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The P&p illusion

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Identical letters can appear to differ in size and shape depending on whether they are interpreted as uppercase or lowercase. The effect is most dramatic with the letter p. Examination of subjects' estimates of the magnitude of the effect for different stimuli suggests that two factors are involved in the illusion. One factor depends only on whether a letter is interpreted as uppercase or lowercase. This factor can be manipulated by changes in the size or case of the surrounding letters. The second factor, which depends on the possibility of interpreting a vertical line alternatively as an ascender or a descender (as in p or y), seems to involve a change in the perceived size of the letters' loops.

For most observers, visual inspection of the array of ps comprising Figure 1 results in some of the letters appearing to shift between uppercase and lowercase. The type-font used in Figure 1 was chosen to minimize feature differences between the uppercase and lowercase letters, and the array was arranged in such a way that each row of letters provides different cues for the interpretation of the row above and the row below it. Because of the absence of competing contextual cues, the top row of ps is usually seen as uppercase and the bottom row as lowercase. An important characteristic of the apparent shift is whether the vertical line of each p is interpreted as an ascender or a descender. There is more to the phenomenon, however, than the interpretation of the vertical line. When seen as uppercase, the letters appear to be larger and somehow different in shape than when seen as lowercase.

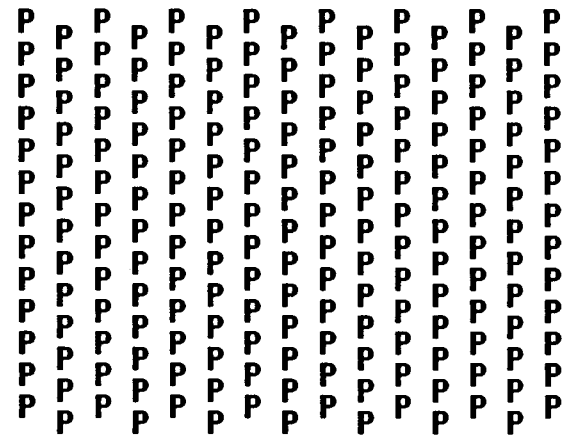

Figure 1. The Ps may appear to fluctuate from uppercase to lowercase.

In the form of Figure 1, the phenomenon belongs to a large class of reversible or multistable figures including such well-known forms as the reversible goblet and the Necker cube (see Attneave, 1971; Fisher, 1968, for reviews). Like other reversible figures, the ps spontaneously alternate if a visual fixation is maintained. In other contexts, this spontaneous alternation has been attributed to satiation or adaptation of the neural mechanism underlying the active configuration (e.g., see Attneave, 1971).

In Figure 2, identical ps are displayed in different relationships to other letters. The ps appear to differ, depending on whether the context suggests an uppercase or a lowercase interpretation.

Fifty students (24 men and 26 women; mean age 25.8 years) from a number of psychology classes were asked to indicate whether the pairs of ps in each row of Figure 2 appeared to be identical in size and shape. Responses were made on a 5-point scale anchored by "clearly identical" (1) and "clearly different" (5). After the observers had entered their responses, the experimenter explained that all of the ps were, in fact, identical and that any appearance to the contrary was an illusion. The observers were then instructed to regard the magnitude of the illusion for the P&p figure as "100" and to scale the magnitude of the illusion, if any, for other stimulus pairs (presented on a new page) relative to this standard. The subjects were explicitly instructed to use a rating of 0 if there was no illusion. Figures 3, 4, and 5 were scaled by the subjects relative to this standard.

There was some inconsistency between the identity ratings and the magnitude estimates for the various rows of Figure 2. On the basis of both types of responses, however, the illusion was most pronounced for rows 2, 4, and 5 of Figure 2, where the ps are displayed in the uppercase or lowercase positions in different words. For these stimuli, the identity ratings averaged between 3 and 4 on the 5-point identity scale, indicating that the typical

The P&p illusion was brought to my attention by Harrie Hess of the UNLV faculty, who first noticed the phenomenon in the process of examining a computer-generated matrix of responses to a true-false test in which a long series of omitted responses were scored "P" for "pass." Perhaps the phenomenon should be called the "Hess illusion" in his honor. Requests for reprints may be addressed to Don Diener, Department of Psychology, University of Nevada, Las Vegas, 4505 Maryland Parkway, Las Vegas, NV 89154.

		Identity Rating		Magnitude Estimate	
		Mean	S.E.	Mean	S.E.
P&p		2.42	(.25)	(100)	
ApE	aPe	3.37	(.21)	116	(7.32)
aPt	APt	1.08	(.04)	30	(6.46)
apt	APt	3.80	(.19)	105	(7.92)
aPt	apt	3.57	(.23)	120	(8.83)

Figure 2. Identity ratings from "clearly identical" (1) to "clearly different" (5), and estimates of the magnitude of the illusion relative to the figure in the first row for the pairs of ps on each row. All of the ps in the figure are identical.

Compare			Magnitude Estimate	
			Mean	S.E.
y	yes	Yes	103	(6.61)
	YES	yes	84	(7.51)
s	say	Say	64	(7.94)
	SAY	say	50	(8.39)

Figure 3. Estimate of the magnitude of the illusion for identical ys (rows 1 and 2) and identical ss (rows 3 and 4).

subject believed the ps to be different in size and/or shape but was not certain of this judgment. The ps in row 3 of Figure 2, both of which appear in the uppercase orientation, were rated as clearly identical by most of the observers. However, the mean magnitude estimate for this comparison was 30, apparently representing a floor on the scaling task.

Apart from p, the only letter for which identical tokens can serve as either uppercase or lowercase without changes in the size of the surrounding letters is y. Identical ys are shown in different relationships to other letters in the first two rows of Figure 3. Most observers estimated the magnitude of the illusion for the first row of Figure 3 as equal to that of the standard, and the magnitude of the second row as somewhat lower. Thus, the ys seem to produce slightly less of an effect than do the ps.

The uppercase and lowercase versions of a number of letters differ primarily in size (e.g., c, o, s, v, x, and z), although in many fonts, the uppercase versions of the letters are distinguished by serifs or are narrower relative to their heights than are the lowercase letters. The ss in the bottom two rows of Figure 3 can be interpreted equally well as uppercase or lowercase depending on the relative size or the case of the surrounding letters. The magnitude estimates provided by the observers indicate some illusory effect for the ss, although the effect is not as great as for the ps or ys.

It is possible that the effect obtained with the ss in Figure 3 is based on an entirely different factor than the effect obtained with the ys and ps. It seems more likely, however, that the illusion for ps and ys depends on at least two factors. One of these factors, present for both the ss and the ps and ys, is entirely a matter of whether a letter is perceived as uppercase or lowercase. A second factor seems to require the presence of a vertical line that can be interpreted alternatively as an ascender or a descender.

The illusion that is present for the ss may be the result of learning that is specific to the interpretation of letters. Uppercase letters are usually assumed to be larger than lowercase letters. In fact, uppercase letters are often called "large" and lowercase letters "small." Perception might be biased in keeping with this expectation. It would be interesting in this regard to see to what extent people with limited exposure to the Roman alphabet would experience the illusion.

For p-shaped stimuli, the magnitude of the illusion depends on the orientation of the letters. If Figures 1 and 2 are turned upside down, so that the ps appear to be lowercase ds, the effect largely disappears. In Figure 4, identical p-shaped letters are shown in different orientations such that they appear as ds, bs, or qs. All of the pairs of p-shaped letters in Figure 4 were scaled relative to the P&p standard in both right-side-up and upside-down orientations.

The magnitude estimates obtained for the stimuli in Figure 4 are informative in several respects. First, there was a greater effect for ps and qs than for bs and ds, even when the ps and qs were created by turning the bs and ds upside down. The relative positions of the letters do not change when the figure is inverted, but the possibility of interpreting the vertical lines alternatively as ascenders or descenders does. Second, the q orientation produced less of an effect than either the ps of the standard figure or the ps created by inverting the ds in row 2. Although the vertical lines of the qs can be interpreted

Upside-Down			Right-Side-Up	
Magnitude Estimate			Magnitude Estimate	
Mean	S.E.		Mean	S.E.
45	(7.33)	b&b	37	(6.75)
56	(7.04)	d&d	37	(6.54)
32	(6.39)	q&q	47	(7.47)

Figure 4. Estimates of the magnitude of the illusion for identical p-shaped letters in different orientations.

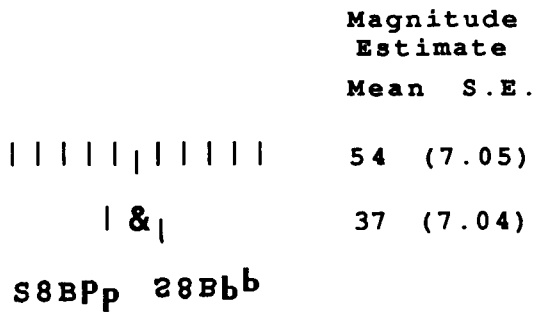

Figure 5. The top two rows show two forms of the bisected-line illusion with observers' magnitude estimates. The two series of letters in the bottom row are identical except for orientation. Note that the disparity in size between the top and bottom loops of the S, B, and 8 is much more obvious in the inverted orientation.

as either ascenders or descenders, the ascender interpretation does not correspond to the typical representation of any letter. Thus, the qs may be subject to the portion of the illusion that is based on the interpretation of the vertical lines but not to the portion that depends on interpreting one letter as uppercase and another as lowercase. Third, the ps created by inverting the ds in row 2 of Figure 4 produced less of an effect than the ps in the standard figure. The inverted ampersand in this orientation interferes with both ascender and descender interpretations of the vertical lines.

Two possible sources of the portion of the illusion that depends on the interpretation of the vertical lines were considered. One possibility is related to the illusion of the bisected line (Finger & Spelt, 1947). The descender of the lowercase p may appear shorter than the ascender of the uppercase p because it is, in effect, bisected by the undrawn line on which the letters rest. The effect of positioning a vertical line such that it is bisected by an undrawn line is shown in Figure 5. The observers' magnitude estimates indicate that the bisected-line illusion is present for the undrawn line in row 1 of Figure 5. There appears, however, to be little effect in row 2 of the figure, where two vertical lines are positioned in the same relationship to an ampersand as are the vertical lines of the ps in the standard figure. It is possible that the bottom of the loop of the lowercase p in the standard figure strengthens the cues for the bisecting line. However, similar cues are present for the bs and ds in Figure 4, for which little, if any, illusion is evident. Thus, the bisected-line effect seems unlikely to be a major factor in the illusion.

A second possibility is that the illusion depends primarily on the interpretation of the size of the loops rather than on the length of the vertical lines. According to this interpretation, the P&p illusion is related to an illusion that is usually illustrated with Ss and 8s. If an S or an 8 is drawn such that the top and bottom loops appear to be subjectively equal in size, the top loop is actually smaller than the bottom loop (Luckiesh, 1922/1965). In many type fonts, the upper portions of 8s and uppercase Ss and Bs are smaller than the bottom portions. Although this size disparity is often great enough to be noticed in the upright orientation, it is even more obvious when the characters are inverted, as shown in the bottom row of Figure 5. Thus, the top loop of a double-looped character is subjectively enlarged relative to the bottom.

A similar effect may be evident in the case of two ps, ys, or qs placed in uppercase and lowercase positions. The loop of the letter seen as uppercase may appear to be larger than that of an indentical letter interpreted as lowercase. The relative position of the loops, however, cannot be the critical factor. The effect is not evident, for example, when ps are inverted (as in Figure 4), despite the fact that the relative position of the loops does not change. The perceived size of the loop must depend on whether the loop is perceived as resting on the undrawn line beneath the lowercase letters or supported above this line by an ascender.

Although it seems likely that the present illusion is related to the illusion apparent with the loops of double-looped figures, the source of the effect is not apparent in either case. It is possible that the effect depends on factors specific to the interpretation of letters. For example, the height of uppercase letters may be assumed to be roughly twice that of lowercase letters, causing a loop to appear larger when it more than fills the vertical difference between the heights of uppercase and lowercase letters. It is also possible that the effect is based on a more general phenomenon—for example, a misapplied size constancy resulting from interpreting the tops of letters as being farther away than the bottoms.

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