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After-effects and the reach of perceptual content

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Abstract

In this paper, I discuss the use of after-effects as a criterion for showing that we can perceive high-level properties. According to this criterion, if a high-level property (for example, an emotional expression) is susceptible to after-effects, this suggests that the property can be perceived, rather than cognized. The defenders of the criterion claim that, since after-effects are also present for low-level, uncontroversially perceptual properties (such as orientation), we can safely infer that high-level after-effects are perceptual as well. The critics of the criterion, on the other hand, assimilate it to superficially similar effects in cognition (such as decision biases) and argue that the after-effect criterion is a cognitive phenomenon rather than a perceptual one, and that as a result it is not a reliable guide for exploring the contents of perception. I argue against both of these views and show that high-level after-effects cannot be identified either with low-level after-effects or with cognitive biases. I suggest an intermediate position: high-level after-effects are not cognitive, but they are nonetheless not a good criterion for exploring the contents of perception.

Keywords Perceptual content · After-effects · Perception · Cognition · Border between perception and cognition

1 Introduction

What can we perceive, rather than cognize?¹ Which properties enter into the contents of our visual perceptual experiences? Some properties are uncontroversially seen: edges, shapes, orientations, and colors are all examples of properties that can enter into the contents of our visual states (Prinz 2006). On the other hand, there are

¹ While this question applies to all sensory modalities (vision, audition, olfaction, touch, taste, and maybe to internal senses, such as proprioception), the focus in this paper is mostly on the visual modality.

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other properties that are surely not seen (unless “see” is used metaphorically), but instead cognized, such as “being a tapestry woven in the 15th century” or “being a trade deal”.

Nevertheless, there are properties that are not obviously perceptual, but that could potentially be seen, rather than cognized. The most telling example of such properties are *emotional expressions*. Emotions are complex mental states. They involve an object or a state of affairs as their target and are holistically interconnected with many other mental states. For example, my happiness at seeing my partner after a long time apart has his arrival as its object and is connected to other mental states, such as the belief that he will land at the airport tomorrow, the intention to take the bus to meet him there, and so on. It is implausible that all facets of my happiness can be seen. Emotional *expressions*, on the other hand, are potential candidates for being seen: a stranger glancing at me on the bus sees my smile and immediately has a visual experience of me as being happy, without cognitive effort on her part. While she can’t access via perception the object of my happiness, nor the other mental states my happiness is connected to, she can visually perceive my facial expression of happiness.

My aim in this paper is not to exhaustively discuss the debate about the reach of the contents of perception (Hawley and Macpherson 2011), nor to show that some non-obviously perceptual properties can literally be seen,² but it is rather to critically discuss the import of *experimental evidence* in the debate about the reach of perceptual content,³ with a focus on one particular kind of evidence regarding the role of *after-effects* (Fish 2013; Block 2014).

The basic idea behind arguments that appeal to after-effects is that if a property is susceptible to after-effects, this suggests that it can be perceived.⁴ After-effects have been discovered not only for uncontroversially perceptual properties, such as orientation, but also for properties that are not *prima facie* perceptual, such as emotional expressions. Thus, if such arguments are sound, they support extending the reach of perceptual content to include such high-level properties. The appeal to after-effects, however, raises (at least) three questions:

1. Are after-effects for uncontroversially perceptual properties and after-effects for controversially perceptual properties instances of the same phenomenon?
2. Are after-effects for controversially perceptual properties *perceptual* or post-perceptual (cognitive) phenomena?

² I have done this elsewhere for emotional expressions (Smortchkova 2017).

³ There is other experimental evidence that could be used in the debate, for example evidence from visual agnosia (Bayne 2009). There is also a method that does not appeal to experimental evidence but to carefully built contrast cases in conjunction with an inference to the best explanation (Siegel 2010). I will not discuss these methods here.

⁴ In the rest of the paper I will write interchangeably that a property can be “experienced” or “represented” in perception. I don’t want to enter into vexed debates about the relation between the representational part and the experiential part of perceptual states. A reader who is against the idea that perception is representational can replace all occurrences of representation with experience.

3. Are there after-effects with high-level properties that do not involve the representation of the high-level property?

Each of these questions constitutes a challenge to the after-effect criterion. In this paper I examine each challenge in turn. First, I argue that the assumption in the after-effect argument that low-level after-effects and high-level after-effects are manifestations of the same phenomenon is not justified (Sect. 4). Second, I critically discuss the cognitive interpretation of after-effects and its limitations in assimilating known after-effects with similar phenomena in cognition (Sect. 5). Third, I show that even if the cognitive interpretation is not successful, this is not enough to save the after-effect criterion, because there is still a third alternative, which is intermediate between the one proposed by the defenders of the criterion and the one proposed by the critics of the criterion (Sect. 6).

The rest of the paper will proceed as follows. In Sect. 2 I present an overview of after-effects. In Sect. 3 I discuss how they have been appealed to in the debate about the reach of perceptual content. In Sect. 4 I criticize this use of after-effects by raising a worry about the assumption that low-level and high-level after-effects are instances of the same phenomenon. In Sect. 5 I consider an alternative view of after-effects as spanning both perception and cognition and show the limits of such an approach. In Sect. 6 I discuss the possibility that high-level after-effects could occur without the representation of the high-level property.

2 A brief overview of after-effects

Our cognitive systems are highly adaptable to variations in the environment. The term “adaptation” covers all the ways in which an organism adjusts to a change in circumstances. For example, we can adapt to working on a night shift, by adjusting our sleeping patterns. *Perceptual* adaptation, in particular, refers to the ways in which perception changes in response to variations in stimulation: for example, in vision we can adapt to the change of lightening at dusk, or in olfaction we can adapt to the perfume we are wearing so we don’t smell it on us anymore. Classic experiments on adaptation were done by the Gestalt psychologist Ivo Kohler, who gave his subjects goggles that inverted the left and right sides of the visual field, or the top and bottom of the visual field, or that distorted colors. In all of these cases, subjects adapted to the change in experience after some time. The focus of this paper is on a specific kind of perceptual adaptation: perceptual after-effects.⁵

Perceptual after-effects are a phenomenon known at least since Aristotle, who described the motion after-effect, a visual illusion that occurs after viewing a moving visual stimulus for a certain amount of time and then switching to a stationary stimulus that then appears to move in the opposite direction to the original moving

⁵ Sometimes perceptual adaptation and perceptual after-effects are used interchangeably, but I will only use after-effects in the rest of the paper to avoid confusion.

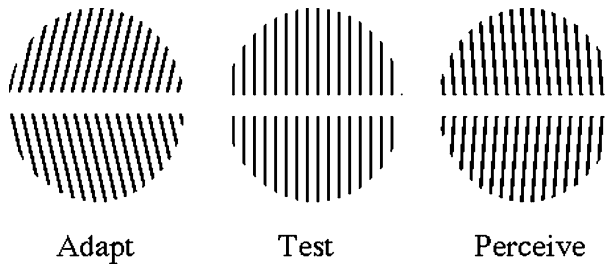


Fig. 1 Illustration for tilt

stimulus (Ross 1955). We find a classic description of an after-effect in the following passage from Gibson and Radner:

The subject observes a grating with lines tilted toward the left for x seconds, after this period, which is the period of adaptation, the subject observes a grating with vertical lines. The subject's experience is of a grating with the lines tilted toward the right (even if, objectively, the lines are vertical). In adaptation, the subjective experience pushes the adapted property in the opposite direction from the adaptive property (Gibson and Radner 1937, p. 558).

Below is an illustration of the effect for the property 'tilt' (Fig. 1).

Properties that show the effect are those that are usually associated with the contents of vision: lines (straight and curved), colors, speed of motion, direction of motion, orientation, spatial frequency, among others (Thompson and Burr 2009). Initially, the effect was explained by the neurons' "fatigue model", according to which there are neurons specifically attuned to, e.g., different orientations or directions of motion, that "saturate" after being exposed to a stimulus. This model was supported by the discovery in the visual cortex of cats and monkeys of cells attuned to orientation and direction (Vautin and Berkley 1977), and whose psychophysical profile corresponded to the time-course of adaptation. This model, however, was called into question by the discovery of effects that could not be explained via an appeal to "fatigue" of single neurons, because they could last for days instead of minutes, and by the discovery of effects not underpinned by only one population of neurons (Thompson and Burr 2009).

The cases just mentioned involve properties that everyone usually agrees are perceived. But similar after-effects occur even for properties that are not obviously perceptual. I will call the first kind of properties "low-level properties" and the latter "high-level properties". High-level properties that have been claimed to be susceptible to after-effects so far include the following properties of faces: gender (Little et al. 2005; Zhao et al. 2011), age (Webster et al. 2004), ethnicity (Jaquet et al. 2008), emotional expressions (Pollak et al. 2009), face identity (Rhodes and Leopold 2011), gaze direction (Schweinberger et al. 2007), attractiveness (Anzures et al. 2009; Rhodes et al. 2003), cuteness (Golle et al. 2013). Some of these properties also apply to the perception of human bodies, e.g. gender (Troje et al. 2006) or attractiveness (Winkler and Rhodes 2005).

As an illustration I present an experiment done by Schweinberger et al. (2010) to test adaptation to age expressed in the face (young or old). Subjects adapt to an induction stimulus consisting of a series of faces in a certain age range (young or old). Then they are presented with a morphed face between age groups and are asked to guess the age of the person. The test stimulus appears⁶ as being older if the induction stimulus consisted of young faces, and as being younger if the induction stimulus consisted of old faces.

While all these experiments involve the visual modality, effects for high-level properties also exist for audition, for example voices appear as older when preceded by the auditory presentation of much younger induction stimulus voices (Zäske and Schweinberger 2011), as angrier after adapting to a fearful voice (and vice versa) (Bestelmeyer et al. 2010), and as more masculine (or feminine) after adapting to a feminine (or masculine) voice (Bestelmeyer et al. 2010; Schweinberger et al. 2008; Zäske and Schweinberger 2011).

The effects also span the boundaries between some sensory modalities: from audition to vision for emotional expressions when subjects judge a face to be sadder after listening to laughter (Wang et al. 2016), and from touch to vision for facial expressions of sadness and happiness (Matsumiya 2013). They also occur from mental imagery to vision, in the case of face identity (Ryu et al. 2008) and of gender⁷ (D’Ascenzo et al. 2014). Remarkably, in some cases after-effects occur between categories of visual stimuli, for example gender transfers between bodies and faces (Palumbo et al. 2015) and age transfers between hands and faces (Lai et al. 2012).

While the properties above are properties of faces or bodies, after-effects also appear in scene perception. Thus, scenes can appear more or less desert-like after the subject has seen a more or less “luscious” natural scene, or some scenes appear more or less natural after the subject has observed a natural or an urban landscape (Greene and Oliva 2008). In this paper I will focus on after-effects involving human faces and bodies, and their properties. However, I expect my discussion to generalize to other cases of after-effects.

3 After-effects and the reach of perceptual content

One philosopher who appeals to after-effects in discussing the reach of perceptual experience is William Fish (2013). According to him, we can use perceptual after-effects to distinguish between properties which appear in the presentational (experiential) component of perception, and those that appear in the interpretative

⁶ I use “appear” in a neutral way and not as a synonym with “perceptual experience”. Finding out whether the experience is perceptual or post-perceptual is exactly what’s at stake in the debate. Similarly, I use “experience” from time to time to describe the displays, but once again I’m using it without *ipso facto* identifying it with “perceptual experience”.

⁷ In this experiment it is shown that adaptation in perception triggers a repulsive after-effect (after seeing a female face, the androgynous faces appears more male), while adaptation in visual imagery triggers an attractive after-effect (that is attractive toward the same gender of the adaptor—after seeing a female face the androgynous face appears as more female).

(post-perceptual or cognitive) component. He cites research on after-effects for numerosity (Burr and Ross 2008) and writes: “Their [Burr and Ross’ 2008] reasoning behind this methodology was the observation that all agreed primary visual properties—the properties (such as size, orientation, shape, colour and motion) that everyone agrees appear in phenomenal character—are susceptible to after-effect. So, if we can show that another property is also susceptible to after-effects, we have an argument that this property appears in phenomenal character too.” (Fish 2013, p. 52).⁸ His argument is an inference to the best explanation.

The evidence from after-effects has also been used by Block (2014) to show that we can perceive certain high-level properties (in particular facial properties). In the paper, he tries to rule out alternative explanations of the phenomenon in order to show that a perceptual representation of a high-level property is in fact the best possible explanation. In particular, Block focuses on: (1) ruling out alternative explanations in terms of low-level properties,⁹ and (2) showing that after-effects with high-level properties are sufficiently dissimilar from alternatives, such as post-perceptual and cognitive after-effects. It is useful to discuss his arguments against post-perceptual options in more detail to elicit one background assumption in the appeal to after-effects: that low-level and high-level after-effects are sufficiently similar so we can project the characteristics of low-level after-effects onto high-level after-effects.

To rule out the possibility that the representation of the high-level property is not perceptual, Block gives several arguments against an appeal to cognitive factors in the explanation of the phenomenon, arguing for the conclusion that there are features that distinguish perceptual effects from cognitive effects (Block 2014, p. 566). First, he tries to distinguish perceptual from cognitive effects by taking an indirect route through multistable perception. In the case of multistable perception (the spontaneous alternation between two or more perceptual states that occurs when sensory information is ambiguous) there are three properties of the experience that cognition and concepts do not have: these properties are exclusivity, inevitability, and randomness (Block 2014, p. 567). The presence of these properties (if one grants that they are absent from cognition) points toward the presence of a perceptual effect. Second, perception is orientation-dependent, since it is easier and quicker to recognize objects in their canonical orientation (for example upright vs. inverted faces) rather than in a non-canonical orientation, and this independently from what the subjects think.¹⁰ The third argument is based on an experiment that compares hysteresis and

⁸ Briscoe (2015) challenges Fish’s appeal to after-effects, and suggests alternative explanations. I’ll come back to his objections in Sect. 6.

⁹ To rule out an appeal to clusters of low-level properties, Block offers two arguments. The first argument is an argument from simplicity of explanation: in order to explain away the phenomenon via configurations of low-level properties, these configurations would have to be very complex, while a high-level property would constitute a simpler explanation. Second, he appeals to an experimental result that compares different after-effect in upright and in inverted faces, and how these effects transfer from and to upright and inverted letter “Ts” (Susilo et al. 2010): low-level features transfer to Ts for inverted faces but not for upright faces, showing that in the upright case there is a face-specific effect not explained via adaptation to a low-level property.

¹⁰ I think that these two arguments are problematic, even if not for the same reasons why the third argument is. First of all, depending on the phenomenon at hand also cognition can exhibit features of exclusivity, inevitability, and randomness: intrusive thoughts are chief examples of this. If I’m alternat-

after-effect in the case of tilt, which shows that after-effects do not elicit activations in frontal and parietal areas, areas known for their involvement in cognitive thought (Schwiedrzik et al. 2012). Hysteresis and after-effects modulate perception in different ways: while hysteresis has an attractive effect where the subject has the impression that a stimulus tends in the same direction of motion (for example) as the stimulus presented just before, after-effects have a repulsive effect (as described in Sect. 2). An example of hysteresis is as follows: after briefly seeing a moving stimulus, another ambiguous stimulus appears to be moving in the same direction. It is often assumed that hysteresis and after-effects have different functions in relating previous experience with a currently perceived stimulus. The study used fMRI to show that hysteresis and after-effects for tilt map into two distinct anatomically and hierarchically segregated cortical networks, with after-effects being localized in a local node in early visual areas (V2/V3). Block uses this evidence to rule out a role of higher cognitive brain areas in after-effects.

A close look at Block's arguments against cognitive interpretations of after-effects reveals a background assumption in the after-effect arguments: that low-level after-effects and high-level after-effects are instances of the same phenomenon, and that features of low-level after-effects can be used to explore high-level after-effects. In the next section I discuss (and challenge) this assumption.

4 Are low-level and high-level after-effects the same phenomenon?

Let's take Block's last argument from hysteresis and after-effect for tilt in favor of the perceptuality of after-effects. This experiment does not show that after-effects with a high-level property work just like after-effects with a low-level property, which is what is at stake. The only reliable conclusion from the experiment concerns the function and localization of low-level after-effects (in this case for tilt). Why should high-level after-effects necessarily involve the very same functions, processes, (type of) localizations, and mechanisms as low-level after-effects? What guarantees that low-level after-effects and high-level after-effects are instances of the same psychological process? Assuming so much threatens to beg the question.

Footnote 10 (continued)

ing between states of paranoia and states without paranoia, I can alternate between the thoughts "My neighbor is a Soviet spy" and "My neighbor is a nice person" randomly and without voluntarily control. Second, while it is true that inverted and upright faces are processed (and adapt) differently depending on the orientation of the stimulus, empirical data suggest that other cases of perceptual after-effect are orientation-independent. After-effect works even when the adaptor is a highly stylized cartoon face and the test a realistic face (Chen et al. 2010), and, crucially, in cross-categorical cases between bodies and faces, it works even if the orientation between the adaptor and the subsequently presented test changes (Kessler et al. 2013). In the latter experiment, the experimenters created a two-by-two design (inverted and upright bodies, inverted and upright faces) and found that all four conditions showed body-face after-effect. They did not find an effect of body orientation nor an interaction between body and face orientation. According to the experimenters, this shows that bodies adapt and activate an orientation-independent representation of faces. Therefore, the orientation-dependency criterion should be (at the very least) weakened.

More evidence and arguments are needed to extend what is known in the case of low-level after-effects to high-level after-effects. While it is undeniable that high-level and low-level after-effects share some characteristic features in common, it is also the case that they are less similar than it *prima facie* seems. I will first review the similarities between them, and then I will point to some of the differences.

Low-level and high-level cases of after-effects are of course similar with respect to their phenomenal profile: in both cases the subjects have an impression of a test stimulus that is pushed in the opposite direction from the adapted stimulus. Another shared property is their timescale. Facial identity, figural face after-effects (Rhodes et al. 2007) and facial expressions after-effects (Burton et al. 2016) follow the time-course pattern of logarithmic build-up and exponential decay that has been found for many lower level after-effects (for tilt: Wolfe (1984)). Such timecourse patterns play an important role in cognitive scientific research on after-effects. Thus, Rhodes et al. (2007) rule out alternative explanations by varying the size of the face between the adapted and the test faces and observing the timecourse of the effect. According to them, “[t]he classic timecourse for identity and figural face after-effects also reinforces their perceptual nature and rules out demand characteristics and other post-perceptual factors as plausible accounts.” (Rhodes et al. 2007, p. 2295).

On the other hand, there are several striking dissimilarities between low-level and high-level after-effects. I will focus on three such dissimilarities: the duration of the effect, the relation to awareness, and the role of categories on the effect. I will discuss each in turn.

The first difference is the duration of the effect. While high-level after-effects can be generated very quickly, by as little as 1 s of after-effect (Burton et al. 2016; Rhodes et al. 2007); low-level after-effects, such as for tilt, by contrast, need more time to occur (Webster and MacLeod 2011).

High-level after-effects show a different susceptibility to awareness than low-level ones. In particular, low-level after-effects seem to be immune to binocular rivalry¹¹ suppression, while high-level after-effects are not immune and are vulnerable to rivalry suppression (Blake and He 2005). More generally, while low-level after-effects can occur in the absence of awareness, many high-level after-effects are suppressed by a lack of awareness. For example, low-level properties (orientation, etc.) presented below the threshold of awareness can trigger the effect, whereas face identity-specific after-effects are cancelled when the adaptor is rendered invisible via rivalry or inattentional blindness (Moradi et al. 2005).

Finally, high-level after-effects exhibit cross-categoriality. *Cross-categorical* after-effects are not the same as *cross-modal* ones or *cross-faculty* ones: in cross-modal after-effects, different sensory modalities are involved in the transfer of the same property, for example from audition to vision; cross-faculty effects, for

¹¹ In binocular rivalry two different images are presented to each eye. The subjects experience oscillating perceptions between the two images and not a combination of the two images. In some cases, however, the subjects experience a merger between the two images. Whether they experience a rivalry or a merger depends on the type of property perceived: rivalry occurs for local (monocular) properties, while merging occurs for global (binocular) properties (Block 2019).

example, occur from visual imagery to vision. In cross-categorical cases, by contrast, effects span different categories: for example, there are after-effects between bodies and faces in the case of gender, in which subjects' being exposed to faces presented frontally, and as a profile of a certain gender, had an impact on an androgynous test body, which appeared more masculine after viewing female faces and vice versa (Palumbo et al. 2015). Another example occurs between hands and faces in the case of age: seeing a young or old face makes the test hands likely to be categorized as older or younger, respectively (Lai et al. 2012). I will come back to this feature of high-level effects in Sect. 6.

The first and second differences (in duration and susceptibility to awareness) have sometimes been used to suggest that after-effects might belong to a set of computations that range across different levels of brain activity, and it has been argued that as a result adaptation cannot be identified with a specific level of visual processing (Webster 2012). But these differences could also be taken to suggest that the current concept of after-effects is too coarse-grained. Future research might end up splitting it into different phenomena, with different features, and different mechanisms, if/when these are discovered. The main point here is that, in applying the after-effect criterion, we also need to supplement the inference to the best explanation with evidence showing that low-level and high-level effects are truly instances of the same phenomenon.

Moreover, the discussion of the differences between low-level and high-level after-effects introduces the possibility, explored in the next section, that high-level after-effects are better accounted for as spanning both perceptual and post-perceptual, cognitive, phenomena.

5 Are there cognitive after-effects?

The challenge from putative cognitive after-effects connects the application of the after-effect criterion with the issue of how to draw the border between perception and cognition: the defender of the criterion needs to show that both types of after-effects are perceptual. Indeed, the differences between high-level and low-level cases are sufficient to justify that a competing explanation should be taken seriously, viz. that some cases of high-level after-effect are cognitive (Helton 2016; Storrs 2015). The reasoning behind this alternative explanation—which I will refer to as the “cognitive alternative”—is that if there are examples of cognitive after-effects, then the after-effect criterion couldn't be used for exploring the contents of *perception*.

The cognitive alternative appeals to the existence of phenomena in cognition that seem very similar to known cases of perceptual after-effects. Helton's original example of a putative cognitive after-effect uses house size as the relevant property (Helton 2016): we browse through a real estate listing that contains only huge houses and we adapt to that size. Afterwards we read the description of an average-sized house and we immediately judge without reflection: “this house is small!”.

One problem with this example, in my view, is that it could be explained via after-effects mediated by visual imagery: the automatic judgement about house sizes might reflect after-effects from visual imagery to visual imagery. When reading a list

Top 10 Most expensive streets in Great Britain			
Rank	Street Name	Area	Average Property Value
1	Kensington Palace Gardens	London	£35,647,605
2	Grosvenor Crescent	London	£21,738,111
3	Courtenay Avenue	London	£21,054,602
4	The Boltons	London	£19,252,295
5	Ilchester Place	London	£15,235,846
6	Compton Avenue	London	£13,599,140
7	Albemarle Street	London	£11,906,934
8	Cottesmore Gardens	London	£11,869,602
9	Frognaal Way	London	£11,627,793
10	Manresa Road	London	£11,271,556

Fig. 2 Snapshot from the guardian

of houses' sizes, we might spontaneously imagine their size in our visual imagery (for example, imagining a mansion for a big house, and a 1-bedroom flat for a small house). An alternative case that avoids confounds from mental imagery is the following: You are planning to buy a house in Great Britain and your real estate agent gives you the listing below, which contains the most expensive streets in the country (Fig. 2).

After adapting to this list, you see a house marketed at the average price in Great Britain, which is £ 226,234, and you immediately think: "This house is cheap!"

There is surely some broad analogy between such cases and perceptual after-effects. But how similar are such putative cognitive after-effects to perceptual after-effects? While I think that the cognitive alternative provides an important challenge to the after-effect criterion, I am not in favor of endorsing it. The reason is that putative cognitive after-effects are, upon closer examination, sufficiently dissimilar from known perceptual after-effects (of either type).

The first dissimilarity comes from the application of a "test": can the effect be de-biased by a top-down strategy? If only the putative cognitive after-effects can be de-biased, but not the known cases of (perceptual) after-effects, this points to a difference deep enough to help us distinguish between genuine cases of after-effects and cases that are only superficially similar.

To explore how de-biasing could work, I appeal to research on "anchoring bias" as an illustration (Furnham and Boo 2011).¹² Anchoring indicates the tendency in

¹² Interestingly, the 'house' example could also be explained by an appeal to the 'contrast effect' in decision making (Bhargava and Fisman 2014). This further supports the point that putative cognitive after-effects are sufficiently dissimilar from known cases of after-effects in perception.

human cognition to rely too much on the first piece of information that has been registered in order to decide or formulate a judgement. A classic example of an anchoring effect is as follows: in a negotiation about the price of a car, the initial price offered sets the subsequent standard for the rest of the negotiation. As a result, offered prices that are lower than the initial price seem acceptable, even if they are actually too high compared to what the product is actually worth.

What is crucial for our purposes is that the anchoring effect can be de-biased via several top-down strategies (even if, unfortunately, they are more effective in the lab than in real life). One such strategy is “consider-the-opposite” strategy,¹³ where the judge has to consider anchor-inconsistent data and arguments in order to access anchor-inconsistent knowledge to mitigate the bias in the final decision (Mussweiler et al. 2000). Another strategy is to consider the opponent’s best alternative in a negotiation by trying to take the other’s perspective (Galinsky and Mussweiler 2001). Yet another strategy is to give participants an anchor in a different semantic category than the target estimate value (for example the value of the height of the Brandenburg Gate does not anchor the judgement about the width of the Gate) (Strack and Mussweiler 1997). Even merely having an anchoring alert message on a computer screen while doing estimates is effective in reducing the bias (George et al. 2000). All these top-down strategies help the judge to stop relying on the first value offered, with a success that depends on the degree of awareness of the bias on the subject’s part.

Can we apply some of these de-biasing strategies to the house price case? It seems that we can. To avoid anchoring our judgements to the price of London’s most expensive streets we can consider the difference between the price seen and the average house price in Great Britain, or we can try to think of a number value in another domain (e.g. the number of windows in a house), or wonder about the intentions of our real estate agent by taking his perspective. Or we can simply become strongly aware of the influence of the list on our final judgement. While these examples are not experimentally tested, they offer a very plausible case for the claim that putative cognitive after-effects are contingent on voluntary top-down decisions.

Known after-effects (including those involving high-level properties), on the other hand, appear to be resistant to revision in light of evidence and voluntary, top-down efforts. Indeed, no de-biasing strategies seem available for perceptual after-effects: being aware of the effect does not make the after-effects go away. Once after-effects have started their course they will persist, up to a week later in the case of some high-level after-effects. This might point towards a “deeper” characteristic of perception—its encapsulation (Firestone and Scholl 2016; Fodor 1983). Encapsulation is a property of modular processes that only use information within the system to perform computations on a domain-specific set of stimuli. The early stages of perception are examples of strongly encapsulated processes, but there are (arguably) many other processes that are modular and encapsulated. Perceptual after-effects are not encapsulated in the strongest possible sense, as the data on cross-modal

¹³ This only works if the judge does not fall prey of the confirmation bias in searching for anchor-inconsistent arguments and evidence.

after-effects from mental imagery to vision suggest, but they are nevertheless encapsulated from decision making processes in central cognition, since they are resistant to revision via top-down strategies. This makes them very different from putative cognitive after-effects, from the perspective of cognitive architecture.

There are other differences between the after-effects discussed in the previous sections and the putative cognitive after-effects. First, putative cognitive after-effects do not seem to show the timecourse of both low-level and high-level perceptual after-effects, viz. logarithmic build-up and exponential decay. Second, while perceptual after-effects usually show a ‘repulsion’ effect,¹⁴ putative cognitive after-effects can manifest both a repulsion and an *attraction* effect, depending on the context. Once again, the anchoring bias can be used as a guide: in the bias the first value offered sets the standard for subsequent judgements which are all compared to this first value. Presenting someone with huge houses as the first value sets her standards higher than usual, and medium-sized houses that she would have accepted in another context now seem smaller than what appears acceptable to her. While this looks like a repulsion effect (away from judging medium houses as average), with a relevantly different task one instead observes an attraction of the first value. For example, in Tversky and Kahneman (1975) subjects are asked to guess a certain number (the percentage of countries in the United Nations that are African countries) and are anchored with either a low or a high number (via a roulette that stops at either 10 or 65). Their guess is in the vicinity of the anchored number (25% and 45% respectively). In this case subjects were not asked to judge a given number, but to spontaneously produce a number themselves. It seems plausible that for the putative cognitive after-effect (whether the size or the price of a house) in a spontaneous judgement context, subjects would produce a number that is closer (rather than farther) to the anchored value when asked to give a number themselves. In the case of the house price, if asked to provide the average price for a house in the U.K. people would produce a number closer to the anchored one. Therefore, whether putative cognitive after-effects exhibit repulsion or attraction depends on the context and question asked.

This brings me to my main methodological and conceptual point: the house size and price examples in fact bear only a vague similarity to core cases of after-effect. Is this similarity really sufficient to support the claim that the house examples and known after-effects to e.g. emotional expressions, are manifestations of the same phenomenon, in any scientifically relevant sense? In my view, while appeals to high-level after-effect for extending the reach of perception may have been too narrowly modelled on known cases of low-level after-effects, putative cognitive after-effects are, by contrast, too loosely modelled on known cases of high-level after-effects.

I’m not denying that for some purposes superficial similarity might be enough. Perhaps for some purposes we might want to group together putative cognitive after-effects with perceptual after-effects. But de-biasing and other properties show that there are deep differences between the perceptual and the cognitive cases,

¹⁴ With few exceptions: in low-level cases, after-effects become “attractive” at small inducing angles, see Westheimer (2011).

differences that can have an impact on how the subject behaves. De-biasing is not a property that is part of our current understanding of after-effects, but it is a property that can help us draw a possible line between perception and cognition, and which is important to our overall understanding of cognitive architecture. To overcome a bias, the subject can apply strategies and replace an initially formulated judgement with a more reflective judgement; in the case of a perceptual illusion (such as the Ebbinghaus illusion or the Müller-Lyer illusion), the subject cannot overcome the judgement formulated on the basis of the illusion, even when she knows that her perception is not veridical. If after-effects are compelling in the same way perceptual illusions are, this might not be merely accidental but an important part of their nature.

This sounds like good news for the proponent of the after-effect criterion. I've just argued that there are important differences between putative cognitive after-effects and perceptual after-effects, with de-biasing playing a crucial role. A defender of the after-effect argument for extending the reach of perception could then modify the criterion as follows: a high-level property can be experienced in perception if (a) it is susceptible to after-effects; and (b) the effect cannot be de-biased. Such a modified criterion doesn't rely on the same phenomenon assumption, criticized in Sect. 4. After-effects might be of different types, but still relevant to the question of the reach of perception. In the next section I will discuss a challenge that even this improved version of the after-effect criterion still faces.

6 High-level after-effects without the high-level property?

The third challenge is that high-level after-effects could be perceptual, but not involve the representation of a high-level property. There are at least two versions of the challenge.

According to the first version, the effect could involve low-level properties only, without involving the target high-level property. This alternative explanation was evoked by Briscoe (2015) in response to Fish. Drawing on Durgin (2008), Briscoe suggests that it is not numerosity per se that supports the effect, but the relative distance of the dots;¹⁵ likewise, in cases involving emotion or gender, it is not emotion or gender per se that provoke the effect, but certain dispositions of facial traits that correlate with these high-level properties. He writes that “[a]n empirically well-motivated, alternative explanation is that the numerosity judgments made in Burr and Ross’s experiment are based on perceived, relative texture density rather than perceived, relative numerosity” (Briscoe 2015, p. 185). This supports the idea that high-level adaptation effects might be “inherited” from low-level processing

¹⁵ There is, however, an objection to Briscoe’s alternative explanation, suggested by Sam Clarke: in the case of analogue magnitude representations it has been shown that simple sensory properties cannot account for cross-modal transfer effects (Meck and Russell 1983). Similarly, for numerosity, the explanation of the effect might not be due to low-level features, but to a high-level, non-perceptual, representation.

and spread towards higher levels of processing, and are therefore not due to high-level properties per se being genuinely perceived [see also Dickinson and Badcock (2013)].

Contra Briscoe it is not clear that all cases of perceptual after-effects can be explained via low-level features or their attentional grouping. The transfer can also occur between an adaptor and a test stimulus that do not share any low-level features. I have reviewed in Sect. 2 data showing the existence of cross-modal after-effects from audition to vision or from touch to vision, and data on cross-modal after-effects. This puts pressure on the objection from low-level properties.¹⁶

Briscoe is aware of this problem and proposes that other high-level after-effects could be due to post-perceptual processes (an option similar to the one explored in the previous section on putative cognitive after-effects). He discusses the existence of cross-category after-effects in an experiment that shows the existence of after-effects from gendered objects (such as high heels or lipstick for “female” objects and razors and motorcycles for “male” objects) to the gender of the face, perceived as being more masculine after the subjects were adapted to a “female” object, and as more feminine after the subjects were adapted to a masculine object (Javadi and Wee 2012).

Nevertheless, data on cross-modal effects of the kind Briscoe mentions is currently limited. There is only one other experiment, to my knowledge, showing a similar effect using gendered objects and names that influence gender perception (Utz and Carbon 2015). There are no known studies that show after-effects from emotionally charged objects onto facial expressions. For example, within the same valence category subjects projected either sadness, disgust, anger or fear into the same face when sad, disgusting, angering or fearful objects were present (Aviezer et al. 2008). Yet, in the case of emotional expressions, adaptation to facial expressions does not occur after seeing non-facial images expressing emotions (such as a dog being afraid) or reading words that convey emotions (such as AFRAID) (Fox and Barton 2007).

This brings me to the reformulation of the challenge. According to the second version of the challenge, some high-level after-effects could be instances of a change in a decision about category boundaries that might *not* be due to the *representation* of a high-level property, but to a shift in the *decision* criterion. I call this option “the decisional bias option”. The decisional bias could be based on low-level properties, and not on a representation of the high-level properties. This possibility brings together the challenge from low-level properties and apparent post-perceptual after-effects in a unique alternative explanation.

Let me develop the challenge in more detail. In the experimental displays, when testing high-level after-effects, subjects have to give a judgement on category

¹⁶ An anonymous reviewer suggests a way of saving the low-level explanation via visual imagery. When the subject hears a happy voice, she imagines a happy face. The happy face and the visually presented stimulus do share low-level features, and the stimulus the subject adapted to is the visually imagined face rather than the voice itself. I don’t have a strong argument against this possibility: it might be empirically tested by looking at subjects with *aphantasia* (an impossibility to engage in visual imagery) to uncover whether they still experience the effect.

membership: either in a forced-2-choice task where they have to decide which category the stimulus belongs to, or via a rating within a certain category, e.g.: Is the face male or female? (forced-2-choice task); How “feminine” does the test face look (rating within a certain category)?

This raises a methodological worry for the experimental design used in testing high-level after-effects, which has been pointed out by Storrs (2015). According to Storrs, current methodologies cannot discriminate between explanations of high-level after-effects in terms of perceptual bias or in terms of post-perceptual bias. Storrs’ main worry is that when the subject assesses to which category a stimulus belongs, her response depends on both her perceptual experience and on her decisional criterion for applying the category to what she sees. This issue is controlled for in the low-level cases by testing the effect through a comparison between a stimulus in the adapted area (situated within a few degrees of the adaptor, since the low-level after-effect is local) and a stimulus in the non-adapted area. This allows for comparisons between test and reference stimuli that do not impinge on a decisional bias—for example, via a matching task consisting in adjusting the test stimulus in the adapted location until it matches the reference stimulus in the non-adapted location. Such a test is not currently available for high-level after-effects since they seem to be spatially global rather than local (Storrs 2015), which makes the comparison between an adapted and an un-adapted area (at least for the time being) an impracticable methodology for high-level properties.¹⁷

Storrs’ methodological worry bears on the debate on how to extend the reach of perceptual content, because it undermines the after-effect criterion. According to the criterion, the best explanation of the effect is that the subject has an experience with the high-level property. But the methodological worry suggests that the response pattern in high-level after-effects is compatible with subjects’ decisional shift without the high-level property necessarily appearing in the content of perception. Of course, the methodological worry is compatible with the high-level property in fact being represented, but the point here is that the defender of the criterion can’t apply it without also having another method to show that the high-level property is experienced by the subject.

There are two experiments that suggest that category membership plays a role in eliciting after-effects (and not necessarily the representation of the high-level property). First, Bestelmeyer et al. (2008) tested the influence of category on high-level after-effects by exploring two sets of faces: (1) the first set contained faces from

¹⁷ Storrs mentions other worries as well. Her first worry is that for low-level cases there are studies on the properties of early visual neurons that support perceptual bias, but the properties of neurons in the high-level visual areas that mediate the effect are unknown. To this one could reply that in due course we might discover properties of neurons and channels in high-level perception. Another worry concerns the reduction of sensitivity in the detection of adapted properties and its increase in discrimination sensitivity. This change in sensitivity is commonly taken to show a perceptual bias (Kohn 2007; Storrs 2015). In the high-level case on the other hand, studies are more mixed: while most studies did not find a change in sensitivity for face after-effect, a few have found improved discrimination for face after-effect for some properties. For example adapting to trustworthy faces improves the discrimination threshold for facial trustworthiness (Keefe et al. 2013).

male and female categories; (2) the second set contained faces within the same category (female and hyper-female). Structural differences were kept mathematically identical between the male and female faces on the one hand, and the female and hyper-female faces on the other hand. The opposite after-effect was present in the between categories case (after adaptation to a female face, the test face looked more masculine, and vice versa). However, the opposite after-effect was not found in the within category case (between female and hyper-female faces). This suggests that at least in the case of gender, after-effects transfer between categories but not within categories. It is an open question whether this generalizes to other high-level properties as well.

Second, in the case of emotional expressions the effect is stronger when stimuli belong to categories distant in valence (positive and negative emotions), while within one valence category the effects are mixed: in investigating anger, fear, and disgust, it was found that after-effect to disgust biases perception away from disgust, after-effect to fear biases toward disgust, after-effect to anger and disgust biases away from anger, while after-effect to anger has no effect on disgust or fear (Pell and Richards 2011).

An effect on category boundaries rather than on the experience of the property per se could also explain cross-categorical cases of after-effect from bodies to faces, and from body parts to faces, and the (rare) cases of after-effects from ‘gendered’ objects to faces. These cases are incompatible with Fish’s proposal (that there is a distinctive look in the case of high-level properties) and with the proposal that reduces effects to the perception of low-level properties, because there are no low-level properties in common between faces and bodies. Seeing a feminine body could push the categorization criterion for the perceived face in the opposite direction when a stimulus situated at the boundary is presented.

A defender of the cognitive option could argue that the decisional shift option actually sides with the post-perceptual/cognitive alternative, similar to the one discussed in Sect. 5. Indeed, Storrs herself talks about a “post-perceptual” bias.

There is another possibility: the decisional bias playing a role in high-level after-effects could still occur *within* the perceptual module. The decision bias might be “modularized” in a downward manner (Pylyshyn 1999). Downward modularization occurs when a process becomes automatic. Automaticity comes with a setback, which is lack of flexibility, exemplified by the inability of the system to use information outside the module: the module is sensitive only to the inputs in a specific domain and to the processes that connect the inputs with the outputs. One example of downward modularization is automatic mindreading, where an effortful ability becomes effortless, after repeated practice, at the expense of flexibility (Apperly 2010). Another example is categorical perception of colors, where being exposed to new color terms for a certain amount of time creates a shift in existing color boundaries (e.g. by introducing a new boundary between blue and light blue, after learning the Russian words ‘sinyi’ and ‘golybou’) (Jraissati 2012). I’m not claiming here that high-level after-effects work precisely like mindreading or categorical perception of colors. Instead I’m providing two rather uncontroversial examples of modularized processes that are not the paradigmatic early visual module, and that involve a

decisional process (such as linking a visual action to the mental state usually causing it) that occurs within the module.

Yet, this is not good news for the proponent of the after-effect criterion: if high-level after-effects are based on the representation of low-level properties and on a modularized decisional shift within the module, then there is nothing we can conclude about the representation of the high-level property. This only suggests that the decisional shift involved in category assignment is not necessarily based on a voluntarily resolution on the part of the subject; it might be a process that occurs within the perceptual module, as the resistance to top-down influence shows. But if there is a decisional bias within the module, and this accounts for (at least) some of the effects, then the after-effect criterion cannot be used to show that a high-level property is *represented* in perception, unless it is also shown that the decision on category assignment is based on the representation of the high-level property.

To sum up, the third challenge to the after-effect criterion is that high-level effects might not be due to the representation of the target high-level property, either because they are based on the representation of a set of low-level properties, or because they are based on the representation of low-level properties plus a modularized decisional bias on category assignment.

7 Conclusion

In this paper I have criticized the use of after-effects in exploring the reach of perceptual content. In the current literature, one finds two opposite positions on the theoretical import of perceptual after-effects. The first position is that after-effects can be used to as a criterion of perception (Fish 2013; Block 2014). The second position is that after-effects are a more general and widespread phenomenon that encompasses both perception and cognition, and therefore cannot be used as a criterion of perception (Storrs 2015; Helton 2016).

I criticized both of these options with the aim of outlining the conditions that would allow us to use the after-effect criterion for the exploration of the reach of perception. First, the existence of differences between low-level cases and high-level cases prevents us from simply projecting what we know about low-level cases to high-level cases. Second, the critical discussion of the cognitive alternative brought forward a supplementary condition for the application of the criterion: the “no-debiasing condition”, which wasn’t part of the original formulation of the criterion. This is good news for the partisan of the criterion, but it’s still not enough: we also need to rule out an alternative in terms of low-level properties plus a decisional shift. To rule out this alternative, the partisan of the criterion needs to show that the decisional shift about category boundaries is based on the representation of the high-level property.

In conclusion, I hope that the discussion in this paper will help the proponents of the criterion in refining their proposal. In particular, they would need to show that low-level and high-level after-effects are sufficiently similar, that the effect is truly non-debiasable, and that the effect is not due to a decisional shift on category

membership based on low-level properties, but on the representation of the target high-level property.

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