of another dot (from edge to edge).

As in Experiments 1a and 1b, there were four possible configurations for adaptor stimuli. Relative to the corresponding target stimulus, it could have: (a) The same total area, but a higher average area, (b) a higher total area, but the same average area, (c) a higher total area and a higher average area, or (d) the same total area and the same average area. The adaptor appeared on the left and right sides equally often. Therefore, there were: 4 possible adaptor configurations, 2 possible adaptor sides (left, right), and 5 possible target area combinations. In practice, this meant that the number of dots in the adaptor stimuli could be either 10, 20, or 40. This setup resulted in a total of 40 trials. The order of trials was fully randomized for each participant. Participants completed a single representative practice trial before starting the main task.

In this experiment, all adaptors were smaller than the target arrays, allowing us to test whether adaptation to smaller cumulative sizes would produce comparable aftereffects.

Results & Discussion

The results of Experiment 2 can be seen in Figure 3. As is evident from the figure, we found a 'reverse' adaptation effect for cumulative size (cumulative: $t(19)=3.32$, $p=0.004$, $d=0.74$) but not average size ($t(19)=.85$, $p=0.41$, $d=0.19$; difference: $t(19)=3.05$, $p=0.007$, $d=0.68$). That is, when the adaptor had a *lower* cumulative size than the corresponding target, participants were more likely to indicate that the adapted side was *greater* in cumulative size. However, when the adaptor had a *lower* average size than the corresponding target, participants were no more likely to indicate that the adapted side was *greater* in average size.

The existence of reverse cumulative size adaptation is surprising, given that (a) prior work has documented effects of average size adaptation, but not cumulative size adaptation (Corbett et al., 2012), and it is intriguing given that (b) many other cases of high-level visual adaptation exhibit only unidirectional or asymmetric effects (such that there is no 'reverse' adaptation effect; see Yousif et al., 2024, 2025; Pooresmaeli et al., 2013). We therefore find these results particularly compelling, as this form of adaptation appears to be more robust than comparable cases of adaptation.

General Discussion

Across three experiments, we have shown that (1) when observers were asked to evaluate *average* size, they readily adapt to cumulative but not average size (Experiment 1a), (2) when observers were asked to evaluate *cumulative* size, they also readily adapt to cumulative but not average size (Experiment 1b), and (3) observers also exhibit 'reverse' cumulative (but not average) size adaptation, such that adapting to a display of a lower cumulative size (but middling average size) exerts upward adaptive pressure on a subsequent stimulus of higher cumulative size (Experiment 2). Collectively, these results suggest that people adapt to some, but not all, properties of perceived ensembles. Furthermore, they contradict prior work which claims to find adaptation to average size (Corbett et al., 2012), and perhaps most surprisingly, indicate that the existence of this adaptation is relatively impervious to the instructions that participants are given.

These results, thereby, point to several distinctive and surprising signature limitations on size adaptation. For us, though, size adaptation is really just a 'case study': What we really care about is *ensemble adaptation* more broadly – adaptation that occurs not over the visual properties of an individual item (e.g., the orientation of a line, or the size of a square, or the motion of a dot), but over the properties of a *set* of items (e.g., the cumulative size of a collection of dots, or their average hue, or their number). Prior work has investigated instances of ensemble adaptation including adaptation to number (Burr & Ross, 2008), texture density (Durgin, 1995) average motion direction (Kar & Krekelberg, 2014), average size (Corbett et al., 2012), variance (Maule & Franklin, 2020), and even *cumulative value* (Clarke & Yousif, 2025), yet most of this work fails to engage with the theoretical significance of such adaptation (but see Corbett et al., 2012).

The significance is not lost on Bayne and McLelland (2019), however, who note that adaptation may help to adjudicate whether ensemble perception should in fact be considered a genuine case of 'perception'. Citing work from Block (2014; see also Block, 2023) and other philosophers (Burge, 2014; Fish, 2013), they note that "...the strongest evidence for a perceptual view of ensemble coding is adaptation" (p. 738). On such a view, evidence of adaptation to average size may be viewed as tantamount to proving that average size is represented by the visual system directly. Indeed, this exact argument is made about cases like number adaptation (Burr & Ross, 2008).

That said, Bayne and McLelland go on to clarify that they are skeptical of the link between adaptation and perceptual processing: "...our own view is that it is very much an open question whether adaptation is a mark of perception" (p. 738). We agree (see Yousif et al., 2024, 2025; Yousif & Clarke, 2024; Clarke & Yousif, 2025; Yousif & Clarke forthcoming;

see also Phillips & Firestone, 2023). Nevertheless, we think it is clear that adaptation has a role to play in understanding perceptual (and plausibly perceptual) processes.

We also think there's also another, lesser examined, side to this coin: In the same way that adaptation may have a role to play in helping us to answer important theoretical questions about ensemble representation, ensemble representation may help us to answer important theoretical questions about adaptation. Namely: What *is* adaptation, exactly (see Clarke & Yousif, 2025; Yousif & Clarke, forthcoming)? What are its limits? Are there *a priori* reasons to expect that certain features should exhibit adaptation but not others? Simple as these questions may seem (if we think that ensemble representations are perceptual, and perceptual attributes exhibit adaptation, then of course ensemble representations would exhibit adaptation!), the present results are just one example of how this picture is more complex than many assume. Prior to any data collection, we suspect that most would have predicted that we would find adaptation to *average* size, with some uncertainty about whether we would find adaptation to *cumulative* size. Yet what we found stands in contrast to the only other evidence on the matter (Corbett et al., 2013), and in a way that complicates our understanding of both ensemble representation and adaptation.

On the adaptation side of the coin, these results demonstrate a clear case in which participants fail to adapt to a plausibly perceptible feature (average size). The failure to observe adaptation in this case is noteworthy in a landscape where it is routinely assumed that every perceptual feature under the sun exhibits adaptation (and even features that are not plausibly perceived, see Clarke & Yousif, 2025). Null findings like these are important for drawing a bounding box around the phenomenon of adaptation. Without such a bounding box, adaptation effects may proliferate endlessly, becoming so ubiquitous that they are unable to serve as a meaningful, theoretical litmus test (see also Clarke & Yousif, 2025). We might now say (in light of these results and others) that the visual system adapts to *some* but not *all* perceptually encoded ensemble properties — leaving open plenty of room for future empirical work to paint a clearer picture of exactly when and where adaptation obtains.

One might be tempted to dismiss our single null effect as an anomaly, given robust evidence of ensemble adaptation in other cases (see Burr & Ross, 200; Corbett et al., 2012; Durgin, 1995; Maule & Franklin, 2020). However, we think that each such case must be examined carefully. We have recently argued, for instance, that there are many unanswered questions regarding both size adaptation (Yousif & Clarke, 2024) and number adaptation (Yousif et al., 2024, 2025). Despite seemingly overwhelming evidence in favor of number adaptation, we argue that this evidence either (a) can be explained by other visual mechanisms that all parties must accept as actual, or (b) is insufficiently robust to license the strong claims that have been made about it. Whether we are ultimately right or wrong about that (for a more recent perspective, see Yousif & Clarke forthcoming), we've highlighted plenty of reasons why that skepticism is warranted until more convincing evidence comes to light.

Truly 'visual' adaptation?

As we (see Yousif et al., 2024, 2025; Yousif & Clarke, 2024; Clarke & Yousif, 2025) and others (Helton 2016; Bayne and McLelland, 2019; Smortchkova 2019; Phillips & Firestone, 2023) have pointed out, there's reason to be skeptical about any strong link between adaptation and perception. Traditionally, adaptation is considered to be diagnostic of perceptual processing insofar as (a) the resulting effects are phenomenologically compelling, such that any observer can (literally) see them with their own eyes, and (b) they are retinotopic (i.e., specific to a location on the retina; see Kominsky & Scholl, 2020; Rolfs et al., 2013) or at least spatiotopic (i.e., specific to a location in external coordinates; see Arrighi et al., 2014; Block, 2023; Clarke & Yousif, 2025). In this case, it isn't obvious that the effects documented here are phenomenologically compelling, at least not when compared against other canonical adaptation effects (although, this is common for higher-level adaptation effects, which often don't work well as demonstrations). And while these effects are spatially selective to some degree (insofar as adaptation only occurs on the side of space in which the adaptor was present), we did not go so far as to test whether these effects are retinotopic.

For us, this 'case study' is not about adjudicating whether adaptation is a genuine marker of perceptual content (for that, see our other work; e.g., Clarke & Yousif, 2025). The aim of this study was to understand whether, among those properties that would fit under the growing umbrella of 'visual' adaptation, on the grounds that the property in question is encoded by the visual system, there are certain properties that decisively fail to exhibit such adaptation. And much to our surprise, these results force an unexpected conclusion — that people may not adapt to *average* size (as many likely would have been expected, and as has been claimed in prior work; Corbett et al., 2012) but do instead adapt to *cumulative* size. Whether this cumulative size adaptation is truly visual in nature remains an open question (and, per our points above, we are not sure how exactly it could be answered). Nevertheless, our results indicate that properties that are typically seen to be represented in perception (average size) can fail to adapt.

Conclusion

Ensemble representation and adaptation are both key theoretical constructs in modern vision science. The study of one constrains the other: Insofar as ensembles are regarded as perceptual properties, as they routinely are, and insofar as adaptation is expected to occur over all perceptual properties (see, e.g., Burr et al., 2025), the presence or absence of adaptation to any putative ensemble property bears on debates about ensemble representation, adaptation, or both. There is more work to be done here, both on the ‘ensemble’ and ‘adaptation’ sides of the puzzle, but findings like these bring us one step closer to a complete and coherent understanding of both — and blunt the force of recent arguments premised on the assumed ubiquity of adaptation effects within perception.

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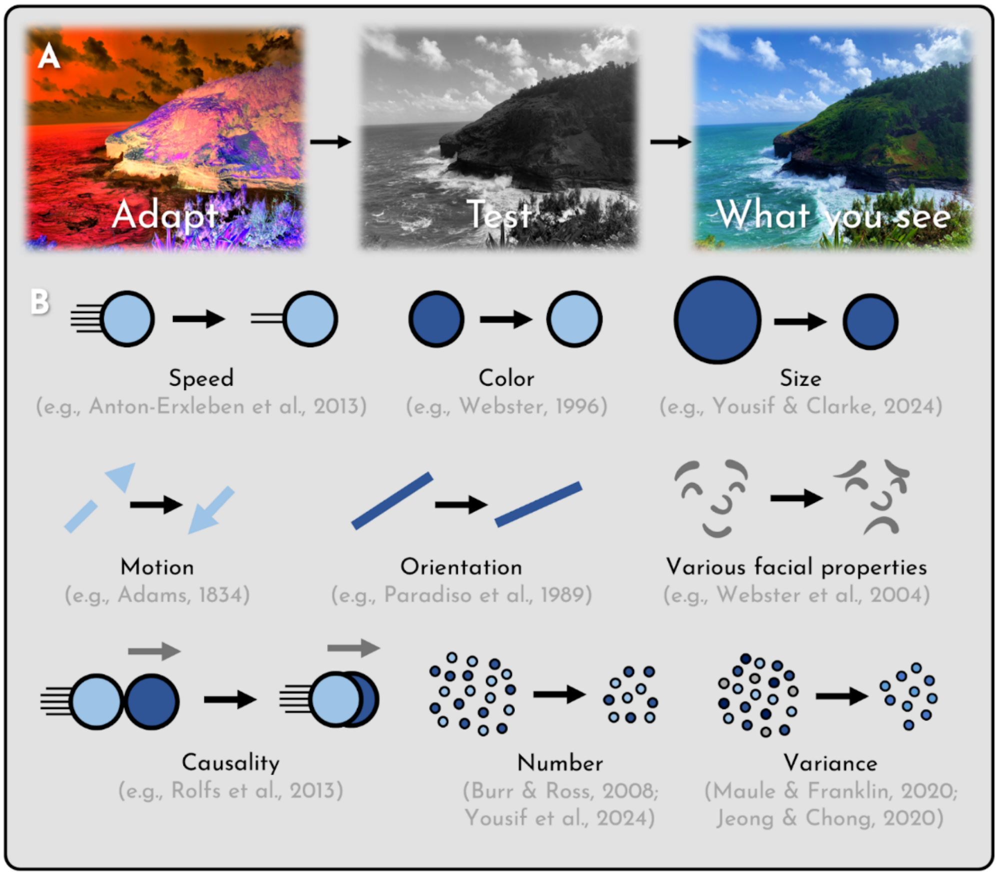

Figure 1. What is adaptation? (A) An example of color adaptation, a canonical instance of visual adaptation. (B) Illustrations of various other instances of visual adaptation.

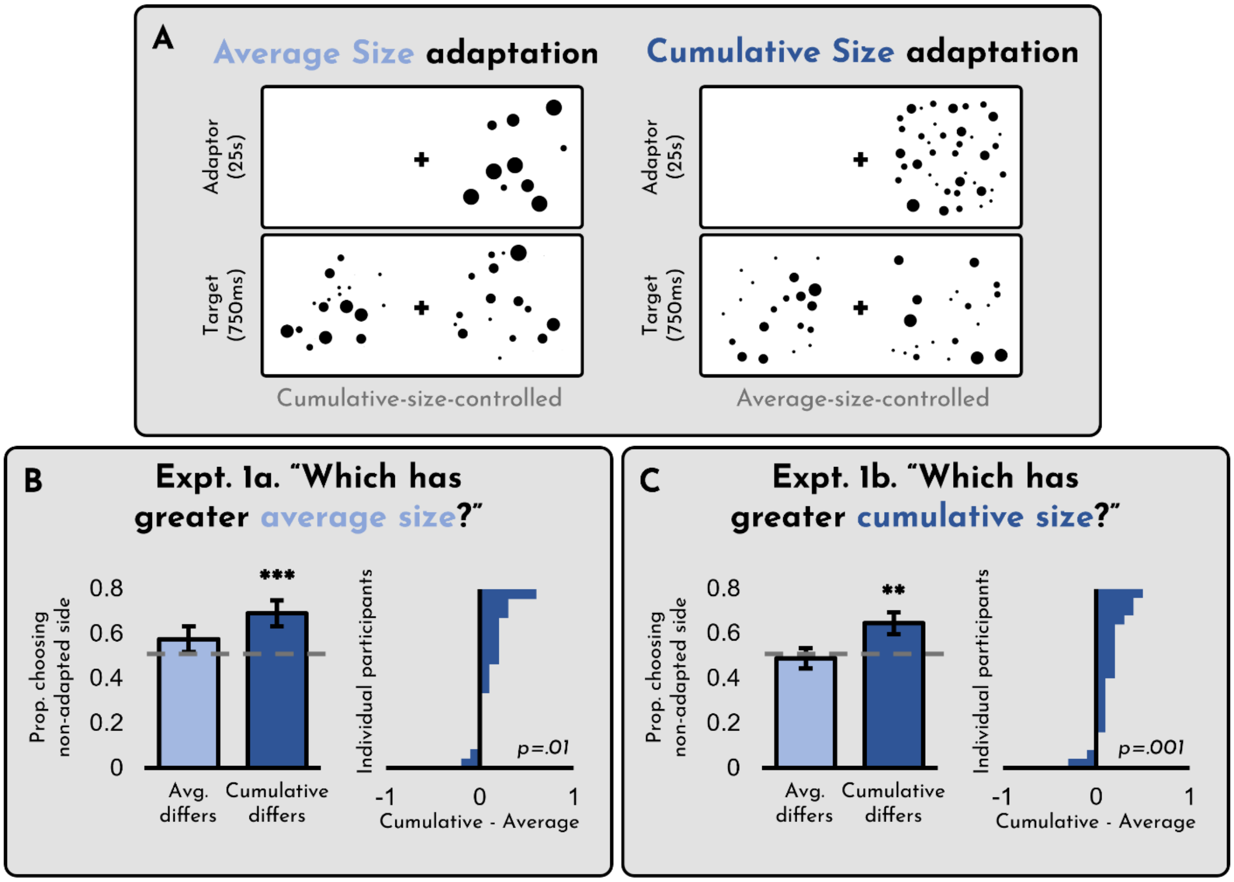

Figure 2. (A) Design of Experiments 1a and 1b. Both experiments included the same trial types; they differed only in what participants were asked to evaluate. (B) Results of Experiment 1a. (C) Results of Experiment 1b.

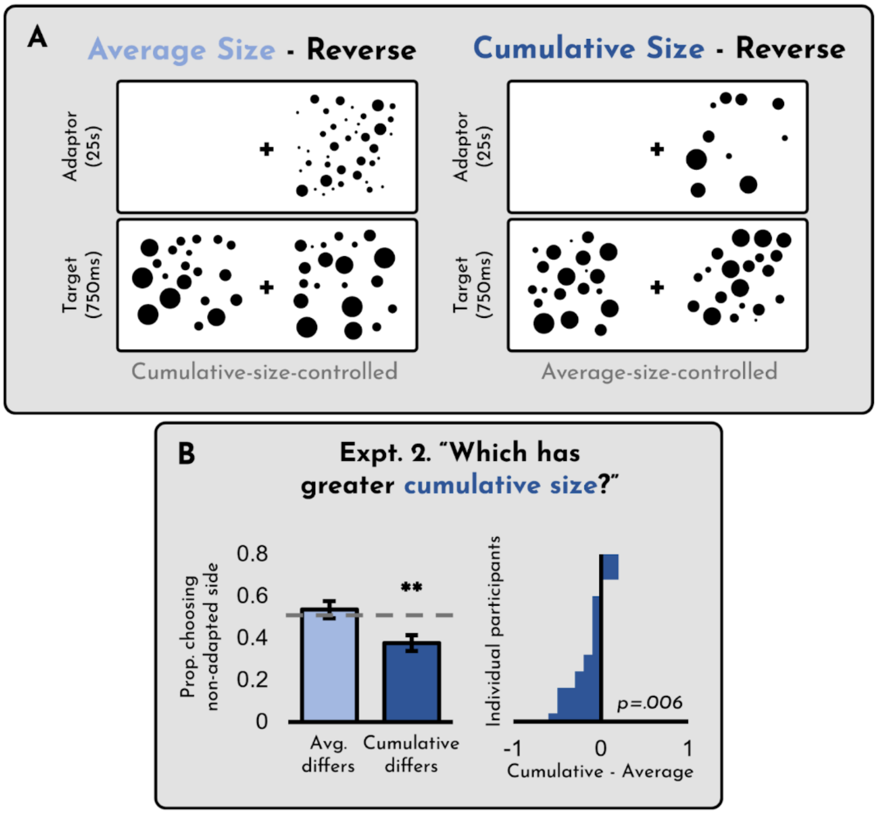

Figure 3. (A) Design of Experiment 2. (B) Results of Experiment 2.