Subjective inflation: phenomenology's get-rich-quick scheme

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Highlights

- Researchers disagree about whether visual phenomenology is rich or sparse.
- Studies show that minimally attended and/or peripheral phenomenology is subjectively overestimated based on what objective perceptual capacity would predict.
- This subjective *inflation* effect points to a theoretical position that that is somewhat intermediate between the Rich and Sparse views: the content of peripheral phenomenology is sparse, but its reliability is subjectively overestimated, making it *feel* rich.

Abstract

How do we explain the seemingly rich nature of visual phenomenology while accounting for impoverished perception in the periphery? This apparent mismatch has led some to posit that rich phenomenological content *overflows* cognitive access, whereas others hold that phenomenology is in fact sparse and *constrained by* cognitive access. Here, we review this Rich vs Sparse debate as it relates to a phenomenon called subjective inflation, wherein minimally attended or peripheral visual perception tends to be subjectively evaluated as more reliable than attended or foveal perception when objective performance is matched. We argue that subjective inflation can account for rich phenomenology without invoking phenomenological overflow. On this view, visual phenomenology is constrained by cognitive access, but seemingly *inflated* above what would be predicted based on sparse sensory content.

Introduction

There is a longstanding and currently lively debate about whether or not visual phenomenology overflows cognitive access (see recent themed issue of Philosophical Transactions of the Royal Society B [1–10]). The question of phenomenological overflow is often rephrased as asking whether phenomenology is rich or sparse. On the Rich view, a snapshot of visual phenomenology is highly detailed across the visual field, while cognitive access is constrained to a subset of that detail given the limited capacities of attention, memory, and reporting

mechanisms [2,11–19]. This view is supported by anecdotal reports from subjects in partial-report studies [18–20] in which they indicate having seen more of a given stimulus array than their objective task performance would suggest. The Rich view further posits, based on both partial-report and dual-task studies [9,21,22], that attention is not necessary for phenomenology.

Proponents of the Sparse view argue, relying largely on the results of inattention blindness [23–25] and change blindness [26] studies, that phenomenology itself is constrained by, and thus scales with, cognitive access. On this view a snapshot of visual phenomenology is highly detailed around the focal point of attention where there is strong cognitive access, but loses detail as attention drops off in the periphery, where there is minimal cognitive access [3–5,27–31]. Furthermore, on the Sparse view, phenomenology and cognitive access tend to scale with attention, though this relationship is not necessarily monotonic. Importantly, proponents of this view argue that, without consensus on an operational definition of attention, we cannot definitively claim that attention is not necessary for phenomenology [28,29,32].

Importantly, it has been suggested that the debate about phenomenological overflow, and by extension, the Rich vs Sparse debate, may be empirically intractable [7,8,27–31,33,34]. The major issue usually raised is that while empirical studies of phenomenology fundamentally rely on subjective reports, unaccessed phenomenology is, by definition, unreportable. Therefore, if unaccessed phenomenology cannot be detected, its presence neither confirmed nor denied, the results of any given study can in principle be interpreted as being consistent with either the Rich or the Sparse view [4,6–8,28,29,33].

George Sperling's iconic-memory experiments [18] provide an example where such alternative interpretations are available. When participants were briefly (50 ms) shown a 3x4 array of alphanumeric characters and asked to report the identities of as many characters as possible, they could successfully remember about four of the twelve characters. However, when the task was modified such that *after* presentation of the array, a postcue indicated one of the three rows from which subjects were to recount as many characters (out of 4) as possible, the task was performed nearly perfectly [18]. On a Rich interpretation, the details of all of the characters in the array were present in high fidelity in phenomenology, and the postcue allowed participants to access and report on a subset of that rich information before it decayed due to the constraints of working memory. On a Sparse interpretation, initially unattended details in the array were represented unconsciously, and postcued attention made those details available for report. Because the only measure of phenomenology is the subjects' reports, neither interpretation is obviously more tenable than the other.

A similar problem arises when trying to address more directly whether attention is necessary for consciousness. A common way to test this is to try to demonstrate that some task can be performed in the absence or near absence of attention, for example using a dual-task paradigm [9,21,22,35,36]. But again, without a working operational definition of attention, it is unclear how either the complete or near-complete elimination of attention could be unequivocally

demonstrated in an experimental setting. Some have argued that this similarly makes the debate about the necessity of attention empirically intractable [28,29,32].

In light of these concerns, Ned Block has suggested that currently the best approach to the Rich vs Sparse debate is to consider the extant empirical evidence and use inference to the best explanation [12,37]. Here, we agree with Block's methodological appeal. We highlight an approach that, instead of attempting to investigate visual phenomenology in the complete or near-complete absence of attention, exploits the fact that attention is graded, and investigates the *interaction* between attention and phenomenology. Such an approach consistently reveals a phenomenon known as *subjective inflation*, wherein study participants exhibit liberal detection criteria or are overly confident when evaluating minimally attended or peripheral stimuli [10]. We argue, in line with [10], that this can explain the subjective impression of richness across the visual field appealed to by Block [12], while accounting for both behavioral [23–26] and physiological [38,39] limitations in minimally attended perception, all without invoking phenomenological overflow.

Empirical evidence for subjective inflation

It is well established that attention boosts objective perceptual performance [40]. It has also been shown that subjective and objective measures of perception can be dissociated in clinical cases of blindsight [41,42], as well as in normal observers [43]. It follows that if we want to isolate a subjective measure of phenomenology for comparison between conditions of low and high attention (or low and high retinotopic eccentricity), then objective task performance should be treated as a potential confound and matched between those conditions [44].

Rahnev et al. [45] employed the strategy described above by matching objective performance, as indexed by the signal detection theory (SDT) sensitivity measure, d' [46], between attended and minimally attended conditions in a visual detection task (Fig. 1). They found that the SDT criterion measure, c , was systematically more liberal in the minimally attended condition (Fig. 1B). On a detection task, a lower value of c equates to a higher proportion of trials in which the observer incorrectly reports the presence of the target stimulus, i.e., a higher false alarm rate [45, Supplementary Fig. 3]. This difference in false alarm rate between attended and minimally attended conditions is of particular note given that stimulus strength is matched (at zero) across all false alarm trials.

One could argue that the observed shift in criterion reflects a change in non-perceptual decisional bias [47]. However, we interpret this shift to reflect a genuine change in subjective perception, as it was robust to trial-by-trial feedback and increases in monetary rewards, manipulations that are thought to minimize non-perceptual response biases [45,47,48]. On this interpretation, the observed criterion shifts in [45] suggest that subjective awareness is systematically *inflated* relative to objective processing capacity in conditions of minimal attention. It is worth emphasizing that this effect may seem, at least initially, to be counterintuitive: despite performance matching, one might reasonably expect that when attention is reduced observers might be more conservative in their detection judgments. This could be due to prior knowledge that, under normal conditions, unattended vision is relatively poor. However, we observe the opposite: given matched objective capacity, when attention is reduced, participants are more likely to say something is there when it is not.

Figure 1. An empirical demonstration of subjective inflation from [45]. **a)** Stimuli and task. Each trial was initiated by a pre-cue that indicated to which diagonal (top-right and bottom-left or top-left and bottom-right) the subject should attend. This was followed by a stimulus array, in which each diagonal (independently) contained either a set of tilted gratings embedded in noise or noise alone. This was followed by a response cue, which prompted the subject to indicate, in a forced-choice manner, whether or not the diagonal in the stimulus array indicated by the response cue had contained a set of gratings. The pre-cue and response cues were congruent on 70% of trials. **b)** Behavioral results show matched detection sensitivity, d' , between cued and uncued conditions, but a more liberal criterion measure, c , in the uncued condition relative to the cued condition. Reprinted with modifications and permission from [45].

This inflation effect has been replicated and extended in several independent studies. One study found a consistent decrease in detection criterion in peripheral vision compared to central vision despite matched detection d' [48]. This effect was again robust to trial-by-trial feedback. Similarly, in a study that was not designed to test inflation, more liberal change detection criteria were observed for fragile visual short term memory compared to working memory, despite matched change detection d' between the two conditions [49]. The authors interpreted this as being analogous to the inflation effect in [45], as there was presumably higher attention in the working memory condition. Another study, which used a relatively naturalistic setting of simulated driving, found that participants had more liberal criteria for detecting the color of a simulated pedestrian's shirt when attention was minimized [50]. To test whether this initial observed inflation effect was due to a decisional-level confirmation bias, a control experiment was conducted in which the detection target (i.e., the color to be detected out of a set of 11 colors) was not revealed until after presentation of color stimuli, and it was found that the inflation effect was no longer present. This suggests that the observed criterion shift in [50] was not due to simple confirmation bias, which, much like the trial-by-trial feedback results in [45] and [48], indicates that the observed inflation effect was perceptual as opposed to decisional.

Inflation was also recently observed in both peripheral summary statistics and crowding tasks [10]. In the latter task, in contrast to previous effects indexed by shifts in detection criteria, inflation was indexed by an increase in confidence ratings on incorrect trials for crowded compared to uncrowded stimuli. Surprisingly, this effect was observed despite discrimination d'

being *lower* in the crowded condition. Also recently, an inflation-like effect, similar to the flashed face distortion effect [51], was found in which repeatedly flashed peripheral color stimuli were rated as more saturated than physically-saturation-matched, non-flashing central color stimuli [52]. Further, an inflation-like effect has been found in which subjects failed to notice drastic changes in peripheral text during reading [53].

Inflation and the richness debate

To see how inflation fits into the Rich vs Sparse debate, it is helpful to consider that phenomenology tends to *feel* rich. For example, in the case of the Sperling experiments [18], participants indicated, anecdotally [4], that they felt as though they saw all of the characters in the 3x4 array in detail when the array was initially flashed, despite not being able to access all of that detail after the fact. Proponents of the Rich view traditionally take these reports at face value and assume that this detail was indeed phenomenologically represented outside of focal attention, albeit in a fragile and fleeting manner. It is worth emphasizing, however, that in many partial-report studies these reports of global richness are not systematically collected per experimental procedure, and instead come from retrospective subjective impressions [4,18–20]. And it is possible that such retrospective reports result from a demand effect [54]. However, for the sake of argument, we take these reports at face-value here.

The Sparse view, on the other hand, suggests that what is phenomenologically represented outside of focal attention is gist-like, a summary representation of low level features [4,28,55]. Indeed, there is ample evidence for the Sparse view from studies in which nonsensical or dramatically homogenized alphanumeric characters in peripheral vision go unnoticed [53,56], and studies in which participants cannot subjectively distinguish between physically distinct images that are matched for low-level image statistics [57,58]. Yet, a proponent of the Rich view might argue that, despite these studies, non-focally attended phenomenology does not *feel* summarized or homogenous, so there is still something left to be explained. In other words, if the Sparse view is correct, why is introspection so mistaken?

We suggest, in line with [10], that this mistaken feeling of richness is the result of subjective inflation. If partially-summarized, minimally-attended representations are subjectively inflated above what would be expected based on objective processing capacity, as in the examples above, then inflation can explain the apparent richness of the resulting phenomenology despite the deficits revealed by inattentional and change blindness [23–26].

The exact mechanism of inflation here may be unclear (but see [10,45,48]). Still, the very occurrence of inflation provides an explanation based on an operationally defined comparison between attended and minimally attended phenomenology. And that explanation is neutral as regards the more difficult and possibly empirically intractable issues surrounding the overflow argument. Therefore, a combination of summary statistics and subjective inflation arguably provides the best explanation of the subjective phenomena that advocates of the Rich view appeal to. Since this view incorporates both the relevant behavioral data and anecdotal reports of richness, which may well be illusory [28], we suggest that it constitutes a position intermediate between the Sparse and Rich views.

This inflation account is consistent with behavioral results observed in several previous studies of peripheral or minimally attended vision. For example, inflation appears to be very similar to perceptual filling-in [10,59]. A recent study showed that filled-in percepts at the blindspot are

rated as more reliable than perceptually equivalent, but externally veridical percepts [60]. Though, operationally speaking, this is not necessarily an inflation effect, it shows a similar pattern in which a percept that is based on a less veridical representation of the external world is actually granted a subjective boost. This leads to the question of whether filling-in at the blind-spot and inflation share a common mechanism. If so, then we might also expect the mechanism that underlies known cases of peripheral inflation [48,50,52] to underlie instances of peripheral filling-in like in the “uniformity illusion” [61] or in the case of peripheral color in natural scenes [62]. Presumably, such questions are empirically tractable. For example, future studies could combine an approach similar to [60] with the performance-matching strategies described above, e.g., [45,48], to see if subjective judgements about filled-in percepts are, operationally speaking, inflated relative to judgments about veridical percepts.

Additionally, as the peripheral filling-in examples above are presumably driven by an *expectation* based on foveal perception, inflation similarly appears to be influenced by expectations based on prior knowledge. For example, the control experiment in [35], described above, suggests that the content of inflation depended, at least in part, on an expectation about a specific color. This is consistent with the studies mentioned above in which participants failed to notice manipulations to alphanumeric characters during partial-report [56] and reading [53] tasks. It is also consistent with the result that stronger filling-in effects were observed when the to-be-filled-in content of a natural scene percept was colored compared to when it was grayscale, presumably based on the prior knowledge that natural scenes contain color [62]. Similar prior expectation effects based on central visual information have been shown for peripheral motion perception [63] and peripheral object recognition [64].

This reliance on expectation supports the important partial awareness hypothesis put forth by Kouider et al. [28,65], and suggests that inflation may provide a common mechanism among cases in which expectation influences minimally attended phenomenology [50,53,56,62]. One benefit is that expectation is an easily manipulated experimental variable; thus, the influence of expectation on minimally attended phenomenology should also be amenable to empirical investigation going forward.

Conclusion

We have argued that subjective inflation explains the apparent introspective content that the Rich view assigns to minimally attended and peripheral phenomenology. Subjective inflation explains why phenomenology may appear to overflow cognitive access, as suggested by some participants' anecdotal reports, without countenancing actual overflow. By denying overflow but explaining why it seems to occur, inflation provides an intermediate position between the Rich and Sparse views that borrows and extends ideas from the partial awareness [28,65] and summary statistics hypotheses [55].

On this position, phenomenology is built on summary representations [55], the subjective reliability of which is inflated above what would be predicted based on objective performance. This operationally definable effect is likely based, at least in part, on prior expectations [28,50,53,56,62,65]. So phenomenological richness need not be seen as mapping onto high representational capacity, as the traditional Rich view claims to be the case in early visual cortex [11–14]. Rather, inflation supports strong physiological evidence that peripheral representational capacity in early vision is limited [38,39], and suggests that our exaggerated sense of rich peripheral phenomenology is mediated by some later stage mechanism [66]. The

neural basis of this mechanism is a topic for future investigation, but at this point, it seems to be at odds with the multi-level overflow account offered by proponents of the Rich view [11]. Most importantly, we hope that the issues raised here in connection with inflation will stimulate new ideas about how to approach the phenomenological puzzle, ultimately giving the field more useful data for resolving the richness debate.

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