Volume Estimation As Simulated Judgment

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In estimating many products' value, consumers must assess package size. We present a novel simulated judgment account of volume estimation—positing that people estimate the size of a receptacle by simulating filling it up. This account correctly anticipates previously-unidentified influences on volume perception: a container's orientation and its top-to-base ratio.

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EXTENDED ABSTRACT

While standing in line at a coffee shop, consumers can eye different-sized cups on display, trying to determine which size looks ideal. While at a container store, consumers may peruse various storage boxes, trying to determine which is the right size to store the junk that has been accumulating on one's dining room table.. Previous research has examined different sources of bias when estimating volume—either the shape of the object to be judged (e.g., Anderson & Cuneo, 1978; Wansink & van Ittersum, 2003; Ordabayeva & Chandon, 2013), or the psychological states of the judge (Cornil, Ordabayeva, Kaiser, Weber, & Chandon, 2014). Although such work has identified robust sources of estimate error, they largely remain "as-if models"—algorithms that can predict when consumers' judgments will err, but that remain agnostic about the actual process by which those judgments are made. We instead propose a specific mental process by which volume estimations often unfold, thereby allowing us to make two novel predictions about what biases such judgments.

We posit that volume estimation is often made through *simulated judgment*. This proposal draws on diverse literatures that converge to suggest the key role of mental simulation in judgments and forecasts. For example, features that make it easier to imagine what global warming would feel like can make the simulations seem sharper and thus more likely (Risen & Critcher, 2011). Closer to physical judgments, Profitt and colleagues (1996, 2003) demonstrate that being weighted down makes hills appear steeper: Because the weight would make the climb more difficult, people simulate the climb (and thus the slope) as steeper.

Building on these literatures, we suggest that estimating a receptacle's volume can involve simulating an interaction with it: how much one can imagine pouring into the container. But given that pouring happens with the flow of gravity—from top to bottom—we suggest that two features can (and do) influence such judgments. First, we hypothesize an *orientation effect*—that the same glass will appear bigger right-side-up than upside-down. We test whether this is explained by the simpler mental simulation of filling an upright cup. Second, we posit a *cavern effect*—that imagining pouring through a narrow top into a wide base (as though into a cavern) makes the volume seem bigger than pouring through a wide top into a narrow base. More precisely, we suggest that—all else equal—a container with a small top-to-base ratio will look bigger than one with a large top-to-base ratio.

Study 1 focuses on the *orientation effect*. Participants (N = 302) were presented with a sequence of 24 images of 12 actual glasses (taken from Google Images) that varied in shape (e.g., plastic cup, coffee mug, stemless wineglass), size, and color. Each image was presented twice—once right-side-up, and once upside-down. In all studies, participants saw a reference cylinder of a specified size (in order to make the scaling clear) before being shown the target cup. Consistent with hypotheses, the exact same cup looked bigger when right-side-up than upside-down $t(5989.90) = 2.92$, $p = .004$.

Study 2 (N = 250) built on Study 1 in two primary ways. First, whereas Study 1 used images of actual glasses (for purposes of external validity), Study 2 used computer-generated images. This allowed us to hold the shape of a cup constant, but vary whether the wide or narrow end was depicted as the open top or the closed base. Second, we modified the images so that the cup appeared empty, or entirely full of water. We then asked participants how much they could pour into the *empty* cup, or pour out of the *full* cup. We observed main effects of orientation and the top-to-base ratio, ts > 4.70, ps < .01, consistent with the orientation effect (right-side-up cups looked bigger) and cavern effect (cups with narrow tops and wide bases looked bigger), respectively. Showing the key role of simulation in these judgments, both effects were larger when participants imagined filling up (as opposed to emptying) the cup, ts > 4.19, ps < .01.

Study 3 (N = 209) delved more deeply into both the orientation and cavern effects. First, we asked participants about the ease of the simulation ("To what extent did you find it easy or difficult to mentally simulate filling up the cup?") Participants' higher volume estimates of right-side-up cups were partially mediated by simulation ease. Second, we held the volume of the cups constant, but varied the top-to-base ratio. This permitted us to observe that the cavern effect emerges only when there is a sufficient mismatch between a narrow top and wide base (versus the reverse), and not from the size of the top or base alone.

Study 4 (N = 388) more precisely tested the role of mental simulation (versus mere container shape) in producing the cavern effect. Participants saw open or lidded cups. In filling an open cup, the size of the top is the size of the aperture through which the cup can be filled. But for the lidded cups, which always included only a small hole through which to fill the cup, this link was disrupted. Showing the key role of simulated judgment (as opposed to mere shape), the lidded nature of the cups moderated the cavern effect: narrow tops and wide bases exaggerated the size of containers, but only when open.

Although considerable attention has been given to biases in psychophysical judgments, the present work is among the first to propose a specific psychological process by which such judgments are made. The present findings suggest that restaurant and store owners would do well to display containers right-side-up. Furthermore, packaging designers may be wise to design products with low top-to-base ratios (e.g., Yoplait yogurt) as opposed to the reverse (e.g., snowcones). Through this talk, we will emphasize the complimentary roles that basic and applied research can play: Only by offering and testing a new theoretical process account of how volume estimation unfolds were we able to make predictions for what externally-valid features should distort such judgment.

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