

**SHORT AND SWEET****“Exorcist illusion”: Twisting necks in the hollow-face and hollow-torso illusions**

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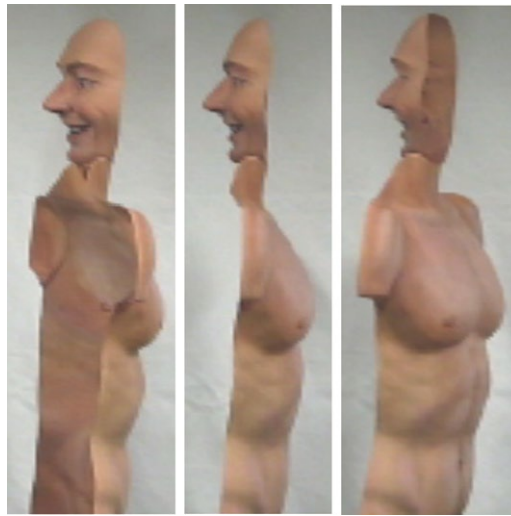
**Abstract.** We combine a convex facial mask with a concave torso—or vice versa—thus creating a single rigid object with a transition area at the neck, where convexity changes to concavity. This combination creates stunning illusions when the rigid object is set to motion. The two simplest effects are (1) when the object is rotated about its axis, the head appears to twist with respect to the torso, as in “*The Exorcist*” film; (2) when it is rotated around an axis parallel to the shoulders, the head appears to hinge around the torso. More complex illusory effects result from more complex motions. The involvement of higher-level perceptual processes may account for the illusory effects.

**Keywords:** hollow-mask illusion, hollow-body illusion, top-down influences, rigidity assumption.

We present a variation of the well-known hollow-mask illusion (Gregory, 1970) and the less-known hollow-torso illusion: in these illusions, a hollow mask/torso appears as a normal convex face/torso. The most prevalent explanation is that, in addition to a bias for convex surfaces (Hill & Bruce, 1994), previous experience and familiarity with convex faces and torsos may cause the illusions (Gregory, 1997, 2005; Hill & Bruce, 1993; Hill & Johnston, 2007; Koenderink, van Doorn, Kappers, & Todd, 2004), thus implicating higher-level perceptual processes. In addition, when the hollow-to-convex illusion is obtained, the face/torso moves vividly as viewers move in front of it, as if it “follows” the moving viewer. Finally, when rotated, each is perceived to rotate in a direction opposite to the actual direction (Cook, Hayashi, Amemiya, Suzuki, & Leumann, 2002; Gregory, 1997; Pappathomas, 2007). If one combines a torso with a facial mask with the hollow sides aligned (*in-phase*), then one obtains an interesting—but expected—“hollow-human” illusion: Torso and face appear to follow a moving viewer and, when rotated, they appear to turn together in the direction opposite to the actual direction of rotation.

The illusion presented here adds an interesting “twist” by combining the torso and facial mask *out of phase*: The hollow side of the torso is aligned with the convex side of the mask and vice versa; three views of this “convex/concave” object are shown in [Figure 1](#). It must be emphasized that this is a *single rigid* object whose parts do not move relative to each other.

Because this object contains both convex and concave familiar parts that are conjoined at the neck, it creates very vivid illusions around the neck when it is set to motion. These illusions are a result of the differences in the perceived motion between convex and concave parts. Convex parts are perceived veridically and they appear to rotate in the actual direction of rotation. On the contrary, concave parts

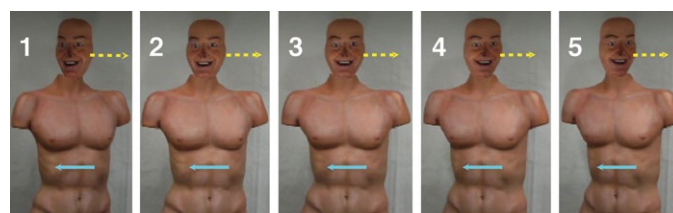


**Figure 1.** Three views of the single rigid object composed of a torso and a mask such that the convex side of one is aligned with the concave side of the other. This is evident in the middle panel. Left panel: a view that shows a hollow torso and a convex mask. Right panel: a view of a convex torso and a hollow mask.

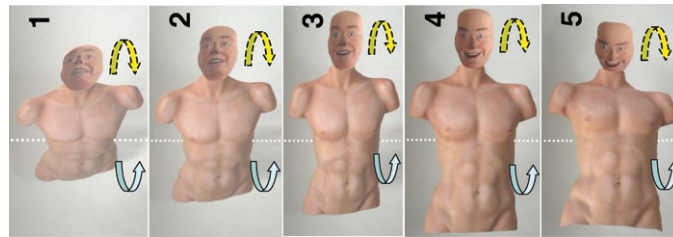
create an illusion and are perceived as convex; they appear to rotate in the opposite direction to the actual direction.

As a result of these opposite directions, interesting illusory phenomena are observed around the neck, which is the transition area between convexity and concavity. Two such illusions are shown in [Figures 2](#) and [3](#), as well as in the accompanying animation sequences. [Figure 2](#) shows five non-consecutive frames in a sequence where the object is positioned so as to have the convex torso and the hollow mask face the viewer. The object rotates clockwise (CW) as seen from above about its vertical axis. The percept is of a convex torso rotating CW and an illusory convex face rotating counterclockwise (CCW), resulting in a twisting neck, similar to the famous scene in the film “*The Exorcist*” (1973). These frames were selected from the first half of animation sequence 1 (supplementary movie 1), showing a 180-degree rotation of the object.

[Figure 3](#) shows five non-consecutive frames of an animation sequence that shows the same rigid body “tumbling,” i.e., rotating about an axis parallel to the shoulder line; this axis is shown by a dotted white line. To achieve such a tumbling rotation, we devised a practical solution: we suspended the torso from a ceiling motor that rotated the object CCW as seen from above. In addition to offering a practical solution, this horizontal orientation, as well as an upside-down one, can be used in future experiments to examine how posture familiarity affects the illusion strength. An explanation involving schema-driven influences would predict an effect of orientation (Hill & Johnston, 2007), whereas a purely data-driven explanation would not. As in [Figure 2](#), the body is positioned such that the torso/face has its convex/concave side facing the viewer. As a result, the convex torso appears to rotate in the physical direction of rotation (CCW), whereas the hollow mask is perceived as a convex face rotating in the opposite direction (CW). The consequence is a strong percept of the head “hinging” with respect to the torso: in frame 1, the head appears to be tilted back as far as it can go; in frame 5, the head appears to be dropped forward, “chin-to-chest”; the head assumes intermediate postures in frames 2–4. These frames were selected from the second half of animation sequence 1.



**Figure 2.** Five frames in a sequence of a rigid object—convex torso with a hollow mask—as it rotates around the body axis. The torso appears to rotate clockwise (CW) to its right, as seen from above (solid blue arrows); the face appears to rotate opposite, CCW to its left (dotted yellow arrows), creating the illusion of a twisting neck.



**Figure 3.** Five frames in a sequence involving the same rigid object of [Figure 1](#) as it rotates CCW around an axis parallel to the shoulders (dotted white line). The torso appears to rotate CCW, as seen from above (solid blue arrows); the face appears to rotate opposite, CW (dotted yellow arrows), creating the illusion of a “hinged” neck. For a proper interpretation of the direction of rotation, the arrowheads are meant to be closer to the viewer than the arrow tails. See text on why we selected this particular orientation.

The above figures and animation sequences were obtained by passively videotaping a *physical rigid* “convex/concave” object as it rotated about different axes. Attaching the object on a board provided some more freedom and created a “floating” illusion, as shown in animation sequence 2 (supplementary movie 2). More freedom was obtained by generating four *virtual rigid* “convex/concave” objects, each of which behaves exactly as the physical object of [Figures 1–3](#). The advantage of using virtual objects is the freedom to set them to complex motion patterns. These patterns create striking illusions around the neck areas of the bodies, as can be witnessed in the choreography of animation sequence 3 (supplementary movie 3). The illusory neck-twisting motion in all the animations presented here illustrates that the global rigidity assumption (Johansson, [1973](#); Ullman, [1984](#)) is violated to accommodate the more powerful prior-experience constraint that faces and torsos are convex. It is noteworthy, as an anonymous reviewer pointed out, that the consistent local processes of perceiving convex torsos and faces result in an inconsistent global percept of twisting necks.

In conclusion, the most parsimonious explanation for the illusions presented in this paper is one that invokes the influence of top-down influences in perception (Gregory, [1997](#), [2005](#); Helmholtz, [1866](#); Rock, [1983](#); Rogers & Gyani, [2010](#)), in this case a life-long exposure to convex faces and bodies. This causes concave faces and torsos to be misperceived as convex, thus setting the stage for the illusory motion (Gogel, [1990](#); Gregory, [1997](#); Pappathomas, [2007](#)).

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## References

- Cook, N. D., Hayashi, T., Amemiya, T., Suzuki, K., & Leumann, L. (2002). Effects of visual-field inversions on the reverse-perspective illusion. *Perception*, *31*, 1147–1151. doi:10.1068/p3336
- The Exorcist*. (1973). Film directed by William Friedkin, “head-turning.” scene, Warner Bros. USA.
- Gogel, W. C. (1990). A theory of phenomenal geometry and its applications. *Perception and Psychophysics*, *48*, 105–123. doi:10.3758/BF03207077
- Gregory, R. L. (1970). *The intelligent eye* (128–131). New York: McGraw-Hill.
- Gregory, R. L. (1997). Knowledge in perception and illusion. *Philosophical Transactions of the Royal Society London B*, *352*, 1121–1126. doi:10.1098/rstb.1997.0095
- Gregory, R. L. (2005). The Medawar Lecture 2001 knowledge for vision: Vision for knowledge. *Philosophical Transactions of the Royal Society London B*, *360*(1458), 1231–1251. doi:10.1098/rstb.2005.1662
- Helmholtz, H. (1962/1866). *Treatise on physiological optics*. New York: Dover/Handbuch der Physiologischen Optik. vol. 3 (Voss).
- Hill, H., & Bruce, V. (1993). Independent effects of lighting, orientation, and stereo on the hollow face illusion. *Perception*, *22*, 887–897. doi:10.1068/p220887
- Hill, H., & Bruce, V. (1994). A comparison between the hollow-face and “hollow-potato” illusions. *Perception*, *23*, 1335–1337. doi:10.1068/p231335
- Hill, H., & Johnston, A. (2007). The hollow-face illusion: object-specific knowledge, general assumptions or properties of the stimulus? *Perception*, *36*, 199–223. doi:10.1068/p5523

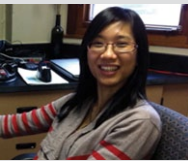
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- Johansson, G. (1973). Visual perception of biological motion and a model for its analysis. *Perception & Psychophysics*, *14*, 201–211. [doi:10.3758/BF03212378](https://doi.org/10.3758/BF03212378)
- Koenderink, J. J., van Doorn, A. J., Kappers, A. M. L., & Todd, J. T. (2004). Pointing out of the picture. *Perception*, *33*, 513–530. [doi:10.1068/p3454](https://doi.org/10.1068/p3454)
- Papathomas, T. V. (2007). Art pieces that “move” in our minds—An explanation of illusory motion based on depth reversal. *Spatial Vision*, *21*, 79–95. [doi:10.1163/156856807782753958](https://doi.org/10.1163/156856807782753958)
- Rock, I. (1983). *The logic of perception*. Cambridge, MA: MIT Press.
- Rogers, B. J., & Gyani, A. (2010). Binocular disparities, motion parallax, and geometric perspective in Patrick Hughes’s “reverspectives”: Theoretical analysis and empirical findings. *Perception*, *39*, 33000348. [doi:10.1068/p6583](https://doi.org/10.1068/p6583)
- Ullman, S. (1984). Maximizing rigidity: The incremental recovery of 3-D structure from rigid and rubbery motion. *Perception*, *13*, 255–274. [doi:10.1068/p130255](https://doi.org/10.1068/p130255)



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