

# Contour repulsion vs. adaptation-level interpretations of the Baldwin illusion

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Within the Baldwin figure, it was found that the hash mark placed between two squares was phenomenally displaced toward the larger square when the visual angle subtended by the figure was large. This result, which was predicted from adaptation-level theory, replicated that obtained by Merryman and Restle (1970) using a similar display. When, however, the Baldwin figure subtended a visual angle of less than 0 deg 30 min of arc, the phenomenal displacement of the hash mark was reversed, as would be predicted from contour repulsion accounts of geometrical-optical illusions.

Reviews of research into explanations of geometrical-optical illusions by Over (1968), Robinson (1972), and Zusne (1970) have all highlighted the need for experimental investigations which are guided by hypotheses predicting different outcomes from contrasting theoretical positions. Merryman and Restle (1970) ostensibly have conducted one such investigation, in which the direction and amount of distortion found with the Baldwin figure was correctly predicted by an adaptation-level theory account of this illusion, while contrary predictions from physiological contour repulsion interpretations of the illusions, notably that of Ganz (1966), were not fulfilled.

As the stimulus for their investigation, Merryman and Restle (1970) used the Baldwin illusion shown in Figure 1. In this figure, the hash mark (h) divides a horizontal line into two equal segments,  $X_1$  and  $X_2$ . According to adaptation-level theory, both the larger box ( $B_1$ ) and the smaller box ( $B_2$ ) should influence the apparent lengths of both  $X_1$  and  $X_2$ . This theory would predict that  $X_1$ , being affected more by the adjacent larger box ( $B_1$ ), should appear shorter than  $X_2$ , which is affected more by the smaller box ( $B_2$ ). If this is so, then the hash mark (h) should be judged as closer to the larger box, so that phenomenally  $X_2$  will be greater than  $X_1$ . In contrast, contour repulsion theory would predict that the larger box should produce a greater field of inhibition than the smaller box. Phenomenally, the effect of this inhibition would be to repel the hash mark (h) more from the larger than the smaller box; hence,  $X_1$  should be judged to be greater than  $X_2$ .

Merryman and Restle (1970) obtained judgments of the extent and direction of the Baldwin illusion from 46 subjects. Results of their experiment agreed in detail with predictions from adaptation-level theory and were thus contrary to those predicted by contour repulsion theory. A second experiment by these authors confirmed the same finding and also successfully eliminated the possibility of giving an adequate account of the Baldwin illusion in terms of a three-dimensional perspective interpretation of the figure. In conclusion, Merryman

and Restle argued that illusions such as that obtained with the Baldwin figure can be characterized as depending upon size contrast, not contour repulsion mechanisms.

This conclusion followed logically from the experiment by Merryman and Restle, but it can be questioned whether the rejected contour repulsion explanation was really a viable alternative theory to explain the Baldwin illusion with the figure drawn the size used in their experiment. Merryman and Restle recognized that Ganz (1966), in this theory, set out to explore the possibility that lateral inhibition may result in repulsion of contours separated by distances of less than 0 degrees 30 minutes of visual angle. However, the Baldwin figure used by Merryman and Restle had a horizontal line representing a visual angle of 2 degrees 30 minutes; therefore, all the distances between the hash mark and the contours of either box must have been greater than the distance over which effects from lateral inhibition are predicted to operate. Contour repulsion explanations of the Baldwin figure based on physiological processes of lateral inhibition are therefore *prima facie* not applicable as explanations of this illusion when drawn with the boxes so far apart.

The experiment by Merryman and Restle (1970) does not, therefore, provide a critical test between the predictions of genuinely competing theories, as there are no grounds for expecting any outcome of the experiment other than that predicted from adaptation-level theory.

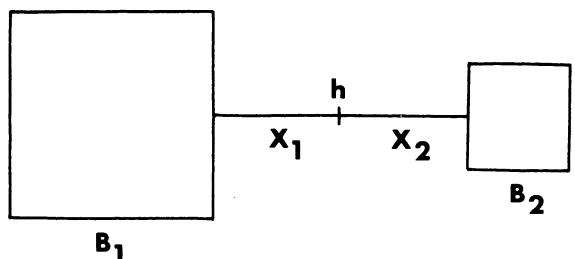


Figure 1. The Baldwin figure.

In order to investigate the possible effects of contour repulsion within the Baldwin figure in situations in which contour repulsion should have an effect on judgment, the present experiment explores the possibility that the Baldwin illusion may reverse as contour separation between the end boxes is reduced. Direction of the illusion in accord with adaptation-level theory was predicted when contour separation is large, but a reversal of the illusion was predicted from contour repulsion theory when the distance separating the end boxes of the Baldwin figure was reduced to subtend a visual angle of less than 0 degrees 30 minutes.

## METHOD

### Stimuli

Stimulus cards were prepared for presentation in one field of a simple tachistoscope having a binocular eyepiece mounted at a distance of 41 cm from the stimulus display. Thirty-two stimulus cards carrying different versions of the Baldwin figure were prepared in two series: 20 cards in Series A and 12 cards in Series B. For Series A, the horizontal line of the Baldwin figure was drawn to give the same visual angle as in the experiment by Merryman and Restle (1970), that is, 2 degrees 30 minutes, which was calculated to be 1.79 cm for the distance between the large and small boxes in the figure. For these end boxes, four large-to-small pairings of the boxes were selected giving size ratios corresponding to 8:6, 6:4, 8:4, and 8:2. The sizes of these boxes relative to the horizontal line were the same as in the experiment by Merryman and Restle. Five hash-mark positions were used; four corresponded to the positions selected by Merryman and, in order of distance from the left-hand box, were .65, .81, .98, and 1.14 cm. These four positions fell on either side of the midpoint of the horizontal line which was the position of the fifth hash mark. The ratios of boxes and hash-mark positions were combined factorially to give the 20 cards for Series A.

For Series B, the length of the horizontal line was reduced to .30 cm to give a visual angle of 0 degrees 25 minutes. This meant that none of the distances between the hash mark and the boxes ever subtended a visual angle of greater than 0 degrees 16 minutes, so, in theory, a strong contour repulsion effect would be expected between contours. The same four ratios of size of box were used as for Series A but, due to the shortness of the horizontal line, only three hash-mark positions were used. One was .12 cm and the other .18 cm from the left-hand box. The third position was again the midpoint at .15 cm from the left-hand box. A factorial combination of these hash-mark positions and ratios of boxes gave the 12 cards used in Series B.

On all cards the hash mark was .04 cm long and was bisected by the horizontal line. The Baldwin figure was drawn in the exact center of each card, so that every card could be presented with the larger box to the right or, when inverted, to the left.

### Procedure

Twenty-four volunteer subjects of both sexes with normal or corrected-to-normal eyesight were tested individually. Each subject was given a pencil and a response sheet carrying 64 rows of digits from 1 to 6. Subjects were then told that the task was to judge the position of the hash mark on the horizontal line by circling a "1" on the response sheet when they judged the hash mark to be quite a bit to the left of the center and circling a "6" when the mark was quite a bit to the right. The intermediate response positions, two to five, were to be used for intermediate positions. Even if a hash mark looked to be in the center, subjects were forced to make a choice between left or right of center by the lack of a central response category.

Subjects were next shown demonstration cards containing examples of all the hash-mark positions and made a number of practice judgments. Half the subjects were then presented with all the cards in Series A before Series B, and the other half of the subjects with Series B before Series A. Each individual card was presented twice, one presentation being the inversion of the other. A separate random order of presentation of the cards within each series was employed with each subject. Although cards were presented in a tachistoscope, the subjects controlled the exposure duration for each card by holding down a button until the judgment had been made. When all 64 judgments had been made, the entire procedure was repeated, each subject making a further 64 judgments in exactly the same way, but with cards within a series presented in a new random order. The first and second sets of presentations were designated Trials 1 and 2.

## RESULTS

Following the pattern of data analysis used by Merryman and Restle (1970), the displays in each condition may be paired such that within each pair the hash mark is located in the same place, the boxes are of the same ratio of sizes, but only the position of the larger box (left or right of the smaller) is different. The response to the first display of a pair, with the larger box on the left, was called  $R_1$  and the response to the second display of that pair, with the larger box on the right, was called  $R_2$ . Because the subjects' scores of one to six ran from left to right on the response sheet, it follows that the mean of the discrepancy  $R_2 - R_1$  for all judgments would be positive if the hash mark was judged nearer the larger box (in accordance with adaptation-level theory) and negative if the hash mark was displaced toward the smaller box (as predicted by contour repulsion theory). A zero score for  $R_2 - R_1$  indicated that subjects judged no systematic illusion.

Preliminary analysis of results indicated that order effects (Series A before B or vice versa) and differences in ratios of sizes of boxes had no statistically significant effect on judgments, though in Series A the illusion tended to be stronger with larger ratios of size of box, as found by Merryman and Restle (1970). Data were thus combined so that, for each subject over all 40 judgments in Series A and over all 24 judgments in Series B, a mean  $R_2 - R_1$  score was obtained as a negative, positive, or zero score. Table 1 shows the distribution of these

Table 1  
Distribution of Subjects Showing a Positive or a Negative Illusion

Figure	Trials	Distribution of Subjects (N = 24)			
		Positive	Negative	Zero	Sign Test
Series A*	1	18	5	1	p < .05
	2	17	6	1	p < .05
	1 + 2	17	6	1	p < .05
Series B**	1	9	10	5	n.s.
	2	15	6	3	n.s.
	1 + 2	12	10	2	n.s.

\*Large Baldwin figure

\*\*Small Baldwin figure

**Table 2**  
**Distribution of Subjects Showing a Positive or a Negative Illusion for Central Hash-Mark Conditions Only**

Figure	Trials	Distribution of Subjects (N = 24)				Sign Test
		Positive	Negative	Zero		
Series A*	1	18	1	5	p < .01	
	2	18	4	2	p < .01	
	1 + 2	21	2	1	p < .01	
Series B**	1	4	15	5	p < .05	
	2	5	15	4	p < .05	
	1 + 2	4	16	4	p < .05	

\*Large Baldwin figure

\*\*Small Baldwin figure

scores for all 24 subjects in each condition along with sign tests to show if the distributions of types of scores were significantly uneven.

A second analysis was carried out using only the data from the eight judgments in Series A and the eight judgments in Series B when the hash mark was actually in the central position and subjects had been forced to decide on a right or left displacement of the hash mark by the lack of a central category in the response scale. Table 2 shows the distribution of mean  $R_2 - R_1$  scores for all 24 subjects in each condition along with sign tests to show if the distribution of different types of scores were significantly uneven.

## DISCUSSION

With the Baldwin figure drawn to subtend the same visual angle as in the study by Merryman and Restle (1970), a positive illusion was obtained in exactly the same direction as in the former study. The hash mark was phenomenally displaced toward the larger box, as was predicted by adaptation-level theory. A significant number of subjects judged the illusion in this direction irrespective of the position of the hash mark on the horizontal line (Table 1, Series A); however, an even more certain illusion in this direction was found when judgments were considered only for those trials with the physically central hash mark (Table 2, Series A). When the Baldwin figure was redrawn to give a horizontal line subtending a visual angle of only 0 degrees 25 seconds, it was found that no consistent illusion was obtained when the hash mark was drawn in a variety

of positions along the horizontal line (Table 1, Series B); however, a significant reversal of the illusion was found when only those judgments made with a central hash mark were considered (Table 2, Series B). The predictions of the experiment were thus largely met. If the dimensions of the Baldwin figure are reduced to those in which contour repulsion effects are predicted to operate, a significant reversal of the typical illusion can be obtained.

The reason both positive (Series A) and negative (Series B) illusions were experienced more often when judgments were made with a central hash mark probably stems from the fact that subjects found the task of making judgments more meaningful with the hash mark in this position. Subjects appeared to take more time and care with these judgments, possibly influenced by the wording of the instructions, which encouraged subjects to consider judgments as deviations from the midpoint. Objectively, central hash-mark judgments would also appear to be less dependent upon the experience of using the response scale, thereby making them more reliable. A hash mark at almost the apparent midpoint must definitely be anchored to points "3" or "4" on the response scale given to the subject, while less obviously specific scale points apply to other hash-mark positions, leading to greater variability in their judged positions.

In general, the implications of this experiment are to highlight the conclusion that different perceptual mechanisms ranging from physiologically definable mechanisms, like lateral inhibition, to more judgmental size contrast mechanisms, such as those entailed in adaptation-level theory, may all give rise to illusory perception under different conditions. This experiment serves to illustrate that, even with the same figure, different explanatory mechanisms may be needed to explain changes in the illusion that can occur with variations in design of the figure. A single theory of visual illusions resting on a single explanatory principle will almost certainly prove untenable in explaining all geometrical-optical illusions.

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