Differences in heaviness in relation to density and weight[1]

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Eight Ss (Group L) judged differences in heaviness between all pairs of stimuli in three series of five weights each, in the range of 100-300 g, presented randomly. Series L varied in weight and density, Series LVW varied only in weight, and Series LVD varied only in density. Another eight Ss (Group H) judged heaviness differences between all pairs of stimuli in three similar series (H, HVW, and HVD) in the range 700-900 g. Differences in density alone yielded relatively greater impressions of difference in heaviness in Group H than in Group L. Predictions from Ross and Di Lollo's vector theory were confirmed.

Ross and Di Lollo (1968) suggest that a difference in density contributes more to an impression of difference in weight for stimuli of high density than it does for stimuli of low density, at least for hand-sized stimuli in the range of 100-900 g. The suggestion is incorporated in a detailed formal model developed to explain the results of a systematic study of magnitude estimation with lifted weights.

The study reported here is designed as a direct test of the effect of differences in density of constant-weight stimuli on judgments of differences in weight in two density ranges, one high and one low. If density becomes more influential in the determination of perceived heaviness as it increases in magnitude, the same density difference should produce a greater impression of weight difference with high-density stimuli than with low-density stimuli.

METHOD

Stimulus Objects

Six series of five weights each were constructed from 2-in. aluminum tubing, sealed at both ends with aluminum disks. Variations in heaviness were obtained by symmetrically placed cylindrical metal inserts glued inside each weight to minimize bottom heaviness and other intertrial characteristics. There were three series of light weights and three series of heavy weights. Within the light set, the stimuli in the first series (Series L) varied with respect to both weight and density; the second series (Series LVW) varied only in weight, and the third series (Series LVD) varied only in density. Uniformity in density was obtained by varying the height of each stimulus object as shown in Table 1, which gives the relevant dimensions for each stimulus object in each of the series mentioned above as well as for the corresponding series (H, HVW, HVD) from the heavy set.

Subjects and Procedure

Sixteen students, chosen haphazardly from a senior psychology class at the University of Western Australia, were allocated randomly to two groups of eight Ss each. The Ss in Group L judged differences between all stimuli in Series L, LVW, and LVD, and the Ss in Group H judged Series H, HVW, and HVD. At the beginning of the experimental session, each S was seated at a table facing E and was read the following instructions:

"You will be presented with a series of weights. The weights will be presented in pairs. Each time I put a weight in your hand, I would like you to look at it while lifting it once and then putting it down. You should lift the weight with a motion of the hand and wrist only, leaving your forearm resting on the table.

"I would like you to judge the difference between the pair of weights, but in doing this, I do not want you to use ounces, or pounds, or grams, or any other standard measure of weight. Instead, I would like you to use numbers. To begin with, I will give you one single weight which you will call 100. After having judged the first single weight, all other weights will be presented in pairs. You are to judge the difference between the two weights in each pair. If the difference is twice as great as the heaviness of the first weight, you should say 200, and if it is half as great you should say 50, and so on. Your judgment of the difference between the weights in each pair should be proportional to the first weight. Do not hesitate to use numbers such as 72 or 217 and so on if they are the ones which best describe your judgment of the difference.

"Remember: You will judge one single weight and then many pairs of weights. You will call the first weight 100, and you should then judge the difference between the two weights in each subsequent pair in terms of the very first weight, which you called 100. You should look at each weight as you lift it."

The standard stimulus for Group L was the middle stimulus object in Series L, which was common to Series L, LVW, and LVD (Table 1). The standard stimulus for Group H was the middle stimulus in Series H.

Since the middle stimulus was the same in each series within the light and heavy stimulus sets (Table 1), there were 13 different stimuli yielding 156 ordered comparisons within the three series in each set. Each S made all 156 judgments in the relevant set in a random sequence that was separately determined for each S by a PDP-6 digital computer. During the testing session, all stimulus objects were out of S's sight except for the pair being judged.

Table 1
Weight (W), Height (H), and Density (D) for Each Stimulus Object in Each Series

Series	Dimension	Stimulus Objects 1	2	3	4	5
L	W (g)	100.00	150.00	200.00	250.00	300.00
	H (cm)	8.00	8.00	8.00	8.00	8.00
	D (g/cm^3)	.62	.93	1.24	1.55	1.86
LVW	W	100.00	150.00	200.00	250.00	300.00
	H	4.00	6.00	8.00	10.00	12.00
	D	1.24	1.24	1.24	1.24	1.24
LVD	W	200.00	200.00	200.00	200.00	200.00
	H	16.00	10.60	8.00	6.40	5.30
	D	.62	.93	1.24	1.55	1.86
H	W	700.00	750.00	800.00	850.00	900.00
	H	8.00	8.00	8.00	8.00	8.00
	D	4.32	4.63	4.94	5.25	5.56
HVW	W	700.00	750.00	800.00	850.00	900.00
	H	7.00	7.50	8.00	8.50	9.00
	D	4.94	4.94	4.94	4.94	4.94
HVD	W	800.00	800.00	800.00	800.00	800.00
	H	9.14	8.53	8.00	7.52	7.10
	D	4.32	4.63	4.94	5.25	5.56

RESULTS AND DISCUSSION

Figure 1 shows the average judgments of differences in weight over Ss and comparisons for each step size within each series. A step size of 1 in Fig. 1 refers to

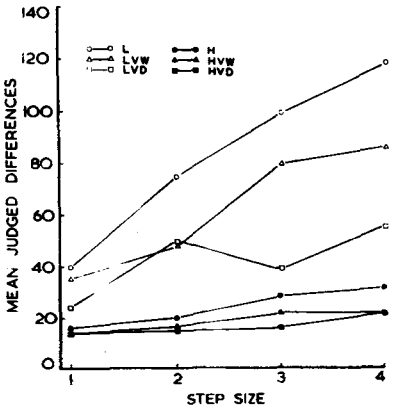

Fig. 1. Mean judged differences at each step size for each series. See text for explanation.

the mean of all ordered comparisons between Stimuli 1-2, 2-3, 3-4, and 4-5, where the numerals refer to the stimulus objects described in Table 1; similarly, a step size of 2 refers to Comparisons 1-3, 2-4, and 3-5; and so on for the other step sizes.

The curves for Conditions LVW and LVD are further apart than the corresponding conditions, HVW and HVD, particularly for the larger step sizes. Figure 2 reports the results averaged over Ss and step sizes for each condition. A Ss by conditions analysis of variance on the scores represented in Fig. 2 yielded significant effects for groups [$F(1,14) = 31.11$, $p < .001$], conditions [$F(2,28) = 44.29$, $p < .001$], and the Groups by Conditions interaction [$F(2,28) = 22.59$, $p < .001$]. A further analysis based only on Conditions VW and VD for both groups confirmed the interaction effect [$F(1,14) = 34.73$, $p < .001$]. Individual scores were calculated by expressing judgments for Series LVD and HVD as a proportion of judgments for Series LVW and HVW, respectively: the two sets of scores differed significantly [$F(1,14) = 8.05$, $p < .02$], showing that the interaction effects obtained in the previous analyses were not an artifact produced by the size of the numbers used by the two groups.

Density differences in the range of Series H are not only mistaken for weight differences, but are judged to be almost as great as differences produced by real differences in weight. Since Ss in this study were asked to judge difference in weight, the findings confirm the assumption made by Ross and Di Lollo (1968) that density comes to exert increasing control over judgments of the weight of stimuli as it increases in magnitude. If the model proposed by Ross and Di Lollo approximates the truth, it may be said that heaviness (the impression of weight) is *defined* predominantly in terms of weight for low-density stimuli and increasingly in terms of density for higher-density stimuli. If so, the well known size-weight illusion may depend upon variation in the subjective definition of weight. An important methodological implication is that psychophysical findings about lifted weights may be specific to the *size* (and even the structure) of the stimuli used.

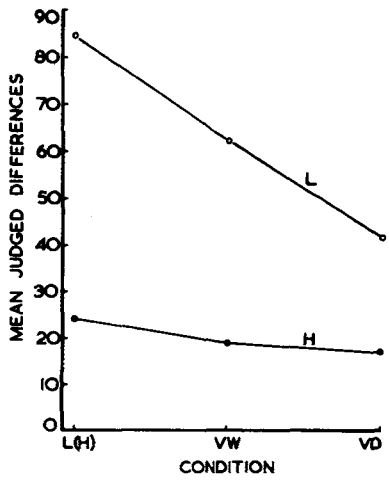

Fig. 2. Mean judged differences for each series in the light and the heavy stimulus sets.

REFERENCE

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NOTES

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