Perceptual precision

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The standard view in philosophy of mind is that the way to understand the difference between perception and misperception is in terms of accuracy. On this view, perception is accurate while misperception is inaccurate. However, there is some evidence (albeit controversial evidence) that perceptual experience actually involves widespread inaccuracy. I add to that evidence in the paper. Then I point toward a way of understanding the difference between perception and misperception, not in terms of accuracy alone, but in terms of precision. That is, I argue that perceptual experience is designed to enable more fine-grained discrimination among the properties that are most useful for action, even if that involves inaccuracy. The view in this paper motivates a new account of illusion, on which illusions are imprecise as well as inaccurate. I call this the Precision Account of Illusion.

1. Introduction

It is a standard view in philosophy of mind that the distinction between successful perception and misperception (like hallucination or illusion) can be understood in terms of accuracy. A subject misperceives when the world is presented to her in perception as being a way that it is not. Philosophers studying perception have generally assumed that misperception is not widespread. However, evidence from psychology suggests that inaccuracy is surprisingly common in everyday perceptual experience. In some of the cases that I will discuss, perception is even successful despite its being inaccurate. In this paper, I use evidence for widespread inaccuracy from perceptual psychology to show that the philosophical account of misperception is problematic. In doing so, I introduce new evidence to the philosophical discussion and point to a way forward for philosophical accounts of misperception. I suggest that the way to understand the difference between perception and misperception is not in terms of accuracy but in terms of perceptual precision: the fineness of grain of discrimination among the actual properties of an object.
This paper thus challenges a central assumption in the philosophy of perception and suggests a new way for philosophers to draw the distinction between successful perception and illusion. On the view that I propose, perception is successful when it enables us to discriminate among those properties that are most useful for action, even if that involves inaccuracy. Roughly and briefly, my argument in this paper is as follows: many philosophers accept that perception aims at accuracy. Inaccuracy is widespread in perception, however, and some cases of inaccuracy should be considered the proper functioning of the perceptual system because they increase perceptual precision (as I will argue). For these two reasons, philosophers should reconsider the view that perception aims at accuracy.

Most philosophers distinguish perception from misperception by appealing to veridicality. Unlike successful perception, misperception involves a mismatch between appearance and reality, or a failure to accurately represent an object or its properties. For example, in distinguishing perception from illusion, Smith (2002) defines an illusion as follows:

any perceptual situation in which a physical object is actually perceived, but in which that object perceptually appears other than it really is, for whatever reason. (p. 23)

Likewise, Fish (2010) introduces the distinction between successful perception and illusion as follows:

Fully successful cases of perception – cases in which an object is seen and seen correctly or ‘as it is’ – will be termed perception or, sometimes, veridical perception… In contrast, illusion refers to cases in which an object is seen but seen incorrectly or ‘as it is not.’ (Fish p. 3)

Macpherson (2009) similarly writes:

Traditionally, philosophers have contrasted perception with sensation. Perception was taken to be a process that involved states that represented – or that were about – something. For example, typical visual experience had at the beach might represent sand, crabs, or the blueness of the sea. These experiences might accurately represent the beach or misrepresent it, if undergoing illusion or hallucination. (p. 503)

These are just a few of many examples. As I will show, this way of drawing the distinction is challenged by empirical cases of inaccurate perception that don’t intuitively fit into the same category as standard illusion cases. The cases that I have in mind are ones in which perception is inaccurate but precise. As I understand it, a perceptual experience is accurate if and only if it specifies some way that the world is, and the world actually is that way; it is inaccurate otherwise. In contrast to accuracy, a perceptual experience is precise if and only if it enables the subject having that experience to make fine-grained discriminations among the actual
properties of an object. It may seem, at first glance, that precision requires accuracy, but this turns out not to be the case, as I will show. In order to make fine-grained discriminations among the actual properties of an object, we don’t need to perceive those properties accurately. In some of the cases that I will discuss, precision is even improved by inaccuracy.

One advantage of appealing to precision is that it can help us to understand the distinction between successful perception and illusion even if inaccuracy turns out to be widespread in ordinary perceptual experience, as many perceptual psychologists believe. There is evidence that perception is frequently inaccurate, though how to best interpret this evidence remains controversial. For example, in the study of visual attention, Carrasco and colleagues have suggested that attention modulates visual appearance in a variety of ways, such that attended objects appear “bigger, faster, earlier, more saturated, stripier” than unattended ones (Block, 2010, p. 41; See also Abrams, Barbot, & Carrasco, 2010; Fuller, Ling, & Carrasco, 2004; Golell & Carrasco, 2004). As Carrasco and colleagues write, “attention augments perception... by emphasizing relevant details at the expense of a faithful representation of sensory input...” (2004, p. 1162). This interpretation of the evidence has been challenged by psychologists (see Schneider & Komlos, 2008; Schneider, 2010; see also Abrams et al., 2010 & Anton-Erxleben, Abrams, & Carrasco, 2011 for a response) and philosophers (see Block, 2010; Nanay, 2010; Speaks, 2011; Stazicker, 2011; Wu, 2011; Ganson & Bronner, 2013; Block, 2015; Prettyman, 2017, & Watzl, forthcoming). The claim that is especially controversial is that attention’s effect on appearance make perceptual representations “less faithful” or inaccurate, rather than simply more determinate. Nevertheless, it is a real possibility that attention augments appearance in the way that the original experimenters suggest.

Watzl (forthcoming) develops Carrasco and colleagues’ suggestion, arguing that the best explanation of the evidence is one which admits that we frequently misrepresent properties in perceptual experience. On Watzl’s view, while perception aims to present the subject with an accurate representation of the world, attention aims to make that representation usable. When the aims of perception and attention conflict, perceptual experience will be determined by a tradeoff between accuracy and usability. As a consequence, we should expect subtle but widespread misrepresentation in ordinary perceptual experience.

Arguments for widespread inaccuracy in perception also have historical precedent in philosophy. As Simmons (2008) has argued, versions of this view can be found in Descartes and Malebranche. Malebranche, for instance, claims to show “that the world you live in is not at all as you believe it to be, because actually it is not as you see it or sense it” (as quoted in Simmons, 2008, p. 81). The reason for this is that perception is
narcissistic rather than veridical (a term that Simmons borrows from Akins, 1996). It aims to tell the subject about the world as it relates to the preservation of the body, and not as it objectively is. As Simmons summarizes, Descartes and Malebranche argue for a view on which the function of perception is to “show us what bodies are like not as they are in themselves, but as they are related to us and, in particular, to our self-preservation” (Simmons p. 84, emphasis original). As a result, perception frequently misrepresents the objective world.

A contemporary defense of the view that perception is narcissistic is developed by Akins (1996). Using thermoreception as an example, Akins shows that perceived temperature is exaggerated for temperatures that are more likely to cause damage or discomfort, such as rapid change caused by placing cool skin in warm water or submerging one’s head (as compared to one’s hand) in a cold mountain lake. This exaggeration comes at the cost of a consistent and accurate representation of temperature. Rather than conclude that thermoreception is an inept or defective veridical system, Akins thinks this shows that thermoreception is not aimed at producing an accurate representation of the temperature of objects in the first place. Perceived temperature is often inaccurate because thermoreception is a narcissistic rather than a veridical system. It aims to present temperature as it is related to our needs and interests (such as our interest in being comfortable or being warned of damage) and not as it objectively is. Under the assumption that thermoreception is narcissistic, we should expect perceived temperature to be distorted. In particular, we should expect distortions that serve to better communicate the relevance of objective temperature for our own comfort and safety. Akins shows that this is exactly what we find across a variety of cases.

Some philosophers may be happy to accept that thermoreception is not veridical but resist the general conclusion that our perceptual systems do not aim at accuracy. After all, philosophers have long distinguished between properties like temperature and taste, which are, in part, dependent on the perceiver and objective properties like shape or motion, which are not. In Section 2, I will add to the evidence that inaccuracy is widespread in ordinary perceptual experience, and I will show that even objective properties like distance, slant, and motion are distorted in perceptual experience. I will also suggest a way forward in Sections 2 and 3. According to the view that I suggest, even if inaccuracy is widespread in ordinary perceptual experience, misperception is not. This is because many cases of inaccuracy should be understood as the proper functioning of our perceptual system. If what I argue is correct, then we should reconsider the standard way of drawing the distinction between perception and misperception or illusion.
2. Distinguishing accuracy from precision

It is a fairly uncontroversial view among perceptual psychologists that accurate representation of the world is not necessary for precise action. Consider an example from Warren and Whang (1987, cited in Durgin 2009). In order to pass through a doorway, a subject needs to perceive its size relative to her own. She could be inaccurate with respect to the size of the door and the size of her body, yet accurately perceive that the door is taller than she is. Likewise, a watchmaker looking through a magnifying glass may adeptly fix a watch even though she misrepresents the size of its parts, and a spear fisherman might catch a fish despite distortion caused by the water (Durgin, Li, & Hajnal, 2010). A dramatic real-world illustration of the dissociability of successful action from accurate perception comes from experiments using inversion lenses in the 1960s. Subjects fitted with light-inverting lenses were able to learn to perform complex actions, like driving a car or fencing, even though they perceived the world as being upside-down (Harris, 1965; Kohler, 1961; Linden, Heinecke, & Goebel, 1999).

Misrepresentation of an object’s properties can even be useful. Consider the case of color. If color anti-realism is true, representing objects as colored may nonetheless enable us to perform visual searches more quickly or make discriminative judgments more accurately (Mendelovici, 2012; Millikan, 1984). For example, representing a berry as red may help me to quickly and accurately distinguish ripe fruit from the surrounding leaves, even if the berry does not actually have the property of being red. This is a hypothetical case in which perceptual inaccuracy increases perceptual precision: the ability to make discriminative judgments among the actual properties of an object. Misrepresenting the berry as red enables me to identify those objects that have the property of being a berry and being ripe. My point is not to defend color anti-realism, and nothing in what follows will depend on this example. I mention the case of color because it is one area where philosophers have discussed the possibility that widespread and reliable inaccuracy might support successful action.

These examples provide precedent for the view that widespread misrepresentation does not always impede – and can even support – successful action. In the next two sub-sections, I turn to empirical evidence that strengthens support for this view. A series of studies in psychology suggests that there is systematic and widespread misrepresentation in perceptual experience. These studies further suggest that misrepresentation serves a useful function: increasing perceptual precision for the sorts of discriminative judgements that are useful for the subject in her environment.
2.1. Misrepresentation of space

Depth perception involves the representation of egocentric distance, or distance from an observer to a target, and surface orientation, the slant or tilt of an object. There is evidence that both are distorted in perceptual experience. This evidence suggests not only that visual representations of space are systematically inaccurate but also that these distortions support successful action by increasing perceptual precision.

Take the case of egocentric distance. It is widely accepted that subjects underestimate when asked to judge their distance from a target (I will say more below about why this should be taken to indicate misperception rather than just misjudgment) (Da Silva, 1985; Foley, Ribeiro-Filho, & Da Silva, 2004; Gilinsky, 1951; Li, Phillips, & Durgin, 2011; Loomis, da Silva, Fujita, & Fukushima, 1992). This has been demonstrated using both verbal (Foley et al., 2004) as well as non-verbal measures. For example, Gilinsky (1951) constructed a scale of perceived distance by asking subjects to sit overlooking a grassy field while the experimenter placed stakes in the ground at intervals that appeared equal from the subject’s perspective. As the intervals became objectively farther away from the subject, Gilinsky had to make the stakes objectively larger in order to retain an appearance of equality. She concluded that apparent distance is not a linear function of objective distance and, instead, is distorted such that distances farther from the subject are underestimated. Similarly, Toye (1986) and Wagner (1985) conducted experiments in which subjects were asked to compare the lengths of two intervals on the ground plane. When one of the intervals lay “in depth,” or along the sagittal plane, they tended to judge that it was shorter than a “frontal” interval of equal length, which lay along the frontal plane. Using a similar paradigm to Toye and Wagner, Loomis and colleagues (1992) asked subjects to adjust the length of a frontal interval to match an in-depth interval placed in the distance. They also found that subjects adjusted the frontal length to be consistently smaller than the in-depth interval, a result predicted by the view that distance is underestimated in visual perception.

A second example of widespread distortion in perceptual experience comes from perception of optical slant. A battery of studies provides evidence that subjects’ perception of the slant of hills is exaggerated (I will say more below about why this exaggeration should be considered a perceptual effect) (Kammann, 1967; Proffitt, Bhalla, Gossweiler, & Midgett, 1995; Ross, 1974). For example, Proffitt and colleagues (1995) found that subjects overestimated the slant of a hill when they were asked to provide verbal estimates or adjust a representation of a cross-section of the hill. They suggest that these distortions of perceived slant serve to make subjects more sensitive to small changes in incline, like those they
encounter in everyday life. The exaggeration of perceived slant has been replicated using other non-verbal tasks like angle-bisection, in which subjects are asked to judge which of two legs of an ‘L’ shape, presented on slanted ground, appeared longer (Li & Durgin, 2010; see also Ooi, Wu, & He, 2006; Wu Ooi, & He 2004). Durgin and Li (2009) further found that downhill slopes appear shallower than they are when viewed from the edge, rather than steeper, and that subjects are systematically inaccurate in their perception of the declination of their own gaze.

While it is fairly uncontroversial that subjects misjudge surface orientation and distance across a wide variety of viewing conditions, perceptual psychologists disagree about how to understand this pattern of findings. It is important for my argument that the distortion of distance and slant is genuinely perceptual. One possible explanation of the data, however, is that subjects’ judgments are distorted, but their perceptual experience is not. Firestone and Scholl state the concern in a compelling way: When looking for top-down effects on perception, it is important to distinguish between effects on “…what we see or instead only our inferences or judgments made on the basis of what we see” (Firestone & Scholl, 2015, section 4.2, emphasis original). When experimenters rely on verbal reports as evidence that a subject misperceives the world, they risk conflating judgment and perception. For example, in the case of perceived distance, a subject may perceive the distance to a target accurately but underestimate the distance when making a judgement about how far away the target is. That is, subjects may perceive the world accurately even if a judgment they make based on that perception is inaccurate.

It is worth looking more closely at the reasons why many psychologists favor views which state that the distortion of distance and slant is genuinely perceptual and not a mere distortion of judgment. The first reason is based on introspection. As Firestone and Scholl point out, perceptual effects that we can directly experience on our own are more plausible than those that we cannot. Consider an example. We can experience the Muller-Lyer illusion for ourselves. One line looks longer than the other even though both lines are objectively the same length (see Figure 1). If we looked at the Muller-Lyer figure and could not experience the effect, we should be suspicious of the claim that the figure induces a genuine perceptual illusion.

There is reason to think that distortions of slant and distance are like the Muller-Lyer illusion in that we can experience them for ourselves. In his introduction to his 1995 paper on optical slant, Proffitt describes a recent drive through the mountains of Virginia. The roads seemed incredibly steep to him, even though he knew that the law required that roads incline at no more than 6 degrees. Other anecdotal reports of distorted space come from hikers and skiers. Climbers report that distant uphill slopes look
“impossibly steep,” while skiers report that, when looking down from the top of a slope, other skiers sometimes appear to ski uphill (Ross, 1974). Similarly, Durgin and Li’s work on optical slant was inspired by a perceptual effect that researchers observed firsthand. They noticed that hills appeared shallower than their objective slant when observed from the edge (Li & Durgin, 2009), an effect which didn’t fit with the dominant view of slant perception. According to the accepted theory, hills appear steeper to people when they are standing at the top and looking down because of a general compression of distance along the lines of sight. The observation that hills actually appear shallower to people when they are looking down from the top led experimenters to re-investigate the accepted theory and eventually propose a new model of slant perception. These are just three examples. The abundance of introspective evidence suggests that the distortion of space is genuinely perceptual and not merely a distorted judgment.

Another way to identify genuinely perceptual effects is to use “performance-based measures” in which “subjects’ success is tied directly to how they perceive the stimuli” (Firestone & Scholl, 2015, Section 4.2.3). In the study of perceived slant, researchers don’t rely on verbal reports alone. Several studies have shown that verbal judgments of slant are largely consistent with nonverbal measures like angle bisection and aspect ratio tasks (Durgin et al., 2010; Li & Durgin, 2010). A related worry for verbal report is that subjects may exaggerate their answers to fit the experimenter’s hypothesis (Durgin, Baird, Greenburg, Russell, Shaughnessy & Weymouth 2009). For example, if a subject has guessed that the experimenters think hills look shallower from the top than the bottom, they may exaggerate their estimates to fit that hypothesis. To address this issue, some experimenters (Durgin & Li, 2011; Li et al., 2011) debrief subjects by asking them to report their beliefs about the aims of the experiment as well as the strategies employed in designing the experimental tasks. Experimenters who include these questions can then compare the data from subjects who guessed the experimenter’s aims with the data from

![Figure 1. The Muller-Lyer Illusion. Though the line on the top looks longer than the line on the bottom, they are objectively equal in length.](image)
those who did not. In the studies cited above, the significance of the findings did not depend on subjects guessing the experimenter’s hypothesis.

If we accept that the evidence supports a genuinely perceptual distortion of visual space, then we are faced with a new question. What explains our success at navigating the world, given that perceived spatial properties (like distance and slant) are so often inaccurate? A problem arises only if we assume that successful action requires accurate perception. Instead, these studies suggest that inaccuracy, far from being a problem that the visual system must overcome, is sometimes useful for guiding action. Akins (1996) has made a similar point in her argument against the view that perception is veridical. She suggests that vision is not a faulty veridical system which aims at accuracy but frequently falls short; rather, vision is better understood as narcissistic. It aims to tell us about the world relative to our own interests and activities, rather than present the world as it objectively is. Given this possibility, a more interesting question would be whether systematic inaccuracy in vision, like that suggested by the study of slant and distance, serves a useful function in supporting action.

One way that systematic inaccuracy might support action is by enhancing perceptual discrimination through scale expansion (an idea put forward by Li & Durgin, 2009; Durgin & Li, 2011). Scale expansion is a “coding strategy” in which a subset of a range of values is coded more “densely,” thereby magnifying that subset. Scale expansion theory starts from the assumption that information is coded in the brain, for example, as when the visual system compresses information from the retina into units that are used in further visual processing. The theory then posits that it would be useful to code the most common units in a way that exaggerates the difference between them, thereby expanding that region of the scale. An example from Li and Durgin helps to flesh out this proposal: Consider your perception of your own gaze. The range of gaze declination from 0 to 60 degrees is a candidate for scale expansion because human gaze tends to fall straight ahead or tilt downward within a 60-degree range (Li & Durgin, 2009). That is, for most actions that we perform, it is not useful to look overhead or down at our feet – though this will, of course, vary for individuals given the sorts of tasks that they might need to perform. If the 0-to-60-degree range is expanded, a subject should be able to tell the difference more easily between declinations of 30 and 35 degrees than between declinations of 70 and 75 degrees, for example. This, in turn, enables her to exert more fine-grained control over gaze declination in the expanded region, where the differences among gaze declination are exaggerated. Coding the typical range more densely than, say, the range from 60 to 90 degrees enables greater precision for the declinations that matter most for typical human action.
Scale expansion provides an elegant explanation of the evidence that perceived distance and perceived slant are distorted (see Figure 2). As we have seen, evidence suggests that both perceived gaze and perceived optical slant are systematically distorted. As Figure 2 illustrates, when both the declination of gaze and the optical slant are overestimated, perceived distance will be compressed – an effect that has been widely demonstrated (Da Silva, 1985; Foley et al., 2004; Gilinsky, 1951; Li et al., 2011; Loomis et al., 1992). A further consequence of these distortions of spatial perception is that differences in slant relative to the horizontal plane are magnified (a result also suggested by Proffitt et al., 1995). While Li and Durgin’s experiment does not test this directly, the magnification of slant could help subjects to be more sensitive to small deviations in slant relative to flat ground. The research summarized in this section suggests not only that we are inaccurate with respect to spatial properties in the world around us but also that inaccuracy serves a useful function: It makes us more precise in our judgments of objective slant regarding the angles that matter most for action. In the next section, I turn to an area of research where psychologists have directly tested the claim that inaccuracy can increase perceptual precision and offer stronger support for that claim.

### 2.2. Misrepresentation of motion

As you walk through a room, the pattern on your retina changes, even if everything in the room is perfectly stationary. This change in the retinal

![Figure 2. Durgin & Li's (2011) illustration of the scale expansion theory of depth perception. In the diagram γ and β represent the objective declination of gaze and optical slant, respectively. In perceptual experience, perceived gaze (γp) and perceived slant of the ground (βp) are each overestimated compared to the objective declination of gaze and objective slant. This results in a compression of perceived distance.](image-url)
image due to self-motion is called visual flow (Gibson, 1966). Since Wallach (1987), it has been widely accepted that visual flow appears to slow down while walking. A series of studies aimed to quantify this effect and to explore its consequences for discriminative judgment. The effect of walking on visual flow provides further support for the view that systematic misrepresentation in vision has the function of enabling greater perceptual precision.

In a 2007 study, Durgin and Gigone aimed to quantify the degree to which visual flow slows down while walking (see also Durgin, Gigone, & Scott, 2005) and to explore whether distortion of perceived motion increased perceptual precision. In their first experiment, subjects were presented with a virtual moving hallway created by an immersive head-mounted display (see Figure 3). The virtual hallway had spotted walls which moved past the subject at a rate controlled by the experimenter. In the first condition, subjects walked while viewing the virtual hallway, and in the second condition, they stood still while viewing it. Each condition lasted just a few seconds. Subjects were then asked to judge which hallway had been moving faster. On average, the speed of the virtual hallway had to be 50 centimeters per second faster for subjects while they were walking than while they were standing, in order for the subjects to reach the point of subjective equivalence, or the point at which the hallways appeared to move at the same speed. That is, if you present a subject with an object moving past them at a fixed rate, that object will appear, to the subject, to be moving more slowly when she is walking than when she is standing still.

Figure 3. Durgin’s (2009) illustration of a subject walking in a virtual hallway. The spots on the walls and floor flow past the walker at a rate controlled by the experimenter. In a speed discrimination experiment, a subject is presented with a hallway with spots moving at one speed, and then, after a short break, a second set of spots moving at either the same or a different speed. In each trial, the subject is instructed to either walk or stand still. The subject’s task is to judge which spots appear to move faster. While walking, the stimulus appeared to move about 50 cm/sec slower than while standing.
To assess the speed of visual flow, Durgin and Gigone asked subjects to report which stimuli appeared to move faster. They were careful to ask for reports about the appearance of motion and not for judgments about the motion of objects themselves (see Durgin & Gigone, 2007). This instruction is important because it helps to address a worry similar to the one raised in the previous section on slant and distance: Subjects may judge that an object is actually moving faster (or slower) than it appears. Just as we can be aware of a shadow on a surface while simultaneously seeing the wall as uniformly colored, so too can subjects learn to distinguish between the appearance of motion and the judgment that an object is actually in motion.

As in the case of slant and distance, there is reason to think that misrepresentation of motion has a useful effect. Reductions in the apparent speed of objects while walking enables greater perceptual precision, such that deviations from expected visual speeds can be discriminated in a more fine-grained way while walking than while standing still. Greater precision with respect to the actual motion of objects will, in turn, have an effect that is useful for the coordination of action, since moving subjects need to adjust their walking speed in response to other moving objects in their environment. To demonstrate that walking subjects make more precise judgements about the actual speed of objects, Durgin and Gigone repeated their study, this time presenting subjects with flow speeds that were very close to the visual flow induced by walking. As before, they compared subjective judgments of flow speeds across two trials, walking and standing still. They found that subjects were better able to discriminate visual flow speeds that were close to walking speed when they were walking than when they were standing still. The experimenters suggest the following explanation for the increase in subjects’ perceptual precision during self-motion: By reducing the perceived speed of objects while walking, small differences in speed become proportionally larger compared to the absolute perceived speed which, in turn, enables more precise discrimination among actual speeds. In this way, the systematic misrepresentation of the speed of objects while walking helps subjects to perceive the motion of objects in a more precise way. It does this by making the subject more sensitive to small deviations from the expected effects of their own self-motion. Durgin explains:

In the control of action, perceptual precision (the fineness of discrimination among actual values of a variable) is more important than perceptual accuracy (direct correspondence between the perceived and actual value of variable). (2009, p. 43)

Since precision is more important than accuracy for navigating the world, perceptual systems misrepresent the world in ways that enable more precise perceptual discrimination for those properties that commonly
play a role in action. Durgin and Gigone’s study provides an example of both the pervasiveness of misrepresentation and its usefulness for making discriminations among the actual properties of objects.

2.3. Does scale expansion involve misrepresentation?

I have suggested that the examples in this section demonstrate widespread inaccuracy in perception and that inaccuracy aids perceptual discrimination in these cases. Before turning to the implications for philosophy, I will consider a challenge to my interpretation of the evidence. Perception in the scale-expansion cases may be inaccurate with respect to objective properties, yet still veridical with respect to relational, view-point dependent, or context-dependent properties. If the empirical examples surveyed in this section involve veridical perception, then the revisions that I propose to the traditional account of perception and illusion may be unnecessary. I will consider two ways of posing this challenge and respond to each of them.

Consider first an alternate interpretation of perceived motion. In their 2007 discussion, Durgin and Gigone suggest that visual representation of motion is contextual. For example, walking and standing provide the subject with different perceptual contexts, and motion is represented differently in each context. One possibility, then, is that the content of perception is context-dependent rather than inaccurate. That is, visual perception represents the object’s speed as well as the context, such as walking or standing, and attributes context-dependent properties to the object. Even if we accept this interpretation, it is hard to see how context-dependence would result in accurate perception for the perceived motion case. Recall that the speed of the spots in the visual array appears to slow down for the subjects while they are walking, but the relative speed of the spots during walking is faster than it is when the subjects are standing still. Thus, the subject represents neither the relative nor the objective speed of the spot accurately, and it is unclear how an appeal to context would help her to do so. Moreover, some philosophers may find it implausible that we represent our own self-motion in the content of visual perception, as context-dependence seems to require (Harman, 1990; Tye, 1995; for a different account of context-dependence see Campbell 2009).

A stronger alternate interpretation can be developed by pointing to relational, viewpoint-dependent properties. By way of illustrating this view, consider Hill’s account of the representation of size (Hill, 2014, 2016). It is widely accepted that the visual system computes constancies for properties like size, resulting in the appearance of a stable world even as viewing conditions change (Palmer 1999). Hill defends a different account on which constancies are only partial, and thus more like the cases that
I describe here. When representing size, for example, partial constancy is useful because differences in apparent size encode information that is relevant for guiding action, such as distance from the viewer. On Hill’s view, the visual system does not represent an objective-size property, but rather a “relational viewpoint-dependent property of the object” (2014, p. 190) that is determined by facts about the viewer as well as the environment. The latter property, which he calls a “sizeance,” encodes information about size relative to distance from the viewer. A similar account could be given for the cases of perceived slant that I discuss in Section 2.2. Rather than maintain that we misrepresent objective slant, as I have argued in this paper, Hill could say that the visual system accurately represents a relational, viewpoint-dependent property that encodes information about the objective angle of the slant, the subject’s location with respect to the slant, her height, and so on.

8 On Hill’s view, viewpoint-dependent properties are properties of the object, and we represent them in perceptual experience. Thus, while viewpoint-dependence is widespread, misrepresentation is not.

The claim that viewpoint-dependent properties can fully explain the phenomenology of constancy has met with a number of objections (see Hatfield, 2016; Hatfield, 2009; for a review see Green & Schellenberg, 2017; for a response, see Hill & Bennett, 2008; Hill, 2014; 2016). However, whether or not viewpoint-dependent properties can explain the phenomenology of constancy, the slant and motion cases that I discuss in this paper differ from constancy cases, and this difference should make us skeptical that they can be given a similar account. To see why, consider that, in size constancy, our perceptual judgments suggest that we are aware of both objective and apparent size simultaneously. For example, things don’t appear to get objectively smaller as they move farther away, even though apparent size decreases. To take Hill’s example, an SUV in the distance does not appear to be the same objective size as a toy car in your hand, even if they are the same apparent size. On Hill’s view, this is because sizeances encode information about visual angle as well as distance from the viewer. With perceived slant and motion, on the contrary, subjects are not able to distinguish between apparent and objective properties in the same way. When slant is inflated, there is not only an increase in apparent slant; the slanted object also appears to be objectively steeper to the subject. This suggests that, in the case of inflated slant, we are not encoding both appearance and objective properties in perceptual content, but, rather, confusing the apparent slant for the objective slant. In this way, perceived slant is dissimilar from perceived size.

3. Illusion as a failure of precision

The argument in this paper relies on establishing two points: First, that inaccuracy is widespread in perception, and, second, that some cases of
inaccurate perception involve a well-functioning perceptual system. So far, I have argued that the evidence for scale expansion in the perception of space and motion supports a view on which perception is frequently inaccurate. I have also provided evidence that these cases involve successful perception. As many experiments from psychology have shown, the well-functioning human visual system distorts objective properties like the slant of a hill, the speed of a moving object, egocentric distance, and the declination of one’s own gaze. These distortions are a feature of vision, not a flaw. By distorting objective properties, we are able to make more precise discriminations among those properties for the purpose of guiding action. In many cases, systematic inaccuracy serves to magnify differences among the actual properties of objects in the world, increasing the precision of perceptual discrimination. It follows that we should reconsider the philosophical position that perception aims at accuracy.

This view has implications for the philosophical account of illusion, which is intended to capture the distinction between successful perception and misperception of an object’s properties. On the standard account, perception is illusory whenever a subject inaccurately represents a property of an object (see, for instance, the quotes from Smith, Fish, and Macpherson in Section 1). The evidence that I’ve presented shows that the standard account of illusion does not track the distinction between successful perception and misperception, since some inaccurate perception is nonetheless successful. A better account of illusion appeals to precision as well as accuracy to distinguish illusion from successful perception. On the account of illusion that I propose, illusions are perceptual experiences that are neither accurate nor precise. More specifically:

**The Precision Account of Illusion**

A perceptual experience is illusory if and only if it is inaccurate and that inaccuracy does not increase perceptual precision.

As I will show in this section, many classic cases of visual illusion involve a failure of precision as well as accuracy, but, for some cases of inaccurate perception, appealing to precision results in a better account than appealing to accuracy alone. What makes the precision account better is that it enables us to articulate a distinction that the traditional account of illusion obscures: The distinction between successful and unsuccessful perception in cases involving inaccuracy.

Although I offer a new account of illusion, the main point of this paper is not terminological; it’s not primarily a claim about how we use the term ‘illusion.’ Rather, the significance of this paper is to show that some cases of inaccurate perception are nonetheless successful. They enable precise discrimination among the actual properties of objects and thereby improve
perceptual contact with the world for the purposes of guiding action. This distinction between successful and unsuccessful inaccurate perception is not captured by existing accounts of illusion in the philosophical literature. Another way forward, in light of this evidence, would be to say that some illusions are cases of successful perception. While this is not the strategy that I pursue here, it is consistent with the main substantive claim in this paper. As I will show, the precision account of illusion that I offer does a better job of distinguishing successful from unsuccessful perception than the traditional account, and, for this reason, I think we should prefer it.

I will discuss two features of this account of illusion, before showing how it handles some cases. The first feature concerns the relationship between inaccuracy and precision. On my account, in order for inaccurate perceptual experience to be non-illusory, the increase in precision must depend on that inaccuracy. The scale expansion cases discussed in Section 2 illustrate this dependence. Subjects are able to make more fine-grained perceptual discriminations precisely because they have distorted the properties of objects in a way that accentuates relevant differences. For example, they are more easily able to distinguish a five- from a six-degree slant because they have magnified that difference in perceptual experience. In cases of successful but inaccurate perception, inaccuracy is not merely incidental to a subject’s discriminatory abilities; rather, inaccuracy partly explains those abilities.

A second feature of my account is that precision comes in degrees. While perceptual experiences may be accurate or inaccurate, they can be more or less precise. This means that illusion, too, will come in degrees and that there will be vague or borderline cases. This feature of my account raises the question of where exactly we should draw the line between illusion and successful perception. Is there a specific threshold of precision that must be achieved in order for inaccurate perception to be successful rather than illusory? As with other cases involving vagueness, stipulating a non-arbitrary threshold may not be possible. Just as we can’t point to the specific grain of sand that transforms a pile into a heap, so too might we be unable to specify a non-arbitrary degree of precision that demarcates illusion from successful perception. Yet, we can still theorize about precise and imprecise perceptual experience, so long as there are clear cases of each. I will now turn to some of these clear cases, which help to illustrate what philosophers can gain by thinking of illusion as involving a failure of precision as well as accuracy.

Consider first a couple of standard cases of illusion that involve a failure of precision. If you stare at a waterfall tumbling over the rocks and then look at the stationary rock beside you, there’s a good chance that you will experience an illusion of motion on the stationary rock – a phenomenon known as the waterfall illusion. In virtue of seeing the rock’s surface as
moving, you are in a poor position to discriminate among its objective properties on the basis of perception. The illusion of motion does not, in this case, enable more fine-grained discrimination among the actual properties of the rock. Similarly, consider the Muller-Lyer illusion (Figure 1). This case, too, involves a failure of precision. If asked to discriminate the length of the horizontal lines based on perception alone, a subject may be misled by her perceptual experience. On the basis of her experience, she judges that one line is longer than the other. As in the waterfall illusion, her perceptual experience of the figure interferes with her ability to distinguish among its objective properties.

Both the waterfall illusion and the Muller-Lyer illusion involve a failure of veridicality that does not increase perceptual precision. In the waterfall illusion, inaccuracy doesn’t help one to make more fine-grained discriminatory judgments about the actual properties of the rock. Likewise, in the Muller-Lyer illusion, one line appears shorter than the other even though the lengths of both lines are objectively equal. While both illusions do involve inaccuracy, this alone is not what makes them illusory experiences on my view. Instead, they are illusions because they do not enable precise discrimination among the actual properties of the object, and not simply because they fail to present the world accurately.

The research on perceived motion and space, however, shows that not all inaccurate perception involves a failure of precision. Some perceptual experiences that are inaccurate nonetheless give us good contact with objects and their properties. Consider the case of reduced visual flow while walking. Suppose a subject, S, views the virtual hallway in Durgin and Gigone’s 2007 experiment. In Trial 1, S is standing while a particular spot in the virtual hallway – call it Spot – moves past her at a rate controlled by the experimenter, say 100 cm/sec. In Trial 2, S walks forward while Spot moves past her at the same rate. Yet Spot appears to S to be moving more slowly in Trial 2 than in Trial 1. If S’s perception of Spot were veridical, then Spot would appear to move at the same speed in both trials. A plausible explanation of S’s mistake is that S’s perceptual experience of Spot is inaccurate in at least one of the trials, but, although S inaccurately perceives Spot, it is not obvious that this case involves an illusion. For one thing, if walking (or standing still) results in illusion, then illusion will be widespread in ordinary perceptual experience. This is not necessarily a reason to reject the view, but it is, at least, a surprising consequence. Second, unlike the waterfall or Muller-Lyer illusions, S’s inaccurate perceptual experience enables her to make more fine-grained judgments about Spot’s actual properties. S inaccurately perceives Spot’s motion, but this serves to make her more precise in judging Spot’s motion for speeds that are close to her own walking speed. Intuitively, S’s perception is a success. If we think about her perceptual experience in terms of
precision, we can understand why exactly it is a success, despite its inaccuracy.

Similar reasoning applies in the case of perceived distance and slant. Consider Proffitt’s example of traversing the Virginia mountains (Proffitt et al., 1995). For a subject standing at the bottom of a hill, it may appear that the road slants upward at twelve degrees, even if the objective slant is only six degrees. If she then climbs to the top and looks down from the edge, the hill will appear shallower than it really is, with a slant of three degrees, perhaps. The objective slant, of course, stays the same. Therefore, at least one of the subject’s perceptions of the hill is inaccurate, and, most likely, both are, since neither matches the objective slant. Yet, despite this inaccuracy, a subject typically won’t stumble when going up- or downhill. By exaggerating slant from the bottom and underestimating slant from the top, a subject is better able to detect small changes in the incline of the ground. Inaccuracy serves to exaggerate inclines that are close to ground level; this exaggeration may make a subject’s judgments and actions more precise than if she were to perceive slant accurately. If we appeal to precision to distinguish successful perception from illusion, then the result aligns with common sense. This is a case of successful perception.

As these examples show, the line between perception and illusion gets drawn in a slightly different way if we appeal to precision as well as accuracy. This alternate way of categorizing specific problem cases is part of the motivation for the view that precision offers a promising way forward for distinguishing successful perception from misperception. A view that characterizes successful perception in terms of precision will struggle to explain the sorts of cases discussed in this paper, in which perception is inaccurate but precise. Perceptual distortions of space and motion would be considered illusions if we were to rely on accuracy to draw the distinction between perception and illusion. However, on the view that I propose, they are not illusions, provided that inaccuracy enables more precise discrimination among the actual properties of objects.10

Notes
1. There are some exceptions. See McLaughlin (2016), as well as the discussion below of Akins (1996) and Simmons’ (2008) interpretation of Descartes and Malebranche.
2. This paper defends a way of distinguishing successful from unsuccessful perception in terms of precision, but there may be other ways of defining ‘success,’ depending on the domain of inquiry. For example, an epistemologist may be more interested in accuracy than precision if accurate perception tends to result in true beliefs. My view is also consistent with the possibility that inaccurate perception can be successful for other reasons in addition to precision. For example, inaccurate perception may be considered successful if it reduces false negatives, such as when a subject mistakes a stick in the woods for a snake. However, this does not involve an increase in
precision. I am grateful to two anonymous reviewers for these suggestions and examples.

3. For readers who would like more information about the philosophical account of accuracy and the content of perception, see Siegel (2016).

4. One intuitive example that illustrates this idea is a caricature in drawing. Caricatures distort a subject’s features in ways that are arguably inaccurate, but this enables better recognition of the person depicted by the drawing. I am grateful to an anonymous reviewer for this example.

5. The subject is accurate insofar as the door really is taller than she is, but she may nonetheless be inaccurate with respect to the door’s height or the magnitude of the difference between her height and the door’s. I think that we represent properties like the door’s height in visual perception and not just relations such as “taller than.” For this reason, I call this a case of inaccurate representation. I am grateful to Chris Hill for discussion of this point.

6. For some time, it was thought that subjects could perform complicated actions because their visual system re-inverted the light hitting the retina, transforming the inverted image into a veridical representation of an upright world. When subjects describe their experience, however, the picture that emerges is not so straightforward. Harris (1965) and Linden et al. (1999) found that the world remained inverted following adaptation, though other reports suggest that inversion may be partial (Kohler, 1961). This evidence from subjective reports suggests that the world does not fully re-invert to a veridical representation following adaptation.

7. Some of Proffitt’s research has been contested, such as his finding that backpacks and sugary drinks influence distance judgments (see Durgin et al., 2009). In contrast, the finding that subjects exaggerate the slant of hills has been replicated and is widely accepted in the literature.

8. I am grateful to Chris Hill for raising this objection at the 2017 Minds Online conference session on perceptual precision.

9. For a review of the literature on vague predicates, see Hyde (2011).

10. Redacted.

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