

Specular highlights as a guide to perceptual content¹

Abstract (172 words): This article is a contribution to a recent debate in the philosophy of perception between Alva Noë and Sean Kelly. Noë (2004) has argued that the perspectival part of perception is simultaneously represented along with the non-perspectival part of perception. Kelly (2004) argues that the two parts of perception are not always simultaneously experienced. Here I focus on specular highlights as an example of the perspectival part of perception. First I give *a priori* motivation to think that specular highlights are experienced at the same time as non-perspectival properties, which challenges Kelly's position. Then I discuss psychophysical work by Andrew Blake and Heinrich Bülhoff (1990) which seems to show that specular highlights are not represented in the way that Noë (2004) would suggest. In the third section I suggest a compromise between Noë and Kelly: specular highlights are not represented, but rather play an evidentiary role in the representation of perspective independent properties, like gloss and shape. I conclude with some thoughts about how this study can generalize to other kinds of experience.

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Specular highlights are the perspective dependent shiny spots appearing on glossy surfaces.² Our visual experiences are filled with them. One can notice them on automobiles, leaves, liquid, food, metals, and many other surfaces. Philosophers of perception have not paid much attention to specular highlights, as far as I can tell.³ But scientists working in computer rendering have studied specular highlights extensively, and have developed some advanced mathematical techniques for calculating the locations of highlights in artificial scenes (Watt and Watt 1992, for example). Here I show how specular highlights are relevant for contemporary issues in the philosophy of perception.⁴

¹ This article takes material from my doctoral dissertation which was supervised by Radu Bogdan for Tulane University. I thank the following people for helpful comments: Harald Atmanspacher, Radu Bogdan, Bruce Brower, Andy Clark, Sean Kelly, Alva Noë, and two anonymous referees. I especially benefited from discussing this material with the late Susan Hurley. Finally, I received helpful comments when presenting this material at the Bristol PPNB conference in March 2007, for which I am grateful.

² In the computer vision literature, they are sometimes called 'specularities,' 'highlights,' or 'specular reflections.'

³ They might be implicit in some of Edmund Husserl's writings, and Maurice Merleau-Ponty was sensitive to the way in which the surface of an object affects our color experience of that object. More recently, Alva Noë has mentioned specular highlights (2004: 125).

⁴ I understand the philosophy of perception to be a part of the philosophy of mind which focuses on perception using both empirical evidence and *a priori* description. For example, some live issues in the philosophy of perception involve whether there is more than one type of perceptual content (Noë 2004, chapter 5), whether perceptual content is fully representational (Tye 2000, chapter 4), and whether perceptual content is partly non-conceptual (Gunther 2003).

The philosophy of perception over the past century has seen a general debate over reasons for attributing a two-part structure to perception. Nowadays, the main, uncontroversial, part of perception is the part of perception that represents the world to be a certain way. Seeing a dog involves representing the fact that a dog is present. But many philosophers acknowledge that there is also another part of perception that is dependent on the perspective of the perceiver.⁵ In general, the perspectival dimension of experience changes during our experience of unchanging properties. Our perception of the shape of the cube does not change, but our experience of the shape of the cube changes as our perspective continuously changes. Our perception of the color of the cube does not change, but experience of the colors on the surface of the cube changes with changes in perspective or with changes in lighting conditions.

Many contemporary philosophers of perception who are concerned with the perspectival part of experience argue that it is representational, and thus has correctness conditions, just like the mundane perspective independent properties that we perceive.⁸ In other words, these philosophers think that we represent normal perspective independent properties of the world *and at the same time* we represent perspective dependent properties of the world. The latter representations are of what Alva Noë calls “perspectival properties” (2004).⁹ Noë suggests that we see the mundane factual content *in* the perspectival content. For Noë, the two levels always go together and both levels are representational.

In contrast, Sean Kelly (2004) has denied the two-stage view of perception.¹⁰ He accepts that we can notice the perspectival dimension, but suggests that we rarely do so. Kelly argues that noticing the perspectival part of perception often requires what he calls the “detached attitude” – the attitude that a painter might adopt, for

⁵ This perspectival part of perception has been called “sensation” by Edmund Husserl (1900/1993 vol II: 349), “sensational properties” by Christopher Peacocke (1983/2002), “perspectival content” by Alva Noë (2004). Husserl, in his breakthrough work on perception, in the 5th and 6th *Logical Investigations*, first examined the changing sensations which accompany our representations of static properties. Kevin Mulligan (1995) has suggested that Husserl was influenced by the psychologist Ewald Hering’s work on color perception in his discussion of sensations. For an interesting account of the way in which Husserl’s work influenced the development of the sense-datum theory, see Küne (1990), and also Spiegelberg (1975), and Milkov (2004). The sense-datum theorists probably also belong on this list of advocates of a two-part structure to perception, but I hesitate mostly because their emphasis on perspective is not as pronounced as in the other thinkers here.

⁸ Gilbert Harman (1991/1997), Michael Tye (2000), and Alva Noë (2004) all advocate a position like this one.

⁹ Tye (2000: 78) and Harman (1991/1997) treat the perspectival element of perception as representations of the way the world is “from here.”

¹⁰ Kelly’s rejection of the two-stage view is evident in his 2004 article, but it is even more explicit in his forthcoming review of Noë (2004).

instance. For Kelly, we are usually in the “engaged attitude,” where we do not experience our changing perspective on things because we pay attention to the perspective independent properties of the things we perceive. Further, Kelly thinks it is false that we always experience both the perspectival and the factual dimensions of perception together. Instead, the perspectival part plays a kind of normative role while we are in the engaged attitude. For instance, when we look at a tilted coin in the engaged attitude, we might feel a tension to turn the coin perpendicular to our line of sight in order to gain a better view on the face of the coin. The perspectival element is only experienced as a deviation from a norm; in this case the norm would be the optimal viewing angle for the coin.

Who is correct, Noë or Kelly? There are some difficult and subtle issues here, to be sure. So in this paper I will only be considering how one aspect of visual perception, specular highlights, makes problems for each of their positions. In the third part of the paper I will suggest an account of specular highlights that is somewhere between the theories of both Noë and Kelly. The first part of the paper will be mostly *a priori* description of the experience of specular highlights and will include some critical remarks about Kelly’s position. The second part of the paper includes some relevant empirical work on specular highlights and some critical remarks about Noë’s position.¹¹

1. Seeing specular highlights

Specular highlights are a good example of the perspectival part of experience because they are manifestly perspective dependent. One can walk around a clean automobile on a sunny day to notice how the specular highlights change with perspective. We do not represent specular highlights to be properties of the object perceived. We might represent gloss as a property of the object perceived, and the highlights seem to play an interesting and complex role in our representation of gloss (figure 1). But the highlights themselves are always changing, and are not seen as properties of the object. Specular highlights change with perspective in a way that,

¹¹ The position I attribute to Noë is the one he expresses in his book (2004). In personal conversation, Noë has said that his current position on this matter is different than that given in his book. The criticism of Noë (2004) also applies to other philosophical theories which take the view that specular highlights are representational. I assume that many representational theories of perception (Tye 2000 and Dretske 1995, for example) would take this view on specular highlights.

say, the spots on a Dalmation do not.¹² Likewise, the color of the specular highlights is often not perceived to be the color of the surface on which the highlights appear.¹³ We will often see bright white or yellowish-white highlights on a black automobile, for example. We do not perceive the automobile to be any color but uniformly black.

Another point to be made here is that we seem to have implicit expectations about the relationship between the locations of specular highlights and the properties of the objects on which they appear. In figure 1, the highlights on the object on the left seem to be legitimate specular highlights. If the object on the left were real, we would expect the highlights to change with our perspective, and we would judge the object to be glossy. In the object on the right, on the other hand, the highlights seem to be “out of place” or seem to have been painted onto a grey lustreless object.

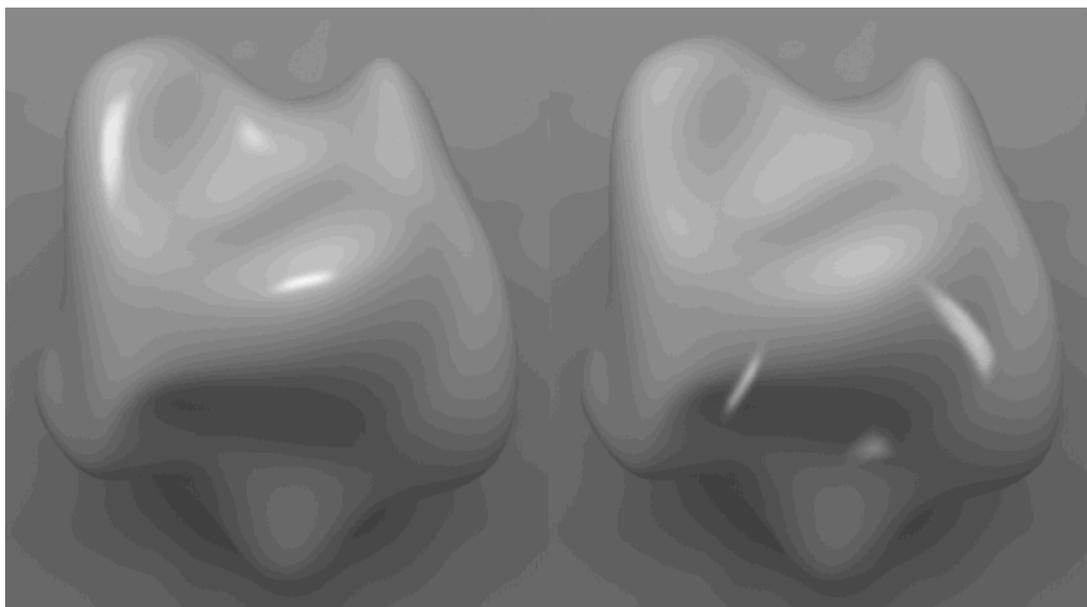


Figure 1: The location of highlights affects the properties that we perceive objects to have. The object on the left looks to have authentic specular highlights and looks glossy. The object on the right seems not to be glossy, but seems to have highlights that are out of place. Taken with permission from Todd et al. (2004).

Specular highlights are a good example of the perspectival part of perception because they change with perspective and are not identical to properties of the objects on which they appear. Also there is reason to think they facilitate our representation

¹² I thank an anonymous referee for suggesting clarification here.

¹³ The relationship between specular highlights and perceived color is a difficult one. For example, specular highlights play a role in our perception of the color of substances which conduct electricity, but not in the color of dielectric materials. Thanks to a referee for pointing this out.

of the glossiness of objects. These observations, if correct, do not look supportive of Kelly's normative theory of the perspectival part of perception. Kelly's position is that the perspectival element can be noticed in the detached attitude, and that entering this detached attitude makes it difficult to experience the normal properties that one would experience in the engaged attitude. A problem for Kelly, then, is that the experience of the specular highlights does not involve any kind of holistic attitude shift. Noticing the specular highlights is a rather mundane act of attention. Further, experiencing the specular highlights does seem to be a part of the experience of perspectival independent properties such as gloss. Figure 1 suggests that specular highlights facilitate gloss perception (also see Beck and Prazdny 1981), and in the next section of the paper I will present some evidence that specular highlights facilitate shape perception as well.

There is also the normative component to Kelly's theory. According to Kelly, the experience of the specular highlights should be felt as a deviation from a norm, just as seeing the coin at an angle is felt as a deviation from seeing the face of the coin directly. But what is the norm from which specular highlights deviate? The answer to this question is not immediately clear. It is true that highly glossy objects in excessive light are not easily perceived because of the intensity of the specular highlights¹⁴ -- because of the glare, as one might say. So perhaps there are situations where specular highlights have a normative component; there are optimal lighting conditions from which intense specular highlights deviate. But for the vast majority of viewing conditions, it seems, specular highlights do not carry any normativity. I do not think that Kelly is making the weaker claim that the perspectival part of perception *sometimes* plays a normative role; it seems as if Kelly wants to maintain that the perspectival part of perception is *essentially* normative. There is no obvious way to defend this stronger claim for the case of specular highlights.

2. The brain uses specular highlights

The discussion above may make some problems for Kelly's account of the perspectival part of perception. In this section I am going to present some psychophysical evidence from Andrew Blake and Heinrich Bülhoff (1990) regarding

¹⁴ Thanks to James Genone for pointing this out.

specular highlights. Then I will explain how it makes problems for Noë's theory that we simultaneously represent both factual and perspectival content.

Blake and Bülthoff have developed a model of the way in which specular highlights appear for concave and convex surfaces. This model is called the "ray-optic specular stereo" model (Blake and Bülthoff 1990, Blake 1985). According to this model, the specular highlight is a virtual image of the light source. The location of the virtual image depends on the curvature of the reflecting surface. For instance, if the surface is convex, the model predicts that the image will appear "behind" the surface of the object. And for concave surfaces, the model has the highlight located "in front of" the object. The model is counterintuitive since we naturally see specular highlights to appear on surfaces, not behind or in front of surfaces. Indeed, Blake and Bülthoff report, "Thus, naïve observers, asked where a specular highlight appears to be in relation to the surface that generated it, usually reply that it seems to lie on the surface" (1990: 168). In order to understand what Blake and Bülthoff mean by the location of the specular highlight, it is necessary to consider depth perception in terms of relative disparity.

For humans with two functional eyes, the right eye and the left eye receive slightly different retinal input and we use the differences, called "disparities," as a cue for constructing a representation of depth (Goldstein 2002: 233 - 242). If two objects are different distances from the eyes of an observer with normal binocular vision, then the disparity of the object that is farther away will be larger than the disparity of the object that is closer. Thus we have the relative disparity between two objects. If specular highlights on convex surfaces appear behind the surface, the human visual system will detect this location by a greater disparity of the surface of the object than the disparity of the highlight. Blake and Bülthoff predicted that the human visual system uses the physics of their ray-optic specular stereo model to represent gloss and shape (figure 2). And the evidence (reported in Blake and Bülthoff 1990) seems to support this prediction.

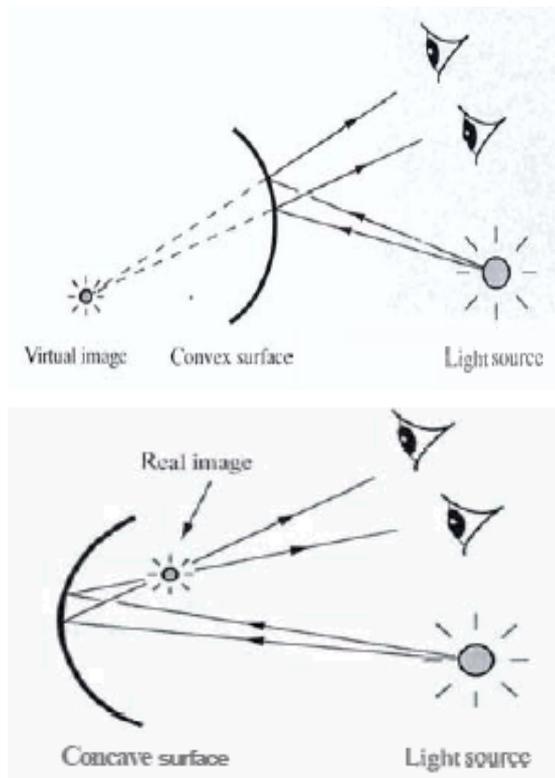


Figure 2: Blake and Bülthoff's ray-optic specular stereo model. Taken with permission from Blake and Bülthoff (1990).

In one experiment, naïve subjects were given stereo images of three dimensional shapes with simulated specular highlights. The subjects were asked to adjust the disparity of the highlights so that the glossy surface of the shape looks realistic. For convex surfaces, the results of the experiment matched those predicted by Blake and Bülthoff's specular stereo model of highlights. Instead of adjusting the disparity in a way to place the highlight on the surface, subjects adjusted the disparity so as to place the highlight behind the surface, just as the model predicts. For concave surfaces, however, the results of this experiment did not match the model. Subjects reported being unable to adjust the disparity to obtain a realistic image. Blake and Bülthoff report suspecting that this result occurred due to shortcomings in the computer graphics rendering of concave surfaces. But, for convex surfaces at least, there is evidence that the human visual system expects the shape of objects to correspond with the physics of the specular highlights on that object.

In a second experiment, Blake and Bülthoff presented subjects with an ambiguous stimulus, a stereoscopic image that could be interpreted as either concave or convex. The experimenters randomly set the relative disparity to place the specular

highlight either in front of or behind the surface, and gave the subjects a two-option forced choice on the shape of the surface. Blake and Bülthoff report “Although initially subjects tended to be locked into either a convex or a concave interpretation, after about 20 exposures they were consistently picking, quite reliably, the interpretation that was consistent with the sign of the relative disparity of the specular highlights” (1990: 168). In this second experiment, the relative disparity of the specular highlights influences subjects’ judgments of three-dimensional shape.

To summarize the evidence, in the first experiment, the shape of the stimulus was clear to the subjects, and they were asked to adjust the relative disparity in order to achieve a realistic look of glossiness. For convex surfaces, the subjects adjusted the disparity to set the specular highlight behind the surface of the stimulus, just as the Blake and Bülthoff model predicts. In the second experiment, the shape of the stimulus was ambiguous, and, under forced choice conditions, subjects used the relative disparity of the specular highlights to choose an interpretation of the shape of the stimulus that is predicted by the Blake and Bülthoff model.

What does all this interesting psychophysics have to do with the philosophy of perception? Blake and Bülthoff’s results could make a problem for Noë’s (2004) claim that the perspectival part of perception is representational. The relevant result from their experiments is that our visual system makes use of the non-surface location of the specular highlights even though subjects report that the specular highlights are seen on the surface of the objects. The brain makes use of the physics, but the physics does not match the phenomenology!

If our experience of specular highlights represents a perspectival property, as Noë (2004) might suggest, then our experience of specular highlights systematically misrepresents. It misrepresents because we experience specular highlights to be on the surface of objects, and, according to the physics, specular highlights are often not on the surface of objects. The physics of specular highlights shows them to be sometimes above, and sometimes below, the surface of objects. One main motivation for saying that a system represents a property would be the fact that the system does, in fact, successfully represent that property. But since our experience of specular highlights often misrepresents, then we lose that motivation for saying that the visual system is supposed to be consciously and accurately representing specular highlights to begin with. So the main challenge from the psychophysics is to Noë’s (2004) claim that the perspectival dimension, in this case specular highlights, are representational.

A related challenge to Noë's theory, a challenge that seems to motivate Kelly's criticism of Noë, is that we do not seem to experience the specular highlights with the same salience that we experience properties like gloss and shape.¹⁵ It does not seem correct to say that we are simultaneously representing both specular highlights and perspective independent properties like gloss and shape, with equal salience. What seems more correct – and in line with the empirical results – is to say that the experience of specular highlights is related to, or necessary for, or in the service of, the representation of perspective independent properties.¹⁶

3. Conclusions for the philosophy of perception

This is how things stand. Kelly's theory is challenged because a holistic attitude shift is not required for the experience of specular highlights, and because the experience of specular highlights accompanies the experience of perspective independent properties. The experience of specular highlights always seems to accompany the perception of gloss, and often accompanies the perception of shape. Both the *a priori* and the empirical evidence suggest that the experience of specular highlights plays a crucial role in the formation of the representation of gloss and shape. Also, it is not clear, *pace* Kelly, that the experience of specular highlights has any intrinsic normativity to it.

Noë's (2004) theory is challenged because he holds that the perspectival part of perception, such as specular highlights, are representational. But our experiences of specular highlights do not correspond with the physics of specular highlights, physical laws which the unconscious visual system exploits in order to form representations of gloss and shape. In addition, the relationship between the experience of specular highlights on one hand, and the experience of gloss and shape on the other hand, looks to be more complex than merely seeing the latter "in" the former (Noë 2004: 166 – 167). There looks to be much more going on than the

¹⁵ The notion that we experience both kinds of representations with the same degree of saliency is one that Kelly seems to attribute to Noë, but I am not sure that Noë deserves it. It is not clear to me exactly what Noë understands to be the way in which both types of representation are experienced simultaneously.

¹⁶ For some more recent empirical work on the relationship between specular highlights and the perception of (perspective independent) properties, see Norman et al. 2004, Todd et al. 2004, and Fleming et al. 2004.

representation of two types of properties, with the same degree of salience, and the seeing of one in the other.

How would a theory look that keeps the virtues of Kelly's and Noë's theories while avoiding the possible shortcomings? Without going into details, it might be fruitful to give a general sketch.¹⁷ Most importantly, it looks like we need a better account of the relationship between specular highlights and the perspective independent properties facilitated by specular highlights, like gloss for example. It is not quite right to say that the experience of specular highlights and the perceptual representation of gloss are mutually exclusive. But nor is it quite right to say that they are simultaneously experienced with the same degree of saliency.

Instead, the specular highlights and the representation of the perspective independent glossiness of the object seem to be intimately related in a complex way. Perhaps the best description of this relationship is that the specular highlights play a kind of evidentiary role in our perception of gloss. In other words, in pre-theoretical perception, we are not concerned with any physical properties to which the specular highlights correspond. (This claim seems to find support in the findings of Blake and Bühlhoff as explained above.) But we are concerned with the perspective independent properties for which the specular highlights give us evidence. When we represent an object to be glossy, we form implicit expectations about how the specular highlights should change with changes in perspective. When these expectations are fulfilled, we have increasing evidence for our representation of glossiness. If these expectations are not fulfilled, we might form new representations of the properties of the object, or perhaps withhold judgment until we can explore in more detail, or take a closer look.

There is a sense, then, in which there is some normativity involved in our perception of specular highlights. But it is not exactly Kelly's normativity in the sense of a deviation from optimal viewing conditions. Instead, the normativity is an implicit sense of the way the specular highlights should change given the perspective independent properties that we represent an object to have. This description of the relationship between the specular highlights and the perspective independent properties looks a lot like a description that Noë would give. But the important element missing in Noë is that, for Noë, the specular highlights do not play an evidentiary role. By claiming that the specular highlights play an evidentiary role, I

¹⁷ What follows is very much influenced by the account of perception in Edmund Husserl's *Logical Investigations V and VI*.

claim that they only serve as evidence for representations of perspective independent properties; they are not themselves represented.

Conceiving of specular highlights as evidence for representations of gloss and shape¹⁸ goes far in accommodating the theories of both Noë and Kelly. In the spirit of Noë, we can claim that the experience of specular highlights includes the simultaneous experience of objective gloss. In the spirit of Kelly, we can add the qualification that the experience of specular highlights is usually not as salient as the experience of the objective gloss so long as we are in the “engaged attitude.”

Conclusion

If there is any truth to what I have claimed, a big question remains: to what extent can we generalize the case of specular highlights to use this framework for understanding other kinds of perceptual experience? One option is that this framework does generalize; another option is that there is something special about specular highlights – something that is not shared by other perspectival features experience. A third option is that there is a general framework which better describes both specular highlights and other cases of the perspectival part of perception.

The most conservative strategy may be to consider different types of perspectival features one at a time. For instance, much of the debate over the perspectival part of experience has focused on perspectival shape, as given in the infamous tilted coin (see Noë, forthcoming, for an overview). Is it best to think that the elliptical appearance of the coin serves as evidence for the representation that the coin is in fact a flat disk?²⁰ Likewise, can the case be made that the changing color appearances on the surface of an object serve as evidence for the representation of the perspective independent color of the object? It would be nice to have answers to these questions that are both phenomenologically satisfying and supported by the psychophysical evidence. For the question of specular highlights, at least, I have tried to give such an answer.

¹⁸ Specular highlights may also play a role in the way we represent the color of objects, but conclusions on this issue are tentative (Yang and Maloney 2001).

²⁰ Kelly (in as yet unpublished work) has pursued psychophysical evidence to support his position in the case of the tilted coin.

Works Cited

- Beck J, Prazdny S, "Highlights and the perception of glossiness" Perception & Psychophysics (1981) **30** 407 – 410
- Blake, A. in Proc. 9th Int. Joint Conf. on Artificial Intelligence (1985) 973 – 976.
- Blake, A. and Bülthoff, H. "Does the brain know the physics of specular reflection?" Nature (January 1990) vol 343.
- Dretske, F. Naturalizing the Mind Cambridge, MA: MIT Press, 1995.
- Fleming, R. et al. "Specular reflections and the perception of shape" in Journal of Vision vol. 4 (2004) 798 – 820.
- Goldstein, E. B. Sensation and Perception. 6th edition, Wadsworth, 2002.
- Gunther, Y., (ed.) Essays on Nonconceptual Content. Cambridge, MA: MIT Press, 2003.
- Harman, G. "The Intrinsic Quality of Experience" in The Nature of Consciousness. Block, et al., eds. Cambridge, MA: MIT Press, 1997. Originally published in 1991.
- Husserl, E. Logische Untersuchungen II/1. Tübingen: Niemeyer, 1900 / 1993.
- Kelly, S. "Seeing Things in Merleau-Ponty" in The Cambridge Companion to Merleau-Ponty. Cambridge University Press, 2004.
- Kelly, S. Review of Alva Noë's Action in Perception, forthcoming.
- Künne, W. "The Nature of Acts: Moore on Husserl" in The Analytic Tradition Bell and Cooper, eds. Blackwell, 1990.
- Merleau-Ponty, M. The Phenomenology of Perception trans. Colin Smith. London: Routledge Press, 1962.
- Milkov, N. "G. E. Moore and the Greifswald Objectivists on the given and the beginning of Analytic Philosophy" Axiomathes vol 14 no 4 (September 2004) 361 – 379.
- Moore, G. E. "Empfindung und Denken" Mind vol. 19 no. 75 (July 1910) 395 – 409.
- Mulligan, K. "Perception" in Cambridge Companion to Husserl Smith and Smith, eds. Cambridge University Press: 1995.
- Noë, A. "Perception and causation: the puzzle unravelled" Analysis 63 (2003) 93-100.

- Noë, A. Action in Perception. Cambridge, MA: MIT Press, 2004.
- Noë, A. “Real Presence,” forthcoming in Philosophical Topics.
- Noë, A. and Thompson, E. eds. Vision and Mind Cambridge, MA: MIT Press, 2002.
- Norman, J. et al. “Perception of Three-Dimensional Shape From Specular Highlights, Deformations of Shading, and Other Types of Visual Information” in Psychological Science vol. 15 (2004) 565 – 570.
- Peacocke, C. Sense and Content. Oxford: Oxford University Press, 1983. Partially reprinted in Noë and Thompson (2002).
- Spiegelberg, H. “Husserl in England: Facts and Lessons” The Journal of the British Society for Phenomenology vol. 1 (1979) 4 – 15.
- Todd, J. et al. “Lightness Constancy in the Presence of Specular Highlights” in Psychological Science vol. 15 (2004) 33 – 39.
- Tye, M. Consciousness, Color, and Content. Cambridge, MA: MIT Press, 2000.
- Watt, A. and Watt, M. Advanced Animation and Rendering Techniques. ACM Press, 1992.
- Yang and Maloney “Illuminant cues in surface color perception” Vision Research (2001) 41 (20) 2581 – 2600.