regions of the scene. Similarly, researchers on inattentional blindness (Mack & Rock, 1998) have shown that rather conspicuous changes near to or even at the point of fixation—that is, right in front of one's eyes—mostly go unnoticed if the observer is attending to something else. An important feature of this line of research, which undoubtedly has contributed much to its huge impact in cognitive science and appeal to the general public, is that it reveals a striking failure of *visual metacognition* (Levin, 2002). That is, it reveals a huge gap between what humans actually perceive and what they intuitively believe they are able to perceive.

To the practicing magician, such failures of visual metacognition provide an excellent tool for producing a strong magical experience (Kuhn, Caffaratti, Teszka, & Rensink, 2014). If the spectators can be prevented from seeing something that they are confident they would be able to see if it happened, the magician has a unique opportunity to do something that the spectators firmly will believe never happened. For instance, as the findings of Kuhn, Tatler, Findlay, and Cole (2008) have shown, one can let a cigarette fall into one's lap right in front of spectators' eyes, but they typically fail to notice it if their attention has been directed elsewhere. Since the spectators firmly believe that they would notice such an obvious event occurring right in front of their eyes, they later will have a very hard time figuring out why the cigarette is no longer in the hand where it is supposed to be.

Performing a trick that is based on attentional misdirection typically requires considerable skill on the part of the magician, but it also requires a considerable amount of boldness. This boldness is needed because the idea that one can let a cigarette fall into one's lap in plain view without anybody noticing is highly counterintuitive. Accordingly, novice conjurers, who still rely on their natural intuitions, are often tormented with "magician's guilt" (i.e., the fear that the spectators will notice immediately how the trick is done). More experienced conjurers coach their apprentices not only by providing advice on how to improve their technical skills of misdirection but also simply by ensuring them that their intuitive fear of getting caught is largely unwarranted. Indeed, learning to let go of this intuitive fear often is regarded as an important stage in the development of aspiring magicians, which makes them more confident and, in turn, more successful in actually performing the technical aspects of the misdirection in a convincing way. With increased practice and experience, magicians learn to overcome their natural intuitions. However, while misdirection is easier than one would intuitively expect, the skill and technique of the magician nevertheless often play a pivotal role.

Our goal in the present article is to draw attention to a largely neglected factor in magic, which we believe is of great practical and theoretical importance but tends to escape the attention of magicians because it is, to a much greater extent than many other forms of misdirection (see Kuhn et al., 2014, for an overview), independent of the magician's skill. Because this factor exerts its influence without any effort on the part of the magician, it tends to go unnoticed. Ironically, another reason that this factor is easily missed or underestimated is that it is even more powerful, robust, and foolproof than many other forms of misdirection (such as attentional misdirection): The magician hardly needs to think about it because it almost always works.

The factor we have in mind is the intuitive experience of and reasoning about hidden things. It is obvious that the hiding of objects plays a central role in magic. When objects magically materialize, it is mostly because they were kept well-hidden just before, and when they magically disappear, it is mostly because the magician suddenly hides them (Gibson, 1982). What is not so obvious, though, is that the experience of hidden things is much more strongly determined by automatic perceptual and cognitive heuristics beyond our conscious control than we intuitively believe and that these automatic processes constrain our conscious thinking and impede our problem-solving abilities. At the level of conscious reasoning, humans all know that we cannot know for certain what might or might not be hidden behind an object in the foreground. However, automatic perceptual and cognitive processes induce intuitive beliefs or gut feelings about the presence or absence of things behind an occluder that are so strong and convincing that we do not even consider questioning them, even though they might well be wrong (and, in the case of magic tricks, usually are).

Experiencing Hidden Things: The Counterintuitive Phenomenon of Amodal Completion

The current scientific understanding of these automatic processes owes much to the pioneering research of Michotte (Michotte, Thinès, & Crabbé, 1964/1991) and Kanizsa (1979) on a phenomenon they called *amodal completion*. An example of this phenomenon is shown in Figure 1. The hardly identifiable fragments shown in Panel (a) are immediately and effortlessly perceived as complete letters (Bs) in Panel (b). Furthermore, one has a strong feeling that the parts of the Bs hidden behind the ink blot in Panel (b) are "really there" although they are invisible and may, in actual fact, very well be absent. If one were to remove the ink blot and see nothing behind them but gaps between the visible fragments, as in Panel (a), one would be thoroughly surprised, although one must admit that this is logically possible. The curious feeling that the hidden parts of the Bs are really there,

a

b
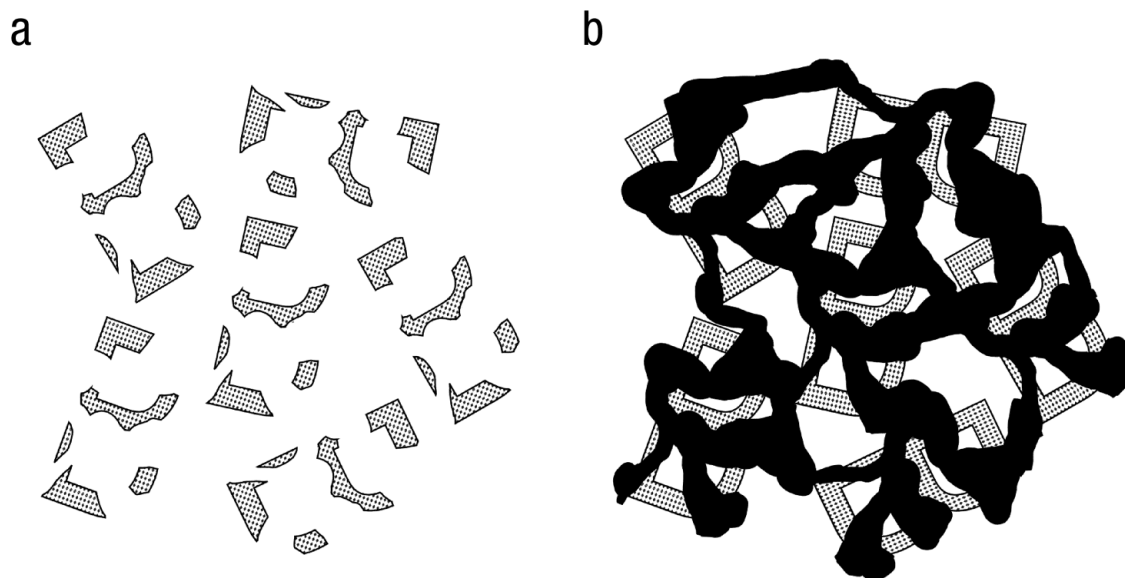
Fig. 1. Example of amodal completion (adapted from Bregman, 1981). When viewing Panel (b), one automatically and effortlessly has the impression of complete letters (Bs) partially hidden behind the black "ink blot," although only the fragments shown in Panel (a) are directly visible.

although they are not seen in the literal sense of the word, is traditionally described by saying that they are *amodally present* (Michotte et al., 1964/1991). The historical reasons for Michotte et al.'s (1964/1991) choice of the term *amodal* are of limited interest here. Essentially, the term just serves to indicate the curious feeling that the hidden parts are really there and that they have a definite shape, although they are obviously not experienced in quite the same way as directly visible object regions.[1]

All extant theories of this phenomenon appeal to various more-or-less literal incarnations of the idea that the visual system somehow completes the directly visible parts of objects via some kind of extrapolation of contours, surfaces, or volumes. Hence, one traditionally speaks of amodal *completion* (van Lier & Gerbino, 2015). Next, we shall consider some examples of how this general phenomenon is exploited in magic tricks and how it impedes our ability to figure out how the tricks work.

Panels (a) and (b) of Figure 2 illustrate the well-known Gestalt principle of good continuation (Wertheimer, 1923/2012). When the two patterns in Figure 2a are brought into register, a radical perceptual reorganization is experienced, where a curved wave pattern superimposed on a square wave pattern suddenly pops out. The essential idea here is that the visual system tends to group contour elements together when one contour element is a "good continuation" of the other. This general principle (or its modern incarnations, e.g. Kellman & Shipley, 1991) is thought to underlie many cases of amodal completion. If the central X-shaped part of the "triangle" in Figure 2c is

covered (say, with a thumb), one has the impression of a complete regular triangle behind the thumb. This may be said to occur because such a regular triangle is the smoothest and most natural continuation of the visible contours. Similarly, if the central part of the two curves in Figure 2d is covered, one has the experience of a complete cross. Again, this is the simplest continuation of the visible contours. Note that these experiences are quite compelling even though one knows very well that there is no complete triangle in Panel (c) or cross in Panel (d) behind one's thumb.

Based on this principle, it is quite easy to create a stunning spoon-bending illusion. As illustrated in Figure 3, the simple secret behind the trick is to use a spoon that has already been bent in advance as well as a spare handle already cut off from another spoon. By aligning the head of the bent spoon with the spare handle and hiding the point of contact and the handle of the bent spoon behind his fingers, a magician can create the illusion of a single straight spoon. Working from there, the magician just lets the spare handle fall slowly into the palm of his hand by releasing the pressure of his fingers. Once it is down in his hand, the magician pulls the bent spoon out with his other hand and shows it to the audience.

Many other magic tricks rely on the same principle. Barnhart (2010) mentioned a few examples, such as the Chinese linking ring routine,[2] in which solid rings appear to link and unlink by magically passing through each other. As illustrated in Figure 4, the main secret behind the trick is that one of the rings actually has a gap in it. When this gap is occluded by the magician's hand, however, it amodally completes into an unbroken ring (Fig. 4b).
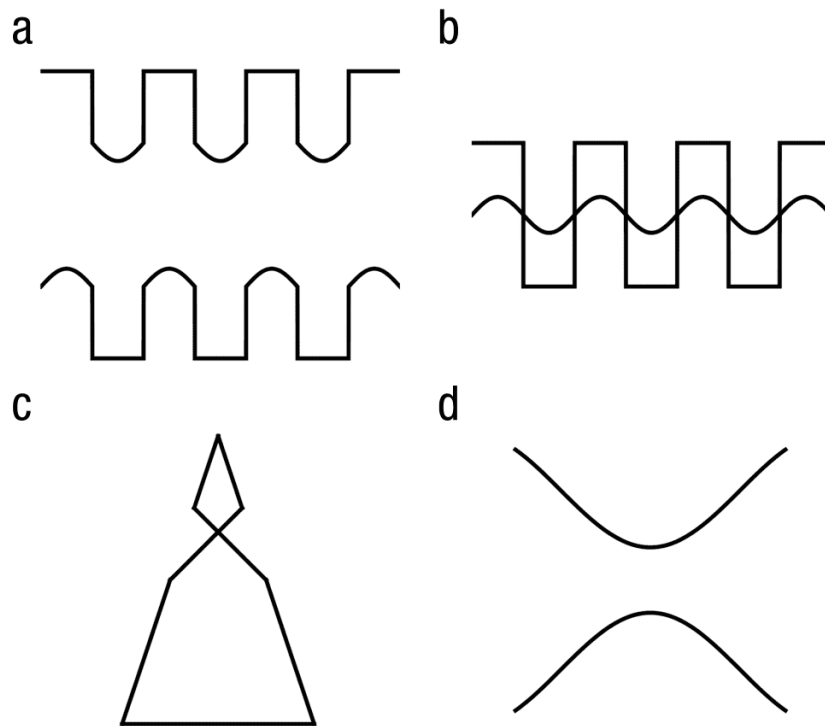
Fig. 2. Illustration of the Gestalt principle of good continuation. When the two patterns in Panel (a) are displaced toward each other such that the curved segments are brought into register (b), a radical perceptual reorganization is experienced, where a curved wave pattern superimposed on a square wave pattern suddenly pops out (adapted from Fig. 13 in Wertheimer, 1923). In Panel (c), if the central X-shaped part of the triangle is covered (say, with one's thumb), one perceives a complete regular triangle (adapted from Fig. 3.7 in Michotte, Thinès, & Crabbé, 1964/1991). The perception of a complete regular triangle can also be explained in terms the principle of good continuation: The perceptual completion of the contours is the smoothest and most natural continuation of the visible contours. Similarly, in Panel (d), covering up the central part of this figure leads one to perceive a complete X.

Note that attentional misdirection plays at best only a subordinate role in these tricks. Nevertheless, the tricks seem to create magical experiences that are no less impressive than those evoked by tricks where attentional misdirection is the main factor (even though the secrets behind these tricks are disappointingly simple once they are known). Indeed, they may be even more difficult to debunk because it is of little use to change what one attends to when viewing the trick a second time. It is also interesting to consider that with tricks based on attentional misdirection, every sense of magic is lost once the way in which the trick is done is known. In the aforementioned cigarette trick, for instance, knowing that the magician just drops the cigarette into his lap in plain view makes a spectator notice this action. The tricks based on amodal completion, in contrast, retain a certain residual magical quality even when the spectator knows what is going on. Even though the spectator knows that the spoon is not complete, it still looks very convincingly like a complete spoon. Magicians sometimes refer to this kind of residual magic as "eye candy" and use it in entertaining "visual jests" (Ortiz, 2006). The art of the magician–comedian The Amazing Johnathan, for instance, is replete with excellent examples of this residual magic.

A further instructive example is the knife-through-arm routine,[3] in which the magician creates the illusion of cutting through his own arm. Although this trick is extremely compelling (and repulsive), the basic underlying method is very simple: A portion of the blade is cut out to make room for the arm (Figs. 5a and 5b). This example theoretically is slightly more complicated than the previous ones because it involves two competing tendencies to good continuation: smooth continuation of the blade versus smooth continuation of the arm. At first blush, one may be tempted to assume that the former dominates the latter due to explicit knowledge of the world: A spectator knows that flesh is softer and more likely to be cut by a knife than the other way around. Contrary to this seemingly plausible explanation, however, the illusion persists if a banana is substituted for the
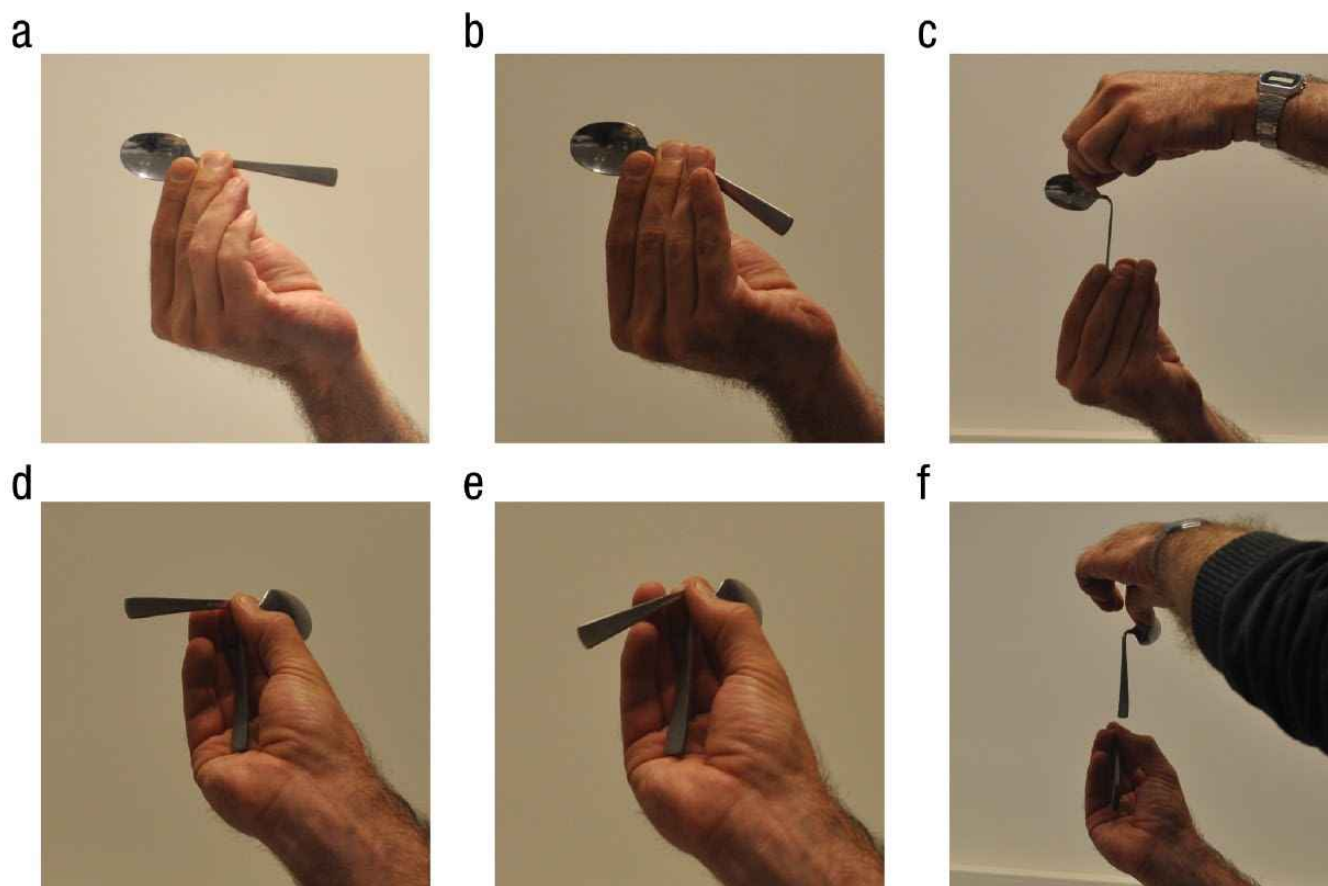
Fig. 3. Illustration of how a magician may rely on amodal completion to create a stunning illusion of spoon bending. First, the conjurer presents a seemingly complete and straight spoon (a), which then gradually bends (b). After the "bending" is complete (c), the magician pulls the bent spoon out of his hand and hands it to a member of the audience. As shown in (d), the spoon was actually bent from the very start, but a spare spoon handle is held in alignment with the head of the spoon. Since the gap between the head of the bent spoon and the spare handle is hidden by the conjurer's finger, the spectators believe they are seeing a single unbroken straight spoon. The illusion that the spoon is bending is created by letting the spare handle fall slowly into the palm of the magician's hand (e). Afterwards, the bent spoon is pulled out of the hand and handed to a member of the audience (f), while the spare handle is kept hidden in the hand. Since the audience is occupied with examining the bent spoon, it is very easy to get rid of the spare handle without it being noticed.

knife and a brick is substituted for the arm (see Fig. 5c). As shown by Gerbino and Zabai (2003), who created the banana-through-brick illusion, which of the two objects is perceived to penetrate the other seems to be determined by idiosyncratic heuristics more characteristic of perceptual processing than rational thought. Essentially, they found (a) that the object which is on top tends to penetrate the other and (b) that the smaller object tends to penetrate the other. These tendencies do not only explain why the knife is perceived to penetrate the arm but also why the banana is perceived to penetrate the brick. Vrins, de Wit, and van Lier (2009) have presented evidence that perceived material hardness may also play a certain role, in the sense that soft materials are more readily perceived as being penetrated. In the case of the knife-through-arm routine, this can be expected to enhance the illusion further.

The immediate and almost visceral nature of the illusion is nicely demonstrated in the Amazing Johnathan's brilliant performance of it.[4] Even before the trick starts, Johnathan starts yelling to the audience, "It's a trick; it's a trick." Yet, the audience not only perceives that the knife penetrates the arm, they also experience it as utterly real (Leddington, 2016; Mausfeld, 2013; Michotte, 1991) and correspondingly repulsive.

Although most of the early research on amodal completion focused on the completion of image contours, the general phenomenon is not limited to the completion of image contours and objects occluded by other objects in the foreground. Rather, in so-called *amodal volume completion* (Tse, 1999; van Lier, 1999; van Lier & Wagemans, 1999), the visible surface of a full-fledged three-dimensional object can complete amodally into the entire boundary surface of a volumetric surface. Thus, to borrow an example from van
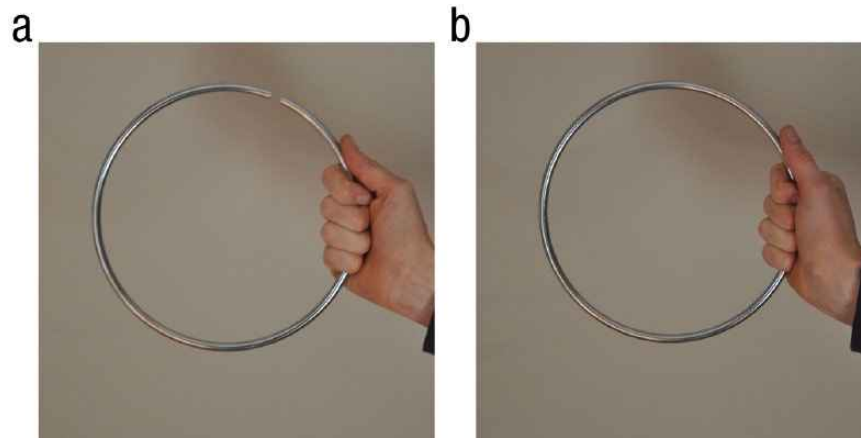
Fig. 4. Main principle underlying the Chinese linking ring routine. One of the rings has a small opening (a), but when the opening is covered by the magician's fingers, the ring looks complete (b).

Lier (1999), "seeing" the backside of a tree trunk can also be considered as an instance of amodal completion.

The well-known Chicago multiplying billiard balls routine provides a good example of the role of amodal volume completion in magic (see Fig. 6).[5] Here, the conjurer begins by holding a single ball between two of his fingers, which suddenly and apparently inexplicably turns into two balls (and so on). The essential secret behind the trick is that one of the balls is a hollow shell, from which the other one is conveniently produced. If you look at Figure 6a, you have an impression of four solid balls, but as can be seen in Figure 6b, in reality, one of them is just a hollow shell.

It is important to point out that the illusory experience of a complete ball persists even when one knows it is actually just a semispherical shell. Indeed, using an empty shell such as the one used in this trick, one can even create a compelling illusion in which the shell seems to morph into complete ball while one is holding it in one's hand simply by lifting it off a table (Ekroll, Sayim, & Wagemans, 2013). Furthermore, putting a finger into such a semispherical shell does not ruin the perceptual impression of a complete ball. Rather, it leads to an illusion of bodily awareness, in which the finger feels shorter, as if to make space for the illusory volume of the ball (Ekroll, Sayim, Van der Hallen, & Wagemans, 2016). This strength
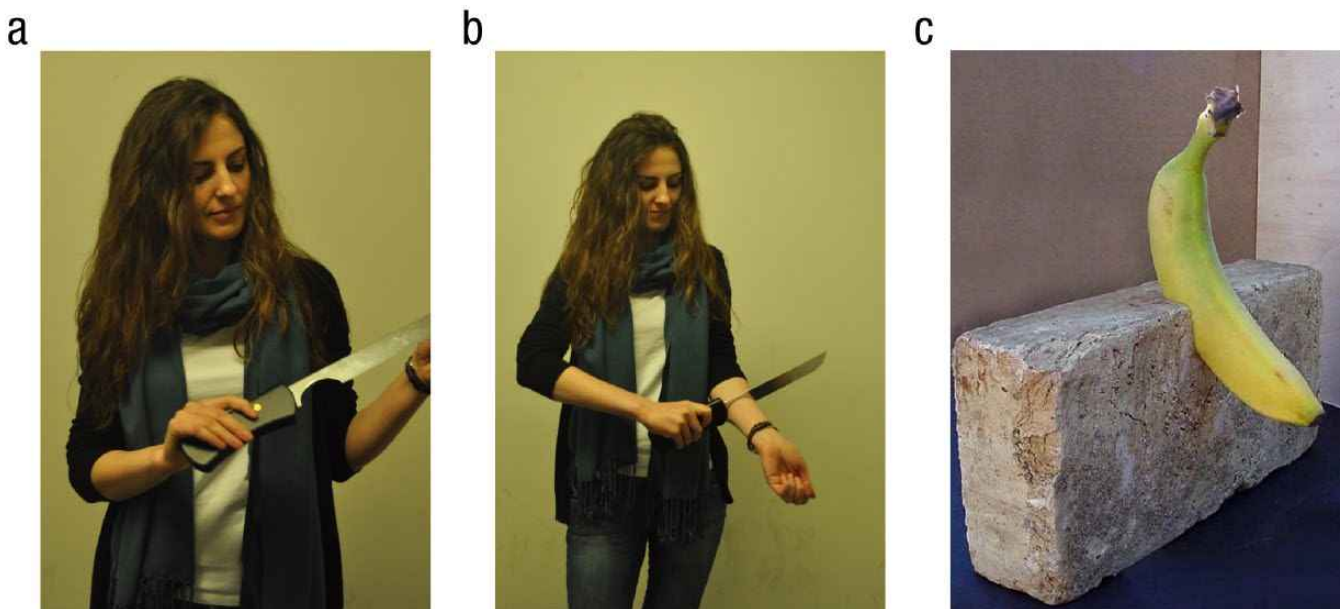
Fig. 5. Knife-through-arm trick. (a) The simple explanation behind the knife-through-arm trick is a hole in the blade. (b) When the arm is put into the hole, the knife appears to penetrate the arm, rather than the other way around.(c) Using essentially the same trick, it is also possible to create the illusion that a banana penetrates a brick (Panel c is reprinted from *Acta Psychologica*, 114/3, W. Gerbino & C. Zabai, "The joint", p. 334, Copyright (2003), with permission from Elsevier.
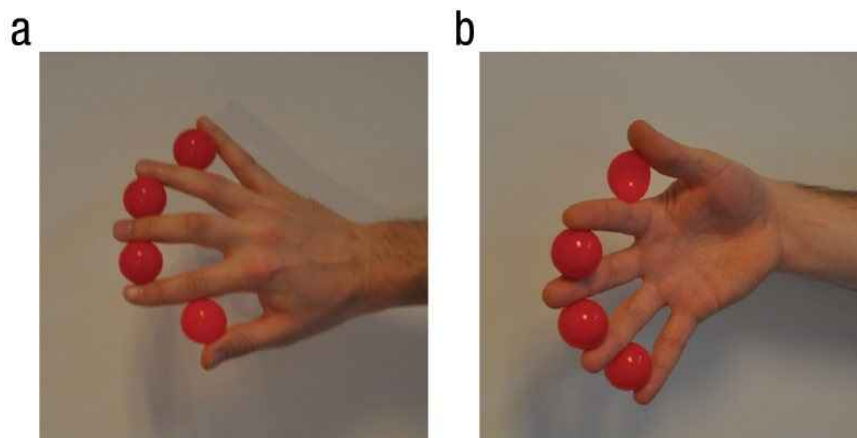
Fig. 6. Chicago multiplying balls trick. The conjurer starts with a single ball held between his thumb and index finger and successively makes additional balls appear until he ends up with showing four balls, as in Panel (a). As can be seen in Panel (b), the main secret behind the trick is that the "ball" kept between the thumb and the index finger is actually just an empty semispherical shell in which a second ball can be hidden. At the beginning of the routine, one complete ball is hidden in the shell. Using the middle finger, the magician then flips this ball out of the shell and holds it between the index finger and the middle finger. After having produced this basic illusion, the magician can produce more balls by surreptitiously loading new balls into the shell while pretending to move the upper ball one step up in the "ladder" of fingers using the other hand. Then, the newly loaded ball can be produced from the shell in the same way as before.

of the tendency to immediately experience the shell as a complete ball neatly explains why it is very difficult to debunk this trick, even after repeated viewings (Danek, Fraps, von Müller, Grothe, & Öllinger, 2014).

Amodal Absence

As already mentioned, extant theories of amodal completion appeal to various more-or-less literal incarnations of the idea that the visual system somehow completes the directly visible parts of objects via some kind of extrapolation of contours, surfaces, or volumes. Hence, the traditional term *amodal completion* seems quite apt. However, an intriguing and rather rude illusion recently circulating on the Internet suggests that this idea might fall short of capturing all of the relevant phenomena, and this may have interesting implications for the understanding of how many magic tricks work. We are referring to the illusion of *amodal nudity* (e.g. Bonnet, 2013; Hill, 2013), in which various bathing-suit models look strikingly naked, although they are actually wearing proper attire that just happens to be occluded. Various blog posts on the Internet (e.g. Hill, 2013) try to convince viewers that this effect has something to do with their dirty minds, but this "theory" is easily disproven. As illustrated in Figure 7, essentially the same effect can be achieved with considerably less erotic material, such as a cluttered office desk. Notice how difficult it is to imagine that the clutter on the office desk shown in Figure 7a is really there behind the

"bubbled" occluder seen in Figure 7b. To appreciate the striking nature of this illusion even better, do the following experiment. First look at the unoccluded picture (Fig. 7a), close your eyes, and try to imagine the clutter on the desk before your "inner eye." Now, repeat the experiment, but rather than closing your eyes, look at the occluded version of the picture (Fig. 7b) while you try to imagine the clutter behind the occluder. You will probably find that the latter is considerably more difficult. Thus, it would seem that merely viewing the occluder somehow interferes with your ability to imagine things behind it (even things you know are actually there). Figure 8 shows that an object that a viewer expects to be there on the basis of high-level expectations can also be experienced as curiously "absent" when it is hidden behind an aptly positioned occluder.[6] This shows that the phenomenon is due to some kind of active perceptual suppression rather than a mere failure to represent invisible things.[7]

Even though this effect is rather counterintuitive, it is not difficult to explain in terms of general heuristics known to play a central role in perceptual processing. The basic idea is that the perceptual system tends to avoid interpretations of the visual input that involve unlikely coincidences and alignments along the line of sight (Biederman, 1987; Freeman, 1994). In this case, the interpretation that the clutter really is there behind the occluder would mean that all of the clutter is positioned such that it is covered by the few and rather small hiding
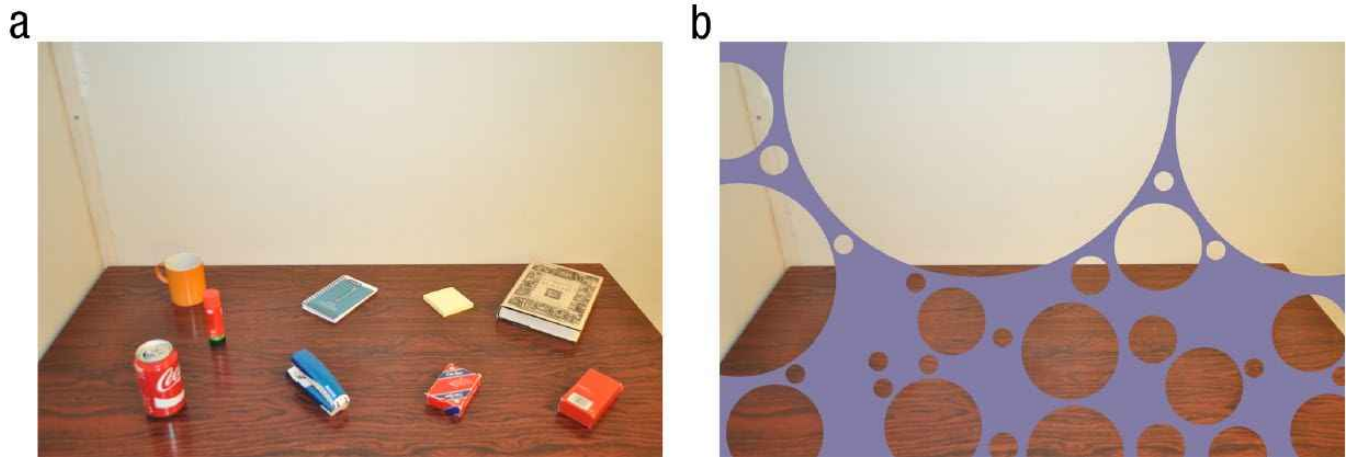
Fig. 7. Example of amodal absence inspired by a currently popular visual joke circulating on social media called "amodal nudity" or "bubble porn" (e.g. Bonnet, 2013; Hill, 2013). In Panel (b), the objects on the table are occluded by a violet "bubbled" occluder. Note how difficult it is to imagine that the objects in Panel (a) really are hidden behind the bubbled occluder in (b).

places actually provided by the occluder, which is highly unlikely to happen by chance. Even small displacements of the occluder or the clutter would make parts of the clutter visible. Hence, the perceptual system seems to discard the possibility that the clutter is actually there behind the occluder.

This phenomenon is similar to the amodal presence of the hidden parts of the letters (Bs) in Figure 1b in the sense that both phenomena are positively different from not having any particular perceptual experience at all (which one might presume to be the case because there is no corresponding sensory input). At the same time, the two

Fig. 8. Another example of amodal absence. Although high-level knowledge makes the viewer expect the middle finger to be there behind the banana, it is still experienced as being curiously absent.

phenomena also seem to be complementary in two respects. While the perceptual system produces a *positive* and *specific* perception in Figure 1b, it seems to produce a *negative* and *unspecific* perception in Figure 7b. In order to highlight both the similarity and the complementarity vis-à-vis the well-known phenomenon of amodal presence, we propose to refer to the new phenomenon as "amodal absence." To emphasize that amodal absence is different from the mere lack of any particular perceptual experience (due to a lack of direct sensory input), we may refer to the latter as *modal* absence. While total occlusion always implies that no perceptual objects are instantiated (they are modally absent), amodal absence means that an abstract set of possible objects that could, in principle, be hiding behind the occluder, is actively excluded by the perceptual system.

Clearly, when one looks at Figure 7b, it is not only the particular objects in Figure 7a that are amodally absent but also a larger set of other logically conceivable possibilities. Exactly how large is this set, and how can it be characterized? An extreme hypothesis would be that the perceptual system excludes every logically possible object that may lie hidden behind the occluder. On the basis of this hypothesis, the phenomenon of amodal absence could be described as some kind of amodal completion of empty space. This extreme hypothesis seems implausible though, because it would make little sense for the visual system to exclude categorically the far-from-unlikely possibility that some object may lie hidden behind the occluders. Therefore, a more plausible hypothesis is that it excludes some but not all of the possibilities. This idea can be appreciated by considering van Lier's (1999) example of "fuzzy" (p. 203) amodal completion (Fig. 9). The different alternatives B1–B3 all look like plausible completions of the partially occluded shape in A, but the different alternatives C1–C3 do not. In our terminology, one may say that the alternatives B1–B3
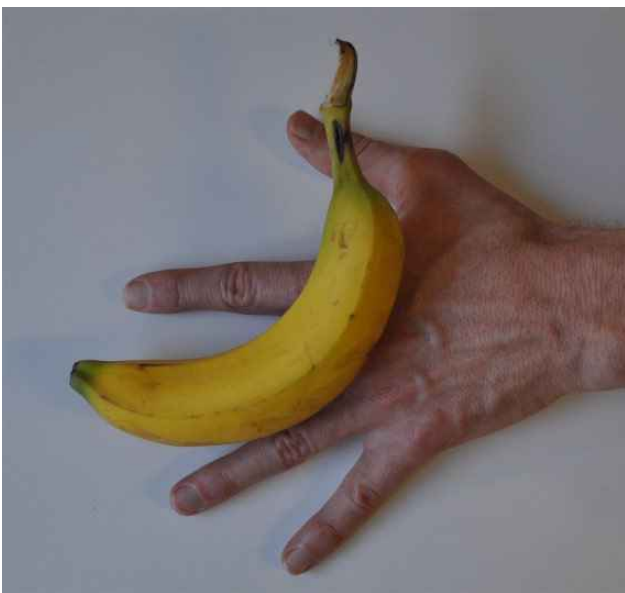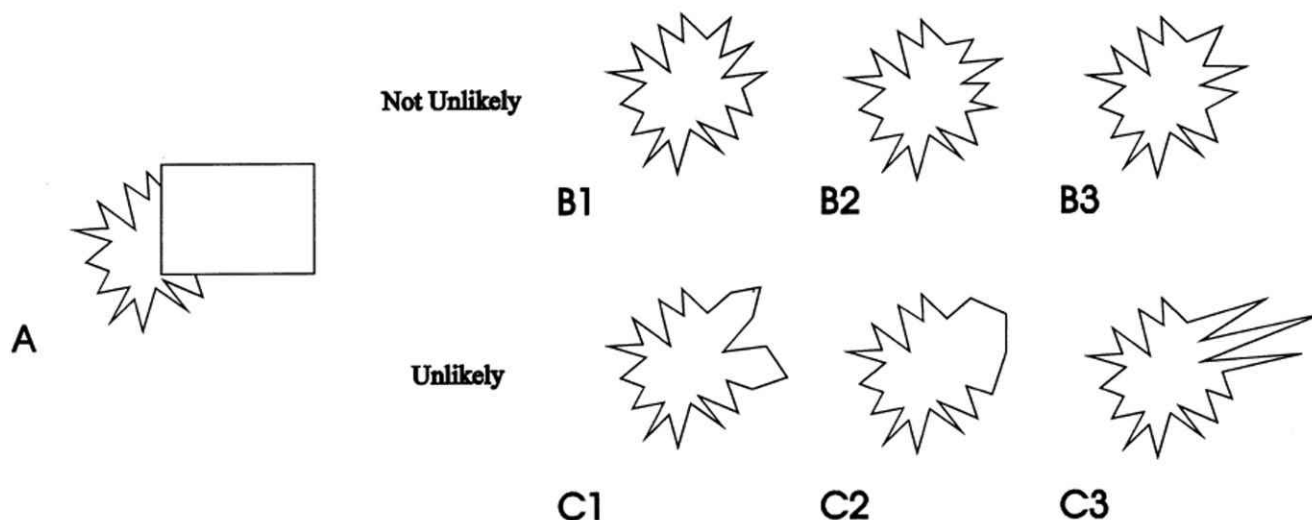
Fig. 9. Example of "fuzzy" amodal completion. Shapes B1–B3 and C1–C3 all are logically possible completions of the partially occluded Shape A. Some of them (B1–B3) are experienced as likely, while others (C1–C3) are experienced as unlikely. Thus, the perceptual representation of the hidden parts of the shape may be better conceived of as a set of possible shapes rather than a specific one. Reprinted from "Investigating Global Effects in Visual Occlusion: From a Partly Occluded Square to the Back of a Tree Trunk," by R. van Lier, 1999, *Acta Psychologica, 102*, p. 208. Copyright (1999) by Elsevier. Reprinted with permission.

all are to some extent amodally present, while the alternatives C1–C3 are to some extent amodally absent.

As illustrated in Figure 10, classical amodal completion, van Lier's (1999) fuzzy amodal completion, and the perceptually even more unspecific experience of amodal absence (Fig. 7b) can all be regarded as resulting from the same overarching logic of inference operating at different levels of stimulus ambiguity. In the example of classical amodal completion (Fig. 10a), the perceptual experience is highly specific because the highly regular visible part provides strong cues to the shape of the hidden part. In the example of fuzzy amodal completion (Fig. 10b), the visible part is still available but provides a poorer basis for perceptual inference because it is less regular, which results in a less well-specified perception. In the example of amodal absence (Fig. 10c), there is no visible part, but there is still some limited form of perceptual inference based on the size and shape of the occluder itself. Although an object of the same (retinal) size and shape as the occluder can, in principle, be hidden behind the occluder, this necessarily requires a perfect alignment of the occluder and the hidden object along the line of sight, which is highly unlikely to happen by chance in a natural real-world scene. The smaller an object is relative to the occluder, however, the more likely it becomes that it could have become totally hidden behind the occluder by mere chance. Thus, on the basis of the well-known idea that the perceptual system tends to avoid interpretations involving unlikely coincidences (Biederman, 1987; Freeman, 1994; Rock, 1983) we may speculate that amodal absence does not involve the perceptual exclusion of all possible objects but only those that are deemed to be particularly unlikely on the basis of cues such as their size and shape relative to the occluder.

This kind of amodal absence may play an important role in many magical tricks. Consider, for instance, a trick in which the magician shows an empty palm and then, with a swift flick of the wrist, seems to grab a coin out of thin air. The simple secret behind this trick is that the coin is kept hidden behind the magician's thumb (Fig. 11). During the quick flick of the wrist, it is simply pulled out using the index and middle finger. It is clear that this trick involves some misdirection. The small movements of the fingers tend to go unnoticed because of the much larger movements of the hand (Hergovich, Gröbl, & Carbon, 2011), and the magician might look into the air to direct attention away from the hand during the critical move. However, the belief that the hand was actually empty before the critical move may be significantly reinforced by the kind of amodal absence also evident in the "tidy-up-your desk" illusion (Fig. 7). In this case, too, accidental alignment (of the coin and the thumb) along the line of sight is presumably the driving principle. From the perspective of the magician, it is easy to see the significance of the elements of misdirection elements involved in this trick because he or she actively performs them. However, it may be less obvious that the clever hiding of the coin not only hides the coin but also produces a compelling impression of absence that adds to the overall robustness and strength of the routine.

This far, we have only considered the phenomenon of amodal absence in connection with static configurations. As beautifully illustrated by Richard Wiseman's (2013) video clip "The Ball," dynamic cases of accidental alignment
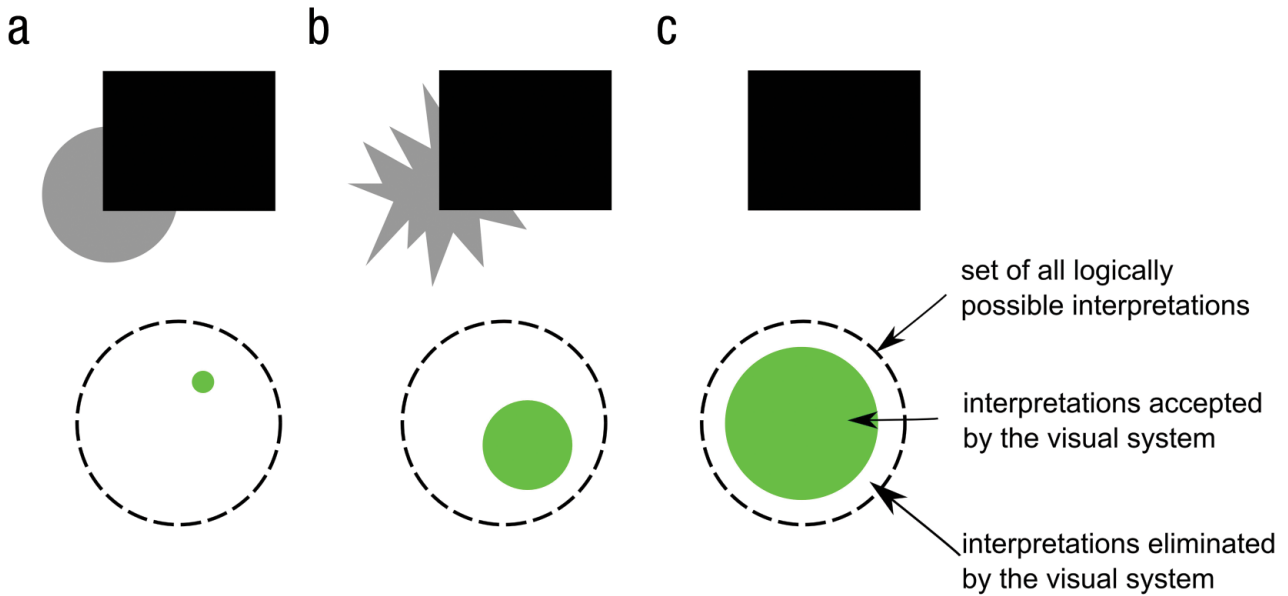
Fig. 10. Illustration of how the perceptual system may generate increasingly fuzzy representations of occluded scene regions as the ambiguity of the stimulus increases. (a) In the most well-known type of amodal completion, the visual system creates a rather specific representation of the parts of the scene hidden behind the square: The visual system creates a representation that encompasses just a small subset (green disk) of the set of logically possible interpretations (dotted circle). (b) In a more fuzzy kind of amodal completion (van Lier, 1999), the visual system creates a representation encompassing a larger subset of the logically possible options. (c) In the case of total occlusion, the stimulus is even more ambiguous, but the visual system may create a representation that, although fuzzy and unspecific, is more specific than the set of logically possible options. Hence, some of the logically possible representations would be eliminated by the visual system.

between the occluder and the hidden object seem to evoke even more impressive experiences of amodal absence. This can be regarded as a straightforward consequence of the increased level of accidentalness introduced by the carefully coordinated motion of the occluder and the hidden object.

Gibson (1982) has argued that a key aspect of the materialization and vanishing of objects typical of so many tricks is that the magician somehow hides the visible optical transitions (such as accretion and deletion) that normally occur when a hidden object becomes disoccluded or a visible one becomes occluded. This is

undoubtedly the case, and the previously discussed example of the coin trick may be regarded as a case in point, where the gradual accretion of the hidden coin is hidden by means of misdirection. However, our analysis suggests that another significant factor may also be involved: the illusion of amodal absence.

We have introduced the term "amodal absence" to describe the compelling perceptual experience that "something is not there," as in Figures 7 and 8. We conceive of this term as directly analogous and complementary to the established term "amodal presence," which
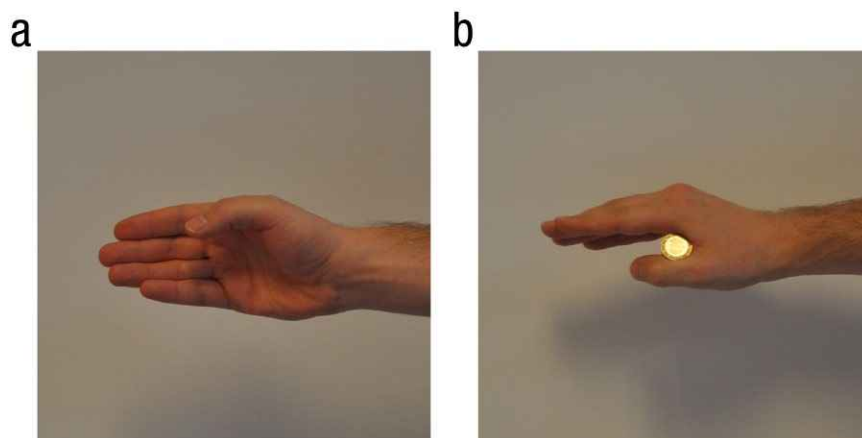
Fig. 11. Simple coin production. The magician shows a seemingly empty hand, as in (a), and grasps a coin out of thin air. In reality, the coin is kept behind the thumb to begin with, as shown in (b).
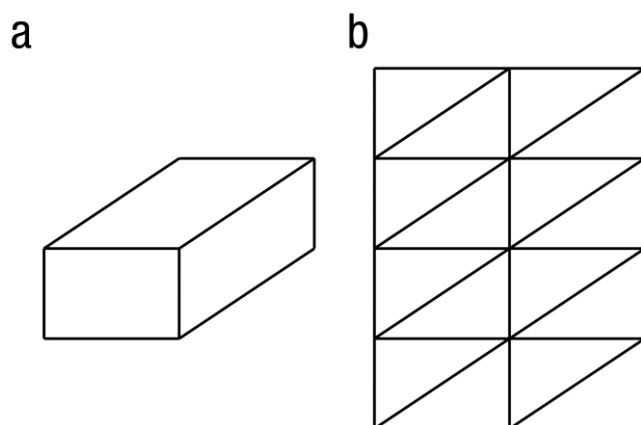
Fig. 12. An example of "visual fixedness": It is very difficult to see that the box in Panel (a) is actually a part of the figure in Panel (b; Koffka, 1935).

refers to the compelling perceptual experience that "something is there," as in Figure 1. Amodal presence hitherto has been discussed only in connection with cases of partial occlusion, whereas we primarily have used examples involving total occlusion to demonstrate the phenomenon of amodal absence. This should not be taken to imply that amodal absence is limited to cases of total occlusion. In van Lier's (1999) fuzzy amodal completion (Figs. 9 and 10), for instance, he clearly illustrated how cases involving partial occlusion can evoke both amodal absence and amodal presence and that they may be regarded as two sides of the same coin.[8]

Magic, Problem Solving, and Visual Fixedness

Trying to find out how a magical trick works can be considered as a problem-solving task (Danek et al., 2014). For magic to be effective, it is obviously of paramount importance that this problem-solving process is unsuccessful. The reader may be familiar with Duncker's (1945) classical idea of functional fixedness as an important factor impeding effective problem solving. However, it is probably less well known that Duncker (1945, p. 85) also related his general concept of "fixedness" to "factors such as visual organization." For instance, he pointed out

> that a chimpanzee who stands in need of a stick (something long, firm . . .) sometimes has difficulties in recognizing the stick in a branch still growing on the tree, in seeing it as a percept apart . . . . On the tree is a "branch," a part of the figural unit "tree," and this part-character—more generally, this "*fixedness*"— is clearly responsible for the fact that to a search for something like a stick, the branch is less "within reach" than the branch on the ground. (p. 85).

Figure 12 provides a compelling demonstration of Duncker's point: Notice how difficult it is to recognize that the box in Panel (a) is actually part of the grid in Panel (b).

We believe that this line of thinking is useful for understanding many aspects of magic in general and the great robustness of tricks based on amodal perception (i.e., amodal completion or amodal absence) in particular. It is difficult to see the visible parts of objects in their own right because after visual organization has taken place, they are but mere parts of more comprehensive figural units (Gestalts), like a complete ball with a backside, a complete spoon, or an unbroken blade. From this perspective, it is easy to see why it is so difficult to debunk tricks that are based on amodal perception: To find out what is going on, the spectator has to consciously disregard the visual organization imposed by the perceptual system and mentally organize the visual input in a different way. Visual organization is a biologically important factor that, for the most part, allows humans to make sense of the noisy, ambiguous, and incomplete visual input actually available at the retinae (Koffka, 1935), and normally, there is no need to reorganize consciously the structure imposed by the visual system. Only in exceptional cases (like those in magic tricks), the very same visual organization can backfire and also lead to misleading illusions.

Cognitive Impenetrability

Visual fixedness may be thought of as a consequence of the cognitive impenetrability of perceptual processes (Firestone & Scholl, 2015; Pylyshyn, 1999). Consider the lightness illusion in Figure 13. Although it may be difficult to believe, the chess figures in the top row are identical to the ones in the bottom row. The only reason that the upper figures look white while the lower figures look black is that they are viewed in different contexts (Anderson & Winawer, 2005; see also Adelson, 2000 and Gilchrist et al., 1999, for similar demonstrations). It is important to note that even when one knows that the figures are actually identical, they still look very different (white and black). Several authors have argued that amodal completion is independent of conscious knowledge (i.e., cognitively impenetrable) in much the same way as this lightness illusion (Kanizsa, 1979, 1985; Kanizsa & Gerbino, 1982; Michotte et al., 1964/1991; Pylyshyn, 1999). Some effects of learning and knowledge on mental processing of occluded objects have been documented, (Hazenberg, Jongsma, Koning, & van Lier, 2014; Hazenberg & van Lier, 2015; Vrins et al., 2009), but whether these effects are part of what should be called amodal perception proper is open to discussion. Amodal perception is clearly less cognitively penetrable than attention, because endogenously controlled attention can be voluntarily directed (Pylyshyn,

Fig. 13. The Anderson-Winawer lightness illusion. The chess figures on the top and on the bottom are actually identical, but those at the top look white, whereas those at the bottom look black. Note that this illusion does not go away even when the viewer knows that the figures are in fact equal. Reprinted from "Image Segmentation and Lightness Perception," by B. L. Anderson and J. Winawer, March 3, 2005, *Nature, 434,* p. 80. Copyright 2005 by Macmillan. Reprinted by permission.

1999). This point suggests that it should be even more difficult to debunk tricks based on amodal perception than tricks based on attentional misdirection. When people try to debunk a trick based on amodal perception, the cognitively impenetrable illusion (or visual fixedness) closes the door to the right solution even before any conscious problem solving starts.

Ortiz (2006, p. 37; see also Leddington, 2016) has argued that magic "can only be established by a process of elimination."[9] The properties of perceptual mechanisms make them seem perfectly suited for achieving this: One of the hallmarks of perception is that it tends to provide unique interpretations of the highly ambiguous sensory input (Hoffman, 2000). That is, the perceptual process typically involves the automatic, cognitively impenetrable, and essentially instantaneous elimination of a large (often infinite) set of alternative interpretations of the sensory input.

Magicians also often highlight the importance of setting up misleading assumptions and expectations in order to conceal the method behind a trick (Kuhn et al., 2014; Ortiz, 2006). Visual fixedness and the cognitive impenetrability of perceptual mechanisms may be regarded as extreme forms of this kind of generation of false assumptions that may be critical to the robustness and potency of many magic tricks. Importantly, the assumptions made by the visual system

are not consciously made, ensuring that the spectators never even suspect that their assumptions have been tampered with by the magician.

Duncker's (1945) concept of visual fixedness can be understood in two slightly different ways. We have highlighted how it may be a good metaphor for how cognitively impenetrable perceptual processes can impede conscious reasoning by automatically excluding the true explanation of a trick. On this reading, Duncker's concept of visual fixedness would not be entirely analogous to his concept of functional fixedness, because the latter refers more to a learned (and potentially reversible) habit of thought than a perceptual process that is cognitively impenetrable in the absolute sense. We believe that the examples we have been considering are best understood as resulting from visual fixedness in the former sense, but it may also be possible that some processes more akin to functional fixedness in the second sense play a role in both perception and magic.

In the present article, we have focused on showing how amodal perception plays an important role in creating strong magic via cognitively impenetrable perceptual mechanisms. Given that inferences about hidden things go far beyond the directly available sensory input, it may appear rather counterintuitive that it is partly based on perceptual mechanisms, but the potency of amodal perception in producing strong magic suggests that this is nevertheless the case. On a more general level, we believe that analogous lines of reasoning may help to flesh out further the role of genuinely perceptual mechanisms in causing people to make inferences about causality (Duncker, 1945, pp. 66–67; Leslie, 1988; Michotte, 1954/1963; Ortiz, 2006, p. 54; Scholl & Tremoulet, 2000), actions and intentions (Scholl & Gao, 2013; Van de Cruys, Wagemans, & Ekroll, 2015), or even "realness" (Leddington, 2016; Mausfeld, 2013; Michotte, 1991; Vishwanath, 2013, 2014). One could argue that it is the automatic nature of amodal perception that makes such a potent tool for creating robust and surprising magical effects. In this view, not only amodal completion but perceptual processes in general can be expected to be particularly potent factors in magic (Ekroll & Wagemans, 2016).

According to a golden rule often applied by magicians, one should never repeat the same trick twice to avoid having spectators notice how the trick works. In the case of tricks that are based on attentional misdirection, this rule obviously makes sense. However, if a trick is based on a cognitively impenetrable perceptual illusion, one would expect that it could be repeated essentially ad libitum. The only potential adverse effect of repeating the trick would be that the spectators gain more time to think, but even then the chances of their figuring out how it works should be rather slim due to visual fixedness. This reasoning leads to the conclusion

that investigating the effect of repeated presentations of magic tricks on the spectators' likelihood of figuring out the method could be a promising tool for elucidating the nature of the mechanisms underlying different kinds of magic tricks. Recently, for instance, Cui, Otero-Millan, Macknik, King, and Martinez-Conde (2011) showed that a sleight-of-hand illusion traditionally believed to be based on social attentional misdirection is very resilient to repeated presentations, which may be taken to suggest that more automatic perceptual mechanisms are at play.

In terms of the taxonomy of misdirection recently proposed by Kuhn et al. (2014), magic based on amodal perception and other cognitively impenetrable perceptual effects fit nicely into the category of nonattentional perceptual misdirection. The present analysis is also consistent with their observation that magic based on "nonattentional perceptual mechanisms is more resilient to the spectator's own intentions" (p. 7) than magic based on attentional misdirection.

Failures of Visual Metacognition as a Key Factor in Magic

In the introduction, we pointed out that the kind of inattentional blindness or change blindness that plays a central role in many magic tricks involves a systematic failure of visual metacognition, where spectators have unrealistic intuitions about how much they actually see. One's immediate phenomenology conjures up the misleading impression that the visual system does much more than it actually does. One may argue that amodal perception involves a similar systematic failure of visual metacognition. In this case, though, one's immediate phenomenology conjures up the misleading impression that the visual system does much less than it actually does. We have a compelling impression of not being able to see hidden things, but the phenomena of amodal perception suggest that we actually do, at least in a functional sense. Thus, magicians can make the spectators see something that is not really there, while they are confident that they would only be seeing it if it were really there.

We believe that these failures of visual metacognition are essential for creating strong magical experiences because they make it almost impossible for the spectators to even suspect that they are being fooled. Hence, on a general level, one may argue that while attention and amodal perception are quite disparate phenomena in their own right, they both involve failures of visual metacognition, which accounts for their exceptional potency as tools for generating strong and robust magical experiences. In an even more general vein, it may prove rewarding to explore the hypothesis that many other types of magic effects are based on analogous failures of visual metacognition that have yet to be systematically discussed and

characterized. As discussed by Kuhn et al. (2014), an important feature of successful misdirection is that it should be counterintuitive. Relatedly, it is essential that the misdirection is not recognized as such. Yelling "Look over there—a gorilla on a bike!" may distract people's attention from a secret move, but it is obviously not a very good recipe for strong magic. Relying on a failure of visual metacognition, on the other hand, ensures both that the misdirection is counterintuitive (because failures of visual metacognition are counterintuitive) and that the misdirection is not recognized as such (because we are not consciously aware of our failures of visual metacognition).

As an example of a further counterintuitive aspect of perception that may qualify as a failure of visual metacognition, one may consider the perception of causality: While people naively tend to think that causality is inferred by conscious reasoning, there is ample evidence to suggest that it is also experienced automatically on the basis of perceptual mechanisms (Duncker, 1945, pp. 66–67; Leslie, 1988; Michotte, 1954/1963; Ortiz, 2006, p. 54; Scholl & Tremoulet, 2000).

Stupid Tricks That Fool Most People Most of the Time: The Role of Psychological Effects in Magic

Our explorations of the role of amodal perception in magic described in the present article were largely motivated by a general and simple heuristic that we believe may be useful for identifying further aspects of magic of particular interest for cognitive science. The basic idea is this: If a magical trick involves an unknown but potent psychological (perceptual or cognitive) factor, it is likely to produce an effect that is more stunning than would be expected from a description of how it is done. Thus, conversely, if a given magic trick exhibits such a discrepancy between the expected and the actual potency of the effect, this may point to hitherto unknown or underestimated perceptual or cognitive phenomena contributing to the magical effect. In fact, in leafing through an arbitrary instructional book on magic, one will probably notice that many of the tricks seem to fall into this category and that most descriptions of how to do a particular trick are preceded by a description of how the spectators experience the trick. Often, this description is quite indispensable because it is far from obvious how the often quite simple and seemingly "stupid" methods being described are sufficient for creating a strong magical experience. That even magicians often lack a true and complete understanding of how many tricks work is suggested by the aforementioned phenomenon of magician's guilt, which is a topic of concern vigorously discussed among practicing magicians: The magician has the feeling that the method behind his trick is so blatantly

obvious that it must be evident to everybody. However, the experienced magician has one important advantage over the novice: Even if he does not really know why a particular trick works so well, he knows from experience that it will work like a charm.

In summary, the strategy of looking for magic tricks that work much better than one would expect based on a description of the method may turn out to be very useful for uncovering unknown psychological factors in magic in general.

Summary and Conclusions

We have argued that automatic perceptual and cognitive mechanisms governing how people experience and reason about hidden things—in particular, those underlying the well-known phenomenon of amodal presence and the less well-known but presumably intimately related phenomenon of amodal absence—play a central role in many magic tricks. We also have argued the causal role of these mechanisms, which cannot be observed directly, is difficult to appreciate even for experienced magicians and that it therefore may have been largely neglected in discussions of how magic works. We also have suggested that the surprising discrepancy between the expected and the actual efficiency of many magical routines may serve as a tell-tale sign of interesting psychological effects that may help guide further research into the psychology of magic.

Notes

1. The interested reader may refer to Michotte et al. (1964/1991) for more details about this definition.

2. See http://www.youtube.com/watch?v=hnMcuODZ-UY; movie last accessed on Jan. 16, 2016.

3. See http://www.youtube.com/watch?v=3eDCHC01VVo; movie last accessed on Jan. 16, 2016.

4. See http://www.youtube.com/watch?v=3eDCHC01VVo; movie last accessed on Jan. 16, 2016.

5. See also http://www.youtube.com/watch?v=seaO1c5awYw for a demonstration; movie last accessed on Jan. 16, 2016.

6. As pointed out by a reviewer, a factor that may make it difficult to imagine the objects in Figure 7a as hidden behind the "bubbled" occluder in Figure 7b is that they are perceived as larger than the relevant parts of the bubbled occluder (which is experienced as being located in the foreground) due to size–distance invariance (Emmert's law; see Holway & Boring, 1941). Although it may be intuitively difficult to imagine, it is a simple geometrical fact that a small object in the foreground can occlude the view of a much larger one in the background, provided that it is sufficiently far away.

7. This may also explain the curious experience evoked by viewing a face covered by an apple in Magritte's well-known painting "The Son of Man," where there is "a sort of conflict . . . between the visible that is hidden and the visible that is present" (Torczyner & Magritte, 1977, p. 172).

8. After acceptance of this manuscript, we noticed that Farennikova (2013) has published a related discussion of the perception of absence.

9. "Magic can only be established by a process of elimination. There is no way that you can directly apprehend that you're witnessing magic. You conclude that it's magic because there is no alternative. Therefore, the primary task in giving someone the experience of witnessing magic is to eliminate every other possible cause" (Ortiz, 2006, p. 37).

References

Adelson, E. H. (2000). Lightness perception and lightness illusions. In M. Gazzaniga (Ed.), *The new cognitive neurosciences* (2nd ed., pp. 339–351). Cambridge, MA: MIT Press.

Anderson, B. L., & Winawer, J. (2005, March 3). Image segmentation and lightness perception. *Nature, 434*, 79–83.

Barnhart, A. S. (2010). The exploitation of Gestalt principles by magicians. *Perception, 39*, 1286–1289.

Biederman, I. (1987). Recognition-by-components: A theory of human image understanding. *Psychological Review, 94*, 115–147.

Bonnet, G. (2013, January 18). Amodal nudity [Web log post]. Retrieved from http://skeptophilia.blogspot.com/2013/01/amodal-nudity.html

Bregman, A. S. (1981). Asking the "what for" question in auditory perception. In M. Kubovy & J. R. Pomerantz (Eds.), *Perceptual organization* (pp. 99–118). Hillsdale, NJ: Erlbaum.

Cui, J., Otero-Millan, J., Macknik, S. L., King, M., & Martinez-Conde, S. (2011). Social misdirection fails to enhance a magic illusion. *Frontiers in Human Neuroscience, 5*, Article 103. Retrieved from http://journal.frontiersin.org/article/10.3389/fnhum.2011.00103

Danek, A. H., Fraps, T., von Müller, A., Grothe, B., & Öllinger, M. (2014). Working wonders? Investigating insight with magic tricks. *Cognition, 130*, 174–185.

Duncker, K. (1945). On problem-solving. *Psychological Monographs*, *58*(5), i–113.

Ekroll, V., Sayim, B., Van der Hallen, R., & Wagemans, J. (2016). Illusory visual completion of an object's invisible backside can make your finger feel shorter. *Current Biology*, *26*, 1029–1033. doi:10.1016/j.cub.2016.02.001

Ekroll, V., Sayim, B., & Wagemans, J. (2013). Against better knowledge: The magical force of amodal volume completion. *i-Perception*, *4*, 511–515. doi:10.1068/i0622sas

Ekroll, V., & Wagemans, J. (2016). Conjuring deceptions: Fooling the eye or fooling the mind? *Trends in Cognitive Sciences*, *20*, 486–489. doi:10.1016/j.tics.2016.04.006

Farennikova, A. (2013). Seeing absence. *Philosophical Studies*, *166*, 429–454.

Firestone, C., & Scholl, B. (2015). Cognition does not affect perception: Evaluating the evidence for "top-down" effects. *Behavioral & Brain Sciences*, *20*, 1–77.

Freeman, W. T. (1994, April 7). The generic viewpoint assumption in a framework for visual perception. *Nature*, *368*, 542–545.

Gerbino, W., & Zabai, C. (2003). The joint. *Acta Psychologica*, *114*, 331–353.

Gibson, J. J. (1982). Ecological physics, magic, and reality. In E. S. Reed & R. Jones (Eds.), *Reasons for realism: Selected essays of James J. Gibson* (pp. 217–223). Hillsdale, NJ: Erlbaum.

Gilchrist, A., Kossyfidis, C., Bonato, F., Agostini, T., Cataliotti, J., Li, X. J., & Economou, E. (1999). An anchoring theory of lightness perception. *Psychological Review*, *106*, 795–834.

Gregory, R. L. (1986). *Odd perceptions*. London, England: Methuen.

Hazenberg, S. J., Jongsma, M. L. A., Koning, A., & van Lier, R. (2014). Differential familiarity effects in amodal completion: Support from behavioral and electrophysiological measurements. *Journal of Experimental Psychology: Human Perception and Performance*, *40*, 669–684.

Hazenberg, S. J., & van Lier, R. (2015). Disentangling effects of structure and knowledge in perceiving partly occluded shapes: An ERP study. *Vision Research*, *126*, 109–119. doi:10.1016/j.visres.2015.10.004

Hergovich, A., Gröbl, K., & Carbon, C. C. (2011). The paddle move commonly used in magic tricks as a means for analysing the perceptual limits of combined motion trajectories. *Perception*, *40*, 358–366.

Hill, K. (2013, January 17). The lurking pornographer: Why your brain turns bubbles into nude bodies [Web log post]. Retrieved from http://archive.randi.org/site/index.php/swift-blog/1985-the-lurking-pornographer-why-your-brain-turns-bubbles-into-nude-bodies.html?widthstyle=w-wide

Hoffman, D. D. (2000). *Visual intelligence: How we create what we see*. New York, NY: W. W. Norton.

Holway, A. H., & Boring, E. G. (1941). Determinants of apparent visual size with distance variant. *The American Journal of Psychology*, *54*, 21–37.

Kanizsa, G. (1979). *Organization in vision: Essays on Gestalt perception*. New York, NY: Praeger.

Kanizsa, G. (1985). Seeing and thinking. *Acta Psychologica*, *59*, 23–33.

Kanizsa, G., & Gerbino, W. (1982). Amodal completion: Seeing or thinking. In J. Beck (Ed.), *Organization and representation in perception* (pp. 167–190). Hillsdale, NJ: Erlbaum.

Kellman, P. J., & Shipley, T. F. (1991). A theory of visual interpolation in object perception. *Cognitive Psychology*, *23*, 141–221.

Kelly, H. H. (1980). Magic tricks: The management of causal attributions. In D. Görlitz (Ed.), *Perspectives on attribution research and theory: The Bielefeld Symposium* (pp. 19–35). Cambridge, MA: Ballinger.

Koffka, K. (1935). *Principles of Gestalt psychology*. New York, NY: Harcourt.

Kuhn, G., Amlani, A. A., & Rensink, R. A. (2008). Towards a science of magic. *Trends in Cognitive Sciences*, *12*, 349–354. doi:10.1016/j.tics.2008.05.008

Kuhn, G., Caffaratti, H. A., Teszka, R., & Rensink, R. A. (2014). A psychologically-based taxonomy of misdirection. *Frontiers in Psychology, 5*, Article 01392. Retrieved from http://frontiersin.org/article/10.3389/fpsyg.2014.01392

Kuhn, G., & Tatler, B. W. (2011). Misdirected by the gap: The relationship between inattentional blindness and attentional misdirection. *Consciousness and Cognition*, *20*, 432–436.

Kuhn, G., Tatler, B. W., Findlay, J. M., & Cole, G. G. (2008). Misdirection in magic: Implications for the relationship between eye gaze and attention. *Visual Cognition*, *16*, 391–405.

Lamont, P., Henderson, J. M., & Smith, T. J. (2010). Where science and magic meet: The illusion of a "science of magic." *Review of General Psychology*, *14*, 16–21. doi:10.1037/a0017157

Leddington, J. (2016). The experience of magic. *Journal of Aesthetics and Art Criticism*, *74*(3), 253–264.

Leslie, A. M. (1988). The necessity of illusion: Perception and thought in infancy. In L. Weiskrantz (Ed.), *Thought without language* (pp. 185–210). Oxford, England: Clarendon Press.

Levin, D. (2002). Change blindness blindness: As visual metacognition. *Journal of Consciousness Studies, 9*(5–6), 111–130.

Mack, A., & Rock, I. (1998). *Inattentional blindness*. Cambridge, MA: MIT Press.

Macknik, S. L., King, M., Randi, J., & Robbins, A. (2008). Attention and awareness in stage magic: Turning tricks into research. *Nature Reviews Neuroscience*, *9*, 871–879.

Mausfeld, R. (2013). The attribute of realness and the internal organization of perceptual reality. In L. Albertazzi (Ed.), *Handbook of experimental phenomenology: Visual perception of shape, space, and appearance* (pp. 91–118). Chichester, England: Wiley.

Memmert, D. (2010). The gap between inattentional blindness and attentional misdirection. *Consciousness and Cognition*, *19*, 1097–1101.

Michotte, A. (1963). *The perception of causality* (T. R. Miles & E. Miles, Trans.). London, England: Methuen. (Original work published 1954).

Michotte, A. (1991). The real and the unreal in the image. In G. Thinès, A. Costall, & G. Butterworth (Eds.), *Michotte's experimental phenomenology of perception* (pp. 187–197). Hillsdale, NJ: Erlbaum. (Original work published 1964)

Michotte, A., Thinès, G., & Crabbé, G. (1991). Les compléments amodaux des structures perceptives [Amodal completions of perceptual structures]. In G. Thinès, A. Costall, & G. Butterworth (Eds.), *Michotte's experimental phenomenology of perception* (pp. 140–167). Hillsdale, NJ: Erlbaum. (Original work published 1964)

Ortiz, D. (2006). *Designing miracles. Creating the illusion of impossibility.* El Dorado Hills, CA: A-1 MagicalMedia.

Pylyshyn, Z. (1999). Is vision continuous with cognition? The case for cognitive impenetrability of visual perception. *Behavioral & Brain Sciences, 22,* 341–365.

Rensink, R. A., & Kuhn, G. (2015). A framework for using magic to study the mind. *Frontiers in Psychology, 5,* Article 1508. Retrieved from http://journal.frontiersin.org/article/10.3389/fpsyg.2014.01508

Rensink, R. A., O'Regan, J. K., & Clark, J. J. (1997). To see or not to see: The need for attention to perceive changes in scenes. *Psychological Science, 8,* 368–373.

Rock, I. (1983). *The logic of perception.* Cambridge, MA: MIT Press.

Scholl, B. J., & Gao, T. (2013). Perceiving animacy and intentionality: Visual processing or higher level judgment? In M. D. Rutherford & V. A. Kuhlmeier (Eds.), *Social perception: Detection and interpretation of animacy, agency, and intention* (pp. 197–230). Cambridge, MA: MIT Press.

Scholl, B. J., & Tremoulet, P. D. (2000). Perceptual causality and animacy. *Trends in Cognitive Sciences, 4,* 299–309.

Simons, D. J., & Levin, D. T. (1997). Change blindness. *Trends in Cognitive Sciences, 1,* 261–267.

Simons, D. J., & Rensink, R. A. (2005). Change blindness: Past, present, and future. *Trends in Cognitive Sciences, 9,* 16–20.

Thomas, C., Didierjean, A., Maquestiaux, F., & Gygax, P. (2015). Does magic offer a cryptozoology ground for psychology? *Review of General Psychology, 19,* 117–128. doi:10.1037/gpr0000041

Torczyner, H., & Magritte, R. (1977). *Magritte, ideas, and images* (R. Miller, Trans.). New York, NY: H. N. Abrams.

Tse, P. U. (1999). Volume completion. *Cognitive Psychology, 39,* 37–68.

Van de Cruys, S., Wagemans, J., & Ekroll, V. (2015). The put-and-fetch ambiguity: How magicians exploit the principle of exclusive allocation of movements to intentions. *i-Perception, 6,* 86–90. doi:10.1068/i0719sas

van Lier, R. (1999). Investigating global effects in visual occlusion: From a partly occluded square to the back of a tree-trunk. *Acta Psychologica, 102,* 203–220.

van Lier, R., & Gerbino, W. (2015). Perceptual completions. In J. Wagemans (Ed.), *Oxford handbook of perceptual organization* (pp. 294–320). Oxford, England: Oxford University Press.

van Lier, R., & Wagemans, J. (1999). From images to objects: Global and local completions of self-occluded parts. *Journal of Experimental Psychology: Human Perception and Performance, 25,* 1721–1741.

Vishwanath, D. (2013). Immersion, tangibility, and realism: Explaining the qualitative experience of stereopsis. *Proceedings of SPIE (*International Society for Optics and Photonics), *8648: Stereoscopic Displays and Applications 24.* doi:10.1117/12.2004902

Vishwanath, D. (2014). Toward a new theory of stereopsis. *Psychological Review, 121,* 151–178.

Vrins, S., de Wit, T. C. J., & van Lier, R. (2009). Bricks, butter, and slices of cucumber: Investigating semantic influences in amodal completion. *Perception, 38,* 17–29.

Wertheimer, M. (1923). Untersuchungen zur Lehre von der Gestalt [Investigations on Gestalt principles]. *Psychologische Forschung, 4,* 301–350.

Wertheimer, M. (2012). Untersuchungen zur Lehre von der Gestalt [Investigations on Gestalt principles]. In L. Spillmann (Ed.), *Max Wertheimer: On perceived motion and figural organization* (pp. 127–182). Cambridge, MA: MIT Press. (Original work published 1923)

Wiseman, R. (2013, May 21). *The ball.* Retrieved from https://www.youtube.com/watch?v=sIQ_8bIco3s