Four Theories of Amodal Perception

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Abstract

We are aware of those parts of a cat that are occluded behind a fence. The question is how we represent these occluded parts of perceived objects: this is the problem of amodal perception. I will consider four theories and compare their explanatory power: (i) we see them, (ii) we have non-perceptual beliefs about them, (iii) we have immediate perceptual access to them and (iv) we visualize them. I point out that the first three of these views face both empirical and conceptual objections. I argue for the fourth account, according to which we visualize the occluded parts of perceived objects. Finally, I consider some important consequences of this view with regards to the content and the evolution of visualization.

Keywords: Amodal perception; Mental imagery; Visualization; The Dependency Thesis; Evolution.

Introduction

Do we see the occluded parts of objects? Suppose that I am looking at a cat behind a picket fence, but the cat's tail is not visible, because it is occluded by one of the pickets. The question is how I represent the cat's tail? Do I see it? Do I have a non-perceptual belief about it?

This problem is sometimes referred to as the problem of amodal perception and sometimes it is called the puzzle of perceptual presence. I will consider three possible solutions, point out that they all face serious objections and then propose an alternative that may fare better than the rival theories. Maybe surprisingly, my claim is that we *visualize* the cat's tail.

I will mainly use visual examples and I will talk about amodal perception as visualization. But amodal perception is not an exclusively visual phenomenon – it is very important in the tactile sense modality, for example: when we hold a glass, we are (amodally) aware of those parts of the glass that we do not have any tactile contact with. A sense-modality neutral way of stating the main claim of this paper would be to say that amodal perception is sensory imagination. All the arguments I give in this paper can be extended to non-visual sense modalities.

Before I turn to the possible ways of explaining amodal perception, I need to make it clear what I am not trying to explain. I am not trying to solve the old philosophical puzzle about what the object of our perception is. A question that is often raised in connection with objects occluding one another, such as the cat's tail behind the fence is about the object of our perception: what is it that we perceive (Clarke, 1965; Strawson, 1979; Noë, 2004, p. 76). Do we perceive the entire cat? Or those parts of the cat that are visible, that is, a tailless cat? I do not intend to answer any of these questions here. My question is not about what we perceive but about the way in which we represent those parts of objects that are not visible to us.

Also, I need to emphasize that amodal perception is not a weird but rare subcase of our everyday awareness of the world. Almost all episodes of perception include an amodal component. For example, typically, only three sides of a non-transparent cube are visible. The other three are not visible – we are aware of them 'amodally'. The same goes for houses or for any ordinary objects. We perceive the back side of any (non-transparent) object only amodally. It is very difficult to come up with a scenario, where one perceives, but does not perceive amodally. Thus, it is not possible to fully understand perception itself without understanding amodal perception.

The first theory: perception

There are two straightforward answers to the question I posed. The first is that we do perceive the cat's tail and the second is that we do not see it, but only infer that it is there: we have a non-perceptual belief about it (Gibson, 1972).

The perceptual view may sound puzzling. The cat's tail does not project onto our retina. We receive no sensory stimulation from it. The necessary and sufficient conditions for perceiving an object have been notoriously difficult to pin down, but the only non-controversial necessary condition for perception is the presence of sensory stimulation. If I receive no sensory stimulation from an object, then I can't perceive it.[1]

Suppose that I receive no sensory stimulation from an object – I have no image of it on my retina. If we counted this case as perception, then having hallucinations would count as perception. Closing one's eyes and visualizing a chair would also count as perceiving a chair, but

[1] One may wonder about the blind spot. When we are looking at objects with one eye (and keep our eye fixated), we do not receive any sensory stimulation from objects that are projected onto the part of the retina where the blind spot is. Does this mean that we do not see them? The short answer is that we may 'fill in' part of objects that are projected onto our blind spot if the rest of the object is visible to us (this phenomenon itself is thought to be a version of the amodal perception problem by some), but we are not aware of those objects that project onto our blind spot entirely. Thus, it does not sound wrong to say that we do not perceive these objects at all.

hallucination and visualization are exactly those mental events that are supposed not to be covered by the definition of perception.

Thus, amodal perception is not perception at all. But then what is it?

The second theory: belief

The second relatively straightforward view about amodal perception is that there is nothing perceptual about it. We see those bits of the cat that are visible – that are not occluded – and we infer, on the basis of perceiving the visible parts of the animal (as well as on the basis of our familiarity with cat tails) that the occluded parts have such and such properties. In other words, we do not see the cat's tail at all, we just come to have a (non-perceptual) belief about it.

There are various problems with this suggestion (see Noë, 2004, pp. 62-64 for a couple of them). I would like to raise a new objection to the belief account. Amodal completion of occluded contours has been examined by psychologists for a long time. One of the most important findings from our perspective is that we use the simplest possible shape for completing the occluded part of a contour.

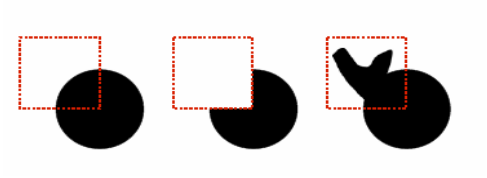

Figure 1: Amodal completion

In the example above (figure 1), for instance, when we see the image in the middle, we tend to complete it in the way shown on the left and not the way shown on the right. More importantly, even if we have some firm beliefs about how we should complete the contour, we cannot help completing it in the simplest way possible. Take the following example (figure 2):

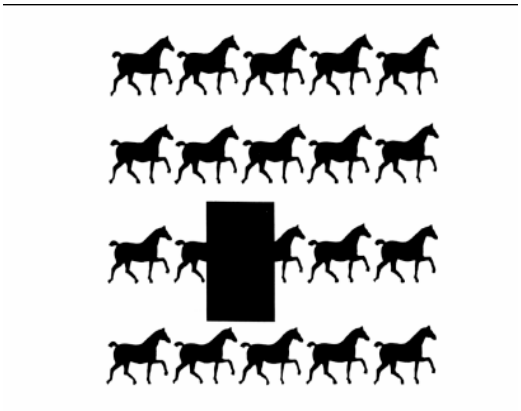

Figure 2: The horse illusion

Because of all the other horse contours, we do know that we should complete the occluded part of the picture with the front half of the horse on the left and the back of the half horse on the right. Still, we cannot help seeing one extremely long horse.

If the belief-account of amodal completion were correct, then this would mean that we infer on the basis of our background beliefs as well as the visible parts of the horses that the occluded shape is such and such. Thus, we form a non-perceptual belief that the occluded shape is such and such. But, as we have seen, we come to represent the occluded shape to be a long horse, in spite of the fact that we have firm beliefs that it is supposed to be completed as two normal size horses. The way we complete this shape is insensitive to our other beliefs. But a belief cannot be insensitive to our other beliefs, at least not too often and not for too long (see, for example, Harman, 1984). Even worse, my belief that is said to represent the occluded long horse is supposed to be inferred from my background beliefs about the shape of (short) horse contours. Even if a belief could at least sometimes be insensitive to some of our other beliefs, it certainly cannot be insensitive to those of our beliefs it is supposed to be inferred from. Thus, the representation of the occluded shape is very unlikely to be a belief.

The third theory: access

It has been suggested recently that what makes us visually aware of the cat's tail is that we have perceptual access to it. I do not see the cat's tail now, but if I moved my head, I would see it. Thus, I have immediate perceptual access to the very fine-grained properties of this object right now – even if it is occluded from me at the moment (Pessoa et al., 1998; Noë, 2002; Noë, 2004; Noë, in press). This suggestion is an interesting alternative to the perceptual- and the belief-view, but I will argue that it will fail to provide a coherent account of amodal perception, for the following three reasons.

First, it is important to emphasize that amodal perception relies heavily on our background knowledge of how the occluded parts of the object (may) look. If I have never seen a cat, I will have difficulties attributing properties to its tail behind the fence. If I am familiar with cats, however, then this would not be a problem. Our perceptual presence of the cat's tail will be very different if we know how cat tails look and if we do not. And here we get a conflict with the access account. I would have the same perceptual access to the cat's tail whether or not I know how cat tails look. Thus, the access account cannot allow for the difference between our awareness of the cat's tail in these two cases.

Second, suppose that the cat has just disappeared behind the corner of the house. I hear it meow, and I can localize where it is. If I know the cat well enough, its tail can be as perceptually present to me as it was when the tail was occluded by the picket fence. It seems that the transition between being aware of the partly occluded cat's tail behind

the fence and of the fully occluded cat's tail is a gradual one.

However, an immediate consequence of the access account is that immediate perceptual access does not come in degrees. I may have immediate perceptual access to the partly occluded cat's tail, but I certainly do not have immediate perceptual access to the tail of the cat in the next room. According to the access account, what constitutes amodal perception is that I have immediate perceptual access to the very fine-grained properties of the occluded object right now – even if it is not visible to me at the moment. We can never have a similar kind of access to anything in the next room. We could have some kind of access to the cat in the next room, but not *immediate perceptual* access.

Thus, it follows from the access account that if the cat disappears entirely behind the fence, my way of representing it must change radically. So far, I had perceptual access to the cat's occluded parts – if I had moved my head, I could have seen them. Now, however, no matter, how I move my head, I cannot see the cat's tail. This is a very problematic consequence of the access account, especially given that in some cases I can localize the cat's tail in my egocentric space (almost) as well as I could when I saw it occluded by the picket fence and I may have almost as vivid an awareness of it in the two cases.

It is not clear what is supposed to constitute the difference between our access to the cat's tail behind the fence and in the next room, according to the access account. After all, I do have some kind of access to the cat's tail in the next room: I could walk over and have a look. The advocates of the access account tried to clarify the distinction between these two cases in several different ways. As Alva Noë points out in his latest attempt to do so, the big difference between our access to the cat's tail behind the picket fence and in the next room is the following. Our sensory stimulation varies as *we* move around in both cases (but in different degrees: I would move my head more in the second case), but in the second case, our sensory stimulation does not vary as the *object* moves. If the cat behind the picket fence wags its tail, this brings about a change in my sensory stimulation. If it does so in the next room, it does not (Noë, 2004, pp. 64-65). My main point is that regardless of the way we draw this distinction, the very existence of such a distinction is problematic.

One would expect that the advocates of the access-account would deny the intuition that there is a gradual transition between these two cases, which would be a valid move and it would weaken this objection significantly. Interestingly, they acknowledge this gradual transition and explicitly state that this is an important feature of amodal perception (Noë, 2002, p. 11, footnote 14; Noë, 2004, p. 65). The problem is that the access-account in general and Noë's way of drawing the distinction (Noë, 2004, pp. 64-65) in particular do not allow for such gradual transition. Thus, as it stands, the access account is inconsistent.

A third argument. Some of the most famous examples of amodal perception are examples of two dimensional figures, like the two pictures above. It is unclear what the access account would say in the case of amodal completion of the occluded parts of two dimensional figures (although the proponents of this account often use these examples of amodal perception when outlining their view. See Pessoa et al., 1998, pp. 729-730; Noë, 2002, p. 9; Noë, 2004, p. 61, p. 70), since there is no head- or eye-movement that would give us perceptual access to the momentarily invisible part of the curve in the first figure above. Thus, we do not have any perceptual access to the occluded parts of the circle.[2] Still, we are visually aware of them.

The fourth theory: visualization

My suggestion is very simple: we visualize the cat's tail.

By visualization I mean roughly what Stephen Kosslyn means by visual imagery (Kosslyn, 1980). A paradigmatic case of visualization would be closing one's eyes and imagining seeing an apple 'in the mind's eye' (see also Ryle, 1949, chapter 8.6; Currie & Ravenscroft, 2002).

The proposal that we visualize the occluded parts of perceived objects does not face the problem that I posed in the case of the access-view. I can visualize a cat in the next room or even thousands of miles away from here. I will not be as accurate in doing so as I would be if I visualized the occluded parts of a cat I am looking at right now. For example, if I visualize the occluded parts of the cat I am looking at, I can use the highly specific properties of the color of the cat's visible parts as a basis for my visualization of the color of the occluded parts. If I visualize the cat in the next room, I cannot help myself to this – the cat's tail will be less accurately visualized. Nevertheless, I can still visualize it. The way I represent the cat's tail in the next room and the way I represent the occluded tail of the cat I am looking at are of the same kind – the difference between them is a difference in degree. As we have seen, the access view needs to say that they are different ways of representing the cat's tail – one is by means of our perceptual access, the other is not.

I pointed out earlier that amodal perception relies heavily on our background knowledge of how the occluded parts of the object (may) look. If I have never seen a cat, I will have difficulties representing its occluded tail behind the fence. The same is true for visualization. In order to visualize a chair, I need to know how chairs look. This is yet another

[2] One could try to block this argument by saying that we do have expectations about how the occluded shape would look were we to look behind the occluding surface, even if I will never look behind the occluding surface. This move, however, would make the notion of 'immediate perceptual access' vacuous, as we could also have expectations about how a cat in the next room would look if we were to look, but the access account, rightly, wants to deny that we have immediate perceptual access to these objects.

indication of the similarity between amodal perception and visualization.[3]

Discussion

Take the following image, which is considered to be an example of not amodal, but modal completion (figure 3).

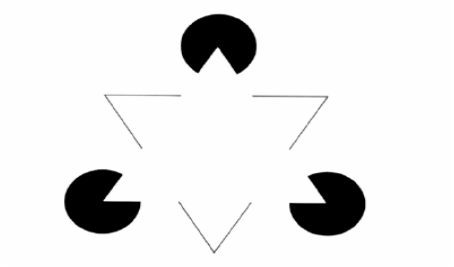

Figure 3: The Kanizsa triangle

Modal and amodal completion are different (see Singh, 2004 for example). The standard way of drawing this distinction is the following. In the case of the amodal perception, we are aware of objects behind an occluder, whereas in the case of modal completion, we are visually aware of an object in front of inducers, such as the three circles in the figure above (See, for example, Michotte et al., 1964; Tse, 1999, pp. 37-38).

There are, however, very important similarities. In the case of both modal and amodal completion we are perceptually aware of shapes or objects we do not see. In both cases, we experience contours that are not there. It is generally assumed that the early stages of the mental processes responsible for modal and amodal completion are the same. It has been argued that the neural mechanisms responsible for modal and amodal perception are the same in early vision and they only come apart in a very late stage of visual processing (Kellman & Shipley, 1991; Ramachandran, 1995; see also Driver et al., 2001). As a result, many early vision researchers as well as philosophers do not even make this distinction (Grossberg & Mingolla, 1985; Noë, 2002; Noë, 2004; Noë, in print).

Thus, in what follows, I assume that what is true for the early neural mechanisms responsible for our awareness of the nonexisting sides of the Kanizsa triangle and of the occluded contour of the horse above are the same. Thus, the empirical study of our awareness of the sides of the Kanizsa triangle may give us some important results about amodal perception.

The perception of Kanizsa triangle has been thoroughly examined experimentally. It turns out that although there is no activation of the cells in the retina that would correspond to the sides of the triangle, we do find such corresponding activation patterns in the primary visual cortex, which is the earliest stage of visual processing (Lee & Nguyen, 2001; see also Kamatsu, 2006). Incidentally, this is also where cells are activated when we visualize objects with our eyes closed (see e.g., Kosslyn et al., 1995). I take this result to be indicative that I am on the right track, but I will not argue that this confirms my suggestion. I do want to argue, however, that these empirical results help us to disqualify the other candidates we have been considering.

It would follow from the perceptual view that the cells of the retina are active when we are looking at the Kanizsa triangle. This turns out not to be the case. The belief-view would predict that there is no cell-activation in the early stages of visual processing. But, it turns out, there is. Thus, both the perceptual and the belief view seem to contradict these empirical results. Also, as we have seen in the last section, it is unclear how the amodal perception of two dimensional contours could even be explained by the access view.

Thus, it seems that the alternatives to my suggestion face some serious objections, both conceptual and empirical ones. Let us see whether similar objections could be raised in the case of my suggestion.

One possible worry about my suggestion is that this view implies that we visualize objects all the time, since we perceive partially occluded objects all the time. However, this sounds intuitively implausible. When I'm walking down the street, looking at one house occluding another one, it does not appear to me as if I visualized anything.

In order to answer this worry, it needs to be pointed out that attention plays a very important role in our everyday perception, thus, we should not be surprised if it played an equally important role in amodal perception. The inattentional blindness experiments demonstrated that we can be shockingly blind to those features of our surroundings that we are not paying attention to. Probably the most famous inattentional blindness experiment is the following (Simmons & Chabris, 1999). We are shown a short video-clip of two teams of three, dressed in white and black, passing a ball around. We are asked to count how many times the white team passes the ball around. On first viewing, most of the observers come up with an answer to this not very interesting question. On second viewing, however, when there is no counting task to be completed, they notice that a man dressed in gorilla costume walks right in the middle of the passing game, makes funny gestures and then leaves. The gorilla spends nine seconds in the frame and most viewers do not notice it when attending to the passing around of the ball (see Mack & Rock, 1998 for more inattentional blindness experiments).

To move to a less radical example for the importance of attention in our everyday perception, I have no idea what color my office telephone is. I must have seen it millions of times, but this was not a property that I have been paying attention to. Properties of objects we are not attending to usually go unnoticed in our everyday perception.

[3] It is important to point out that this dependence of amodal perception on background knowledge is an issue that is independent from the question of the way we represent occluded parts of perceived objects. A number of our representational abilities (perception, belief, visualization) can depend on our background knowledge, after all.

Given the similarities between perception and visualization (see Kosslyn, 1980; Laeng & Teodorescu, 2002; O'Craven & Kanwisher, 2000), it is hardly surprising that the same is true for the way we visualize objects. If I visualize the house I grew up in as seen from the front, I am unlikely to be aware of whether there is light in the left window on the first floor. But if I attend to this specific feature of the visualized image, I can be aware of this.

Finally, if visualizing in general depends on our attention, then it the same argument can be run in the case of visualizing partially occluded objects. Most of the time, the shape, size or color of occluded object-parts go unnoticed, because we pay no attention to them. If, however, we do attend to them – if, for example, we wonder, what color an occluded part of the building is – then we do visualize them.

To sum up, the worry was that we do not seem to be consciously visualizing every occluded part of every object that surrounds us. But neither do we consciously perceive of every part (or property) of every object that surrounds us. We only perceive those parts (or properties) of objects consciously that we attend to. Similarly, we only visualize those parts of objects consciously that we attend to. The worry turned out to be unjustified.

The Dependency Thesis

One of the most interesting recent debates about visualization is the following. When I imagine seeing a chair, what is it that I imagine? What is the object of my imagination? The chair or the experience of the chair? Mike Martin, following Christopher Peacocke, argues that when we visualize a chair, we imagine experiencing the chair (Martin, 2002; Peacocke, 1985). The content of my imagination is an experience, not an object. This suggestion has been criticized (Noordhof, 2002; Currie – Ravenscroft, 2002, section 2.2), but it still seems to be a very influential view about the content of visualization.

If it is true that we visualize the unseen parts of objects we are looking at, then we can construct a new objection against the Dependency Thesis. If seeing the cat's tail is visualization, but seeing the rest of the cat is not, then it would follow from the Dependency Thesis that our way of representing the tail and the rest of the cat is very different. The content of one is (some part of) the animal, whereas the content of the other is an experience. When the cat disappears behind the fence, not only the way we represent the cat changes (we perceived it before, but we visualize it now), but the content of our awareness of the cat also changes. Before it disappeared, the content of our awareness was the cat, but now the content is an experience. This consequence may be especially troubling if one sees the cat through a wire fence or a mosquito net, because in this case the content of one's experience changes radically several times within a very small area of the visual field.

The advocate of the Dependency Thesis may bite the bullet and accept these consequences of the conjunction of my claim about amodal perception as visualization and the Dependency Thesis, but this would not be a very attractive option. Further, if my argument is correct, then we can seriously weaken the most important argument in favor of the Dependency Thesis.

The most serious and most convincing argument among the ones Martin gives in support of the Dependency Thesis (Martin, 2002, p. 410) is the following:

> (a) Visualize a red light on the left and a right light on the right. There is nothing else in the visualized world.
> (b) What I visualize is *not* in the actual world, but in an imagined one. But the red light is still on the left. Then what is it left of? Certainly not of myself, because I'm not in the imagined world.
> (c) Thus, the red light must be on the left *in the experience I imagine*.

Note that this argument takes it for granted that *what I visualize* is in the imagined world, not the actual one. As Martin explicitly puts it, visualization can only "have consequences for what one accepts about the imagined situation" (Martin, 2002, p. 414), that is, not about the actual one. But if this is true, then visualization could never provide us with a way of attributing properties to objects in our actual surroundings, which contradicts the claim I have been arguing for in this paper.

One can, of course, respond that while the Dependency Thesis is true for visualizing with our eyes closed, it is not true for the kind of visualizing that constitutes amodal perception. This response, however, would seriously limit the scope of the Dependency Thesis and, as we have seen in the discussion of the second objections above, positing such strict boundary between these two kinds of visualization is unmotivated.

In short, if my claim about amodal perception as visualization is right, then we have one less reason to subscribe to the Dependency Thesis.

Conclusion: the evolution of visualization

It is not obvious whether visualizing has significant selective advantage. Action planning does have some selective advantage, but action planning may happen in an entirely non-perceptual manner. If visualization has an evolutionary explanation, it is likely to lie elsewhere. Notice, however, that amodal perception has huge selective advantage. Being able to localize the unseen parts of an animal hiding in a bush is an extremely survival-enhancing skill (Ramachandran, 1987 makes a similar suggestion). Thus, if amodal perception is nothing but visualization, then we can say that as amodal perception have a considerable selective advantage and amodal perception is a version of visualization (another variant of which is visualizing with one's eyes closed), visualizing with one's eyes closed could be thought of as an evolutionary exaptation.

Acknowledgments

I am grateful for the comments of Alva Noë and Robert Van Gulick as well as the members of my PhD seminar on Imagination at Syracuse University.

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