Some varieties of shadow illusions: split shadows, occluded shadows, stolen shadows, and shadows of shadows. Perception, 41, 357-360.

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▶ **To cite this version:**

Roberto Casati. Some varieties of shadow illusions: split shadows, occluded shadows, stolen shadows, and shadows of shadows. Perception, 41, 357-360.. Perception, 2012, 41, pp.357-360. ijn_00803847

HAL Id: ijn_00803847
https://hal.science/ijn_00803847

Submitted on 23 Mar 2013

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Perception, 2012, volume 41, pages 000–000

doi:10.1068/p7156

SHORT AND SWEET

Some varieties of shadow illusions: Split shadows, occluded shadows, stolen shadows, and shadows of shadows

Roberto Casati
Institut Jean Nicod, CNRS-EHESS-ENS, Paris; and Design, Università IUAV, I 30123 Venice, Italy;
e-mail: casati@ehess.fr
Received 19 October 2011, in revised form 8 March 2012

Shadows are visual objects and as such are subject to preference rules for segmenting the visual scene (such as Gestalt laws). These rules govern shadows along two dimensions: their general unity and individuation (eg they describe a certain area as a unitary shadow as opposed to a set of two distinct shadows), and their being the shadow of a given object, as opposed to being the shadow of any other object in the scene (the shadow correspondence problem—Mamassian 2004). I describe a few phenomena that indicate the interplay of preferences in determining the final visual aspect of scenes in which shadows are present.

1 Split and occluded shadows

A single object can cast more than one shadow, but in general an object cannot cast more shadows than there are distinct sources of light. If more than one surface is present, an object can cast shadows on each surface, but these are typically seen as incomplete, partial shadows. However, the scene can be engineered so that a single object, in the presence of a single source of light, appears to have two complete shadows. Figure 1 shows one such scene.

The pen appears to have two distinct shadows in the presence of a single light source (the Sun at noon in May, ca 50° latitude North). Two distinct shadows appear: a curved one and a straight one. The curved shadow terminates in the pen's cups.

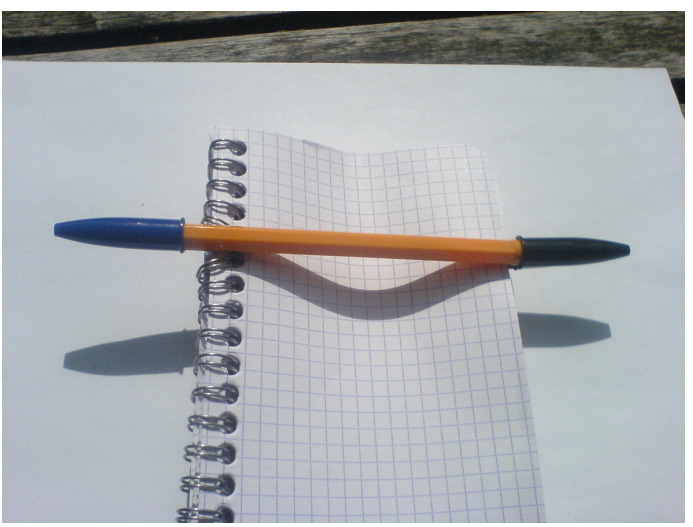

Figure 1. [In colour online, see http://dx.doi.org/10.1068/p7156] An object with two shadows, one of which is impossibly occluded.

The shadows of the two cups appear to be part of a longer, straight shadow that is occluded by the notepad. The rule of good continuation thus creates a shadow with illegal properties (shadows cannot in general be occluded by lighter surfaces that are interposed between the light source and the projection plane).

2 Shadow capture

In the left middle part of his *Pharaoh with his Butler and Baker* of about 1515 (London, National Gallery) Jacopo da Pontormo (1494–1557) depicts a shadow neatly cast on a wall (figure 2).

Figure 2. [In colour online.] Jacopo da Pontormo, 1494–1556/7, *Pharaoh with his Butler and Baker*, about 1515. Oil on wood, 61 cm × 51.7 cm, London, National Gallery. Bought with the aid of the National Art Collections Fund (Eugene Cremetti Fund), 1979. © The National Gallery, London.

Whose shadow is it? It looks as if the first, unreflective answer, privileges the character immediately to its right, a person who is ascending a flight of stairs. However, upon inspection, it is easily seen that the shadow's profile matches the profile of a statue erected to the left of the shadow. Indeed, the first candidate has his own shadow. We are here in front of a case of what I shall call *shadow stealth* or capture. A shadow capture occurs whenever a character—a solid, 3-D character, or a depicted character—captures the shadow of another character. Shadow capture provides an incorrect solution to the shadow correspondence problem, ie the problem of matching a shadow to its caster. In Pontormo's *Pharaoh* the correct solution is delivered by an object that cannot cast the shadow in question, as the shadow copies the visible profile of the object. Indeed, the correct association would be the consequence of the copycat solution to the shadow correspondence problem (Casati 2008). Interestingly, shadow capture in this painting testifies a conflict between a proven solution to the shadow-correspondence problem (copycat) and another type of solution, that seems to be regulated by sheer proximity. In this sense, shadow correspondence relies upon strategies that are the same

as those used by the visual system in Gestalt grouping, such as similarity and proximity. As it is known, Gestalt factors may play against each other—as it happens with the Pontormo case—or else act synergetically. It should be noted that if capture occurs, we may infer to an incorrect position of the light source.

The phenomenon of shadow capture is not limited to pictorial representation, and occurs in ecological situations. Figure 3 documents one such example.

Figure 3. [In colour online.] Shadow capture. The cornice captured the shadow of the roof of a facing building.

3 Shadows of shadows

But who captures whom? Is it objects that in a scene populated with shadows search for their likely shadow, or is it shadows that look for their likely object? Or both at the same time? Gestalt preference rules were studied in a monocategorical world, for which these questions are generally meaningless. Each of the dots that constitute a line has the same object status as any other dot in the same line. But shadows are sui generis visual objects, as they are asymmetrically related to the concrete objects that cast them; they belong to a different category than the one of the objects casting them.

Some ideas on the who captures whom question comes from the phenomenon of shadows of shadows. Shadows are not opaque objects, hence they cannot cast shadows. However, it is possible to create a situation in which something that is clearly seen as shadow appears to cast a shadow in turn. When a shadow is cast on a semi-transparent surface—a piece of loosely woven fabric, say—part of the light passes through the surface and reproduces the shadow pattern on the next available surface. Under some conditions, the second shadow may appear to be cast by the first shadow (figure 4).

Indeed, it may even look as if the second shadow has created an object to justify its own being cast. It has conferred object status to the first shadow, thereby attributing it to causal powers that it is not supposed to have. This suggests that it is shadows that look for objects to cast them in the scene, ie shadows are the starting items in the process of solving the shadow correspondence problem.

Figure 4. [In colour online.] A shadow of a shadow.

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