METHODOLOGICAL STUDIES OF SIZE CONSTANCY (1): SIZE CONSTANCY MEASURED BY TWO EXPERIMENTAL METHODS

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A classification is given between size constancy in two stimuli comparison situation and size constancy in single stimuli situation. Both types of size constancy are compared experimentally. Results are: (a) Constancy of perceived size in single stimuli situation is higher than that of perceived size in two stimuli comparison situation. (b) In two stimuli comparison situation, the effect of change in observational conditions is predominant, whereas in single stimuli situation it is not so. (c) Constancy of familiar object is higher than that of unfamiliar object.

As an object moves away from an observer, its perceived or apparent size remains constant, though its proximal or retinal size decreases. This phenomenon has been called *size constancy*.

The first experimental study on size constancy was made in Wundt's laboratory by Martius in 1889 (Boring, 1942). Since this experiment, there have been many experimental works on this problem. As a consequence of these investigations, we have now a number of informations concerning size constancy, including depth and distance perception (Graham, 1951; Epstein, Park & Casey, 1961).

Despite such informations, however, the problem of size constancy is not fully clarified. This may primarily be due to operational definitions of the phenomenon in question. The present study was designed with respect to this point and hence was methodological.

TWO EXPERIMENTAL METHODS OF SIZE CONSTANCY

It is quite indispensable to describe two methods which specify operationally size constancy, in order to offer a methodological clarification. In such stimulus arrangements as are

found in Martius (1889) and Holway and Boring (1941), observer is always required to make comparative judgments between the standard and comparison stimuli presented at different distances. We shall refer to this type of size constancy as *size constancy by the method of two stimuli comparison* (or *size constancy in two stimuli comparison situation*). Here, the term "two stimuli" implies the standard stimulus and the comparison stimulus, respectively. Most of the experiments since Martius have been made by this method.

Is it possible, on the other hand, to say that size constancy of familiar objects seen in our everyday life is identical with the size constancy demonstrated in two stimuli comparison situation? Is it possible to say that size constancy of single object, e.g., matchbox, cigarette, playing-card, etc., is in the line of constancy of the matched size in traditional laboratory-experiments? From a methodological point of view, answers to these questions must be negative. Size estimation of familiar objects can operationally be made by so-called single or absolute stimuli judgments. Therefore, we shall refer to this type of constancy as *size constancy by the method of single stimuli* (or *size constancy in single stimuli situation*). Several experimental studies have been done concerning perceived or esti-

TABLE 1
The structure of the comparison stimulus series (in cm) at each
comparison distance

Stimulus series	Distance				
	100 cm	300 cm	400 cm	500 cm	600 cm
S_1	4.5	15.5	21.0	26.5	32.0
S_2	5.0	15.0	20.0	25.0	30.0
S_3	5.5	14.5	19.0	23.5	28.0
S_4	6.0	14.0	18.0	22.0	26.0
S_5	6.5	13.5	17.0	20.5	24.0
S_6	7.0	13.0	16.0	19.0	22.0
S_7	7.5	12.5	15.0	17.5	20.0
S_8	8.0	12.0	14.0	16.0	18.0
S_9	8.5	11.5	13.0	14.5	16.0
S_{10}	9.0	11.0	12.0	13.0	14.0
S_{11}	9.5	10.5	11.0	11.5	12.0
S_{12}	10.0	10.0	10.0	10.0	10.0
S_{13}	10.5	9.5	9.0	8.5	8.0

mated size of familiar objects seen in our everyday perceptual situation (Makino, 1954; Brunswik, 1956; Bolles & Bailey, 1956; Mckennell, 1960). However, systematic studies of this type of size constancy are few, compared with those by the method of two stimuli comparison.

The present works were planned to compare size constancy by the method of two stimuli comparison with that by the method of single stimuli. Size constancy in two stimuli comparison situation was investigated in Experiments I, III and IV. Experiments II and V dealt with size constancy in single stimuli situation.

EXPERIMENT I

The principal purpose of the present experiment consisted in obtaining data by the method of two stimuli comparison. Two-dimensional unfamiliar object was used as stimulus-object.

Observers: Six undergraduate students, majored in psychology at Osaka City University, served as *Os*. All had normal vision or were corrected normal. Three of them participated in Exp. I first and Exp. II second; the other three *vice versa*.

Stimuli and Stimulus Arrangements: A white cardboard disk was selected as a sample of two-

dimensional *unfamiliar* object. The standard stimulus (S_s) was a white cardboard disk, 10 cm in diameter and was always placed at 200 cm (D_s) away from *O*. The comparison stimuli (S_c) consisted of the same kind of white cardboard disk as S_s . Presentation distances (D_c) of S_c from *O*, located at right side of S_s , were 100, 300, 400, 500 and 600 cm. The angular separation between S_s and S_c was $18^\circ 55'$. Fig. 1 shows the stimulus arrangement employed.

FIG. 1. The layout of stimulus arrangement.

TABLE 2 (Exp. I)
Perceived size (in cm) as a function of distance under
three sets of observational conditions

Observational conditions	Distance				
	100 cm	300 cm	400 cm	500 cm	600 cm
Binocular	8.2(0.64)	11.7(0.45)	13.5(1.56)	14.3(0.84)	16.4(1.92)
Monocular	7.4(0.58)	12.3(1.46)	15.3(2.24)	16.8(2.75)	19.2(2.97)
Monocular (reduction-tube)	7.3(0.64)	13.4(1.23)	16.5(1.90)	18.8(1.30)	21.6(3.65)

The series of S_c using at each D_c , is shown in Table 1. This type of S_c series was designed to cover completely the whole range between two boundary laws, i.e., the law of size constancy and the law of the visual angle, throughout all the D_c s¹. Under the present condition, the law of size constancy is $S_c=10$, where 10 represents the diameter (in cm) of S_s . On the other hand, the law of the visual angle is $S_c=10 \times D_c/200=D_c/20$, where 10 represents the diameter of S_s and 200 represents the presentation distance of S_s . Therefore, it follows from this that the stimuli denoting by S_2 in Table 1 are in accord with the law of the visual angle, and that the stimuli denoting by S_{12} correspond to the law of size constancy. Both S_s and S_c were attached to metallic rods and were fixed at O 's eye-level, 125 cm in height.

Two projectors were employed to illuminate S_s and S_c . Illumination was adjusted by means of two voltage-regulators, and hence brightnesses of the two stimuli were always identical throughout the experiments.

Procedure: The O sat in front of a table and placed his head on the chin rest. Observations were always made through an aperture (8.5 cm in height and 30 cm in width), located at 46 cm away from O 's eye. The O was instructed to observe the apparent size relation between S_s and S_c , and to judge each of the S_c s in terms of 9 response categories: "very, very large" (9), "very large" (8), "large" (7), "slightly large" (6), "equal" (5), "slightly small" (4), "small" (3), "very small" (2), and "very,

very small" (1). The numerals assigned to these categories were used to compute the PSEs. The order of presentation of S_c was random, and the experimental order of D_c was also random. Each S_c was presented 5 times after two preliminary judgments for each of 13 S_c s at each D_c . Hence, the O judged 65 times for each comparison distance. Calculation of the PSEs was made by a short method for estimating the adaptation-level (Helson & Himelstein, 1955).

Three sets of observational conditions were employed; binocular regard, monocular regard and monocular regard through a reduction-tube (4.5 cm in diameter and 28 cm in length). For all the regards, the O was allowed to move his eye from S_s to S_c or from S_c to S_s . At each D_c , the order of observation was random. The length of time taken for size judgment was not restricted. All of the experiments were carried out in a dark room.

Results and Discussion: Data obtained are expressed in terms of the average values of the PSEs of six O s and shown in Table 2. Values parenthesized represent the SD s. Table 2 indicates that the matched sizes under binocular observation tend toward the law of size constancy and gradually approach the law of the visual angle according to successive elimination of distance cues.

It is known that the functional relation between apparent or perceived size (S_c) and physical or viewing distance (D_c) is expressible in the following equational form:

$$S_c = K D_c^n \quad (1)$$

where K is a constant and n represents the

¹ For a detailed discussion of this type of the comparison stimulus series, see Ueno (1962).

TABLE 3

Exponents (n) of perceived size, values of $1-n$ and coefficients of correlation (r), which are calculated from the data in Table 2

Observational conditions	n	$1-n$	r
Binocular	0.371	0.629	0.993
Monocular	0.526	0.474	0.996
Monocular (reduction-tube)	0.599	0.401	0.999

TABLE 4 (Exp. II)

Perceived size (in cm) as a function of distance under three sets of observational conditions

Observational conditions	Distance				
	100 cm	300 cm	400 cm	500 cm	600 cm
Binocular	10.0(1.82)	12.8(1.99)	14.3(1.45)	14.6(3.41)	16.4(3.66)
Monocular	8.9(1.40)	13.1(2.11)	14.6(2.25)	16.3(4.01)	17.9(5.15)
Monocular (reduction-tube)	9.4(1.88)	14.2(3.29)	15.3(3.20)	16.7(4.27)	20.7(7.68)

exponent relating apparent size to physical distance².

Equation (1) indicates a straight line, plotted in log-log coordinates, and its slope is determined by n . If Equation (1) holds in the present stimulus arrangement, the law of size constancy is obtainable when $n=0$, and the law of the visual angle when $n=1$. Therefore, it can be said that the exponent n is inversely related to the Brunswik-Thouless index ($\mathcal{Z}$). As a matter of fact, the following relation has been found between n and $\mathcal{Z}$: $\mathcal{Z}=1-n$ (Leibowitz, 1956; Ogasawara & Mori, 1959; Oldfield, 1960; Kuroda, 1961).

We shall now assume for a first-order approximation, perceived size is a power function of physical distance. In Fig. 2, logarithms of the diameter of the matched comparison stimuli are plotted against logarithms of the corresponding comparison distance. Three straight lines running among the dots in Fig. 2 are estimated

from the data given in Table 2 by the method of least-squares. In the figure, the law of size constancy is shown by $\log Sc = \log 10$, whereas the law of the visual angle $\log Sc = \log Dc - \log 20$. These two laws can be derived from taking logarithms of both sides of $Sc=10$ and $Sc=Dc/20$. The exponent n , the corresponding $1-n$ and coefficients of correlation r as a indicator of goodness of fit, are shown in Table 3. As is clear from the r s, the fits are fairly good. Statistically significant differences exist among three obtained n s ($F=22.95$, $df=2/9$, $p<0.01$).

Perceived sizes obtained under three conditions of observation are intermediate between the law of size constancy and the law of the visual angle. This finding agrees with the facts discovered by many workers (e.g., Holway & Boring, 1941; Makino, 1956; Makino & Ueno, 1959; Kuroda, 1961; Ueno, 1962). However, it should be noted that, in this experiment, the change in observational conditions has some effects on apparent or perceived size. As shown in Table 3, the calculated n s vary from 0.371 under binocular vision to 0.599

² For some problems on the relationship between apparent size and physical distance, see Makino (1956), Makino and Ueno (1959), Kuroda (1961), Oyama (1959) and Ueno (1962).

FIG. 2. The functional relation between perceived size and physical distance. The solid lines are the best-fitting curves by the method of least squares, the circles represent perceived sizes as follow: open circles, data under binocular observation; black circles, data under monocular observation; circles with bars, data under monocular observation through reduction-tube.

under monocular vision through reduction-tube. This variation is quite large compared with that in single stimuli situation in Experiment II, which will be seen later (see Tables 3 and 5). Methodologically, it seems that this finding is highly important.

EXPERIMENT II

In Experiment II, size constancy in single stimuli situation is investigated by employing the same observer and the same stimulus-object as in Experiment I in order to compare size constancy by the method of two stimuli comparison with that by the method of single stimuli.

Observers: All six observers were common with Exp. I. Three of them participated in Exp. I first and Exp. II second; the other three in the reverse order.

Stimuli and Stimulus Arrangements: The stimulus series employed was identical with S_c series in Exp. I (see Table 1). The stimuli were presented at distances and locations as S_c in Exp. I (see Fig. 1).

Procedure: Such an unfamiliar object as white cardboard disk does not possess any fixed subjective size, i.e., the so-called *assumed size* (Hastorf, 1950) or *assumed objective referent* (Ittelson, 1951), and therefore, is very difficult to judge its size by the method of single stimuli. In order to solve this difficulty, the O was required to hold a cardboard disk (10 cm in diameter) in his right hand to increase his own *manipulative familiarity* (Bolles & Bailey, 1956). This manipulated disk was identical with the S_s employed in Exp. I. The O judged each of the stimuli in terms of 9 adjective categories ranging from "very, very large" (9), through "equal" (5), to "very, very small" (1). In this case, it was particularly emphasized that the O should judge each stimulus, referring to the stimulus size held in his hand. The rest of the procedure was the same as in Exp. I.

Results and Discussion: Data obtained are expressed by the average values of six O s and shown in Table 4. Values in parentheses indicate the SD s. The similar tendency found in Experiment I is seen again in Table 4. Let us assume that the power function expressed in terms of Equation (2) be applicable to the single stimuli data in Experiment II.

$$S = K D^{n'} \quad (2)$$

where K is a constant and n' represents the exponent relating perceived size (S) to physical distance (D).

In Fig. 3 logarithms of perceived size were plotted against logarithms of physical distance. In this experiment, the law of size constancy can be expressed by $\log S = \log 10$, where 10 represents the diameter (in cm) of the stimulus being held in O 's hand. Now, the question at issue is concerned with the law of the visual angle. Is the law of the visual angle in Experiment II expressible by the same way as in Experiment I? Strictly speaking, it is not. If, however, a reference point is chosen, then the law can be determined. The law of the visual angle shown in Fig. 3 is expressed in terms of $\log S = \log D - \log 10$. This can be derived from taking a stimulus,

TABLE 5

Exponents (n') of perceived size, values of $1-n'$ and coefficients of correlation (r), which are calculated from the data in Table 4

Observational conditions	n'	$1-n'$	r
Binocular	0.261	0.739	0.988
Monocular	0.382	0.618	0.998
Monocular (reduction-tube)	0.401	0.599	0.979

FIG. 3. The functional relation between perceived size and physical distance. The solid lines are the best-fitting curves, the circles represent perceived sizes as follows: open circles, data under binocular observation; black circles, data under monocular observation; circles with bars, data under monocular observation through reduction-tube.

10 cm in diameter at 100 cm, as a reference. Notice that slope of the law in question is always unity. Thus, it follows that the exponent n' in Equation (2) specifies two boundary laws in the same way as n in Equation (1). The values of n' , those of $1-n'$ and coefficients of correlation r are given in Table 5. The obtained r s indicate that the fitness is not so good as that in Experiment I.

Although the difference between the calculated n' s is statistically significant ($F=5.50$, $df=2/9$, $p<0.05$), the difference between three slopes is small, as is clear from Fig. 3. The range of variation of

n' from 0.261 under binocular condition to 0.401 under reductive condition, is fairly small compared with that in Experiment I (see Tables 3 and 5).

As expected, three n' s obtained in Experiment II are significantly smaller than the corresponding n s obtained in Experiment I (for binocular regard, $F=9.86$, $df=1/6$, $p<0.05$; for monocular regard, $F=17.54$, $df=1/6$, $p<0.01$; for monocular regard through reduction-tube, $F=15.31$, $df=1/6$, $p<0.01$). This implies that perceived size in single stimuli situation (Experiment II) shows higher constancy than that in two stimuli comparison situation (Experiment I).

EXPERIMENT III

In Experiments III and IV, two stimuli comparison experiments are conducted with different kinds of stimulus-objects in order to examine the effects of the nature of stimulus-objects on size constancy. Three-dimensional familiar and unfamiliar objects were used as stimulus-objects.

Observers: Seven undergraduate students served as Os. They all had normal vision or were corrected normal.

Stimuli and Stimulus Arrangements: A cigarette-box "Peace" as a sample of three-dimensional *familiar* object was chosen. The normal (or standard) size of the cigarette-box is 7.1 cm in height, 4.3 cm in width and 1.7 cm in depth, and its color is dark blue. The series of the cigarette-box stimuli were made from photographic prints.

In the first session of this experiment, the standard stimulus (S_s) was the normal size

TABLE 6 (Exp. III)
Perceived size (in cm) as a function of distance under two
sets of observational conditions

Standard stimuli	Size	Observational conditions	Distance			
			150 cm	250 cm	350 cm	450 cm
Cigarette-box	7.1 cm	Binocular	6.5(0.31)	6.8(0.27)	7.1(0.21)	7.8(1.05)
		Monocular	6.3(0.84)	6.6(0.48)	7.1(0.42)	8.7(1.22)
White-box	7.1 cm	Binocular	6.1(0.41)	6.4(0.41)	7.1(0.42)	7.7(0.84)
		Monocular	5.5(0.74)	6.2(0.25)	7.2(0.42)	8.7(1.26)

TABLE 7
Exponents (n) of perceived size, values of $1-n$ and coefficients of
correlation (r), which are calculated from the data in Table 6

Standard stimuli	Observational conditions	n	$1-n$	r
Cigarette-box	Binocular	0.154	0.846	0.944
	Monocular	0.265	0.735	0.886
White-box	Binocular	0.211	0.789	0.963
	Monocular	0.402	0.598	0.966

FIG. 4. The functional relation between perceived size and physical distance when using normal cigarette-box as the standard stimulus.

cigarette-box, 7.1 cm in height. The comparison stimuli (S_c) consisted of nine cigarette-boxes: 4.9, 5.3, 5.9, 6.5, 7.1, 7.8, 8.6, 9.5 and 10.4 cm in height, and needless to say their width and depth are proportional to their height. This

series is geometric and its ratio is approximately 1.10.

In the second session, a white cardboard box was used as a sample of three-dimensional *unfamiliar* object. Physical dimension of the standard and comparison boxes (S_s' and S_c') was the same as the above-mentioned cigarette-boxes.

Presentation distance of S_s (or S_s') was always 300 cm (D_s or D_s') from O . And S_c (or S_c') which was placed to the right of S_s (or S_s'), was presented at 150, 250, 350, and 450 cm (D_c or D_c'). Both S_s (or S_s') and S_c (or S_c') were attached to the metallic rods as employed in Exp. I and fixed at O 's eye-level, 125 cm in height. The angular separation between S_s (or S_s') and S_c (or S_c') was $18^\circ 55'$. Accordingly, the present stimulus arrangement was quite similar to that in Exp. I, though the distances adopted were different.

Procedure: The essential part of the procedure was identical with Exp. I.

Results and Discussion: The average PSEs and the SDs are shown in Table 6. Values parenthesized represent the SDs.

Fig. 5. The functional relation between perceived size and physical distance when using white cardboard box.

We assume again that Equation (1) holds for the data obtained in Experiment III as in Experiment I. In Figs. 4 and 5, matched size is plotted against physical distance in log-log coordinates. In both figures, the law of size constancy and the law of the visual angle are expressed in terms of the same way as in Experiment I. The exponent n , the corresponding $1-n$ and coefficients of correlation r are given in Table 7. The calculated rs indicate that fitness of Equation (1) to the monocular data of cigarette-box is not so good.

As shown in Figs. 4 and 5, perceived sizes are intermediate between the law of size constancy and the law of the visual angle as in Experiment I. Of particular importance is the finding that $1-n$ as to cigarette-box, as shown in Table 7, always appears larger than those of white cardboard box through two sets of observational conditions. In other words, constancy of familiar object is higher than that of unfamiliar object. However, further experimentation is needed in order to examine carefully the effect of stimulus-object in two stimuli comparison situation.

EXPERIMENT IV

Data obtained in Experiment III suggest that familiar object shows higher degree of constancy than unfamiliar object under binocular and monocular observation. Experiment IV was designed to confirm this finding.

Observers: All of seven observers were common with Exp. III.

Stimuli and Stimulus Arrangements: The familiar stimulus-object consisted of the same cigarette-box as employed in Exp. III. The standard stimulus in Exp. III was the normal size box, whereas in Exp. IV, a large cigarette-box, 10.4 cm in height was used as the standard stimulus (S_s). The series of the comparison cigarette-boxes (S_c) was as follows: 7.1, 7.8, 8.6, 9.5, 10.4, 11.4, 12.6, 13.8 and 15.2 cm in height. This series is geometric as in Exp. III and its ratio is 1.10.

The *unfamiliar* object was white cardboard box as in Exp. III. The dimensions of the standard box (S_s') and the series of the comparison box (S_c') were physically equal to those of S_s and S_c . The stimulus arrangement was exactly the same as that used in Exp. III.

Procedure: The task of O , the observational conditions, the order of presentation of the stimuli and the statistical treatment of data were identical with Exp. III.

Results and Discussion: The results of the present experiment, i.e., the average PSEs and the SD s, are shown in Table 8. In Figs. 6 and 7, the functional relations of perceived size to physical distance are represented by the same way as in Experiment III. The values of the exponent n , those of $1-n$ and coefficients of correlation r are given in Table 9. Goodness of fits is satisfactory, with an exception of the white cardboard box data seen monocularly.

Table 9 indicates that the results of Experiment IV are consistent with the facts found in Experiment III. Constancy of familiar objects is always higher than that of unfamiliar object through two conditions of observation as in Experiment III.

TABLE 8 (Exp. IV)
Perceived size (in cm) as a function of distance under two
sets of observational conditions

Standard stimuli	Size	Observational conditions	Distance			
			150 cm	250 cm	350 cm	450 cm
Cigarette-box	10.4 cm	Binocular	9.2(0.39)	9.5(0.41)	10.1(0.33)	10.8(0.97)
		Monocular	8.7(0.74)	9.5(0.43)	10.4(0.51)	11.9(1.29)
White-box	10.4 cm	Binocular	8.6(0.90)	9.5(0.37)	10.3(0.62)	11.3(0.99)
		Monocular	7.9(1.01)	9.2(0.45)	10.3(0.60)	12.8(2.11)

TABLE 9
Exponents (n) of perceived size, values of $1-n$ and coefficients of
correlation (r), which are calculated from the data in Table 8

Standard stimuli	Observational conditions	n	$1-n$	r
Cigarette-box	Binocular	0.142	0.858	0.958
	Monocular	0.272	0.728	0.964
White-box	Binocular	0.242	0.758	0.987
	Monocular	0.356	0.644	0.831

FIG. 6. The functional relation between perceived size and physical distance when using large cigarette-box as the standard stimulus.

Equation (1) holds well for the binocular data, but it does not always so for the monocular data as is clear from Figs. 4-7. It seems that other mathematical functions, e.g., linear function, may well be fitted

to the monocular data. Further researches would be required to this point.

EXPERIMENT V

In Experiment II, size constancy was investigated by the method of single stimuli using two-dimensional unfamiliar object. However, the procedure adopted was not necessarily the same one that was generally used regarding absolute or single stimuli judgments. The main purpose of Experiment V is to examine size constancy in single stimuli situation employing three-dimensional familiar object (cigarette-box), and to compare the obtained data with those in Experiment III.

Observers: All of the seven observers were common with Exps. III and IV.

Stimuli and Stimulus Arrangements: The cigarette-box series ranging from 4.9 cm to 10.4 cm in height was used. This series was the same as that of S_c in Exp. III. Presentation distance of the stimuli was ranging from 150 cm to 450 cm away from O .

Procedure: The O was told to judge each

stimulus in terms of 7 categories. In the instructions, it was emphasized that a judgment should be made referring to the cigarette-box of normal size. The observational conditions were binocular and monocular. All the experiments were carried out in the same dark room as in Exps. I-IV. Other aspects of the procedure were identical with Exp. II.

Results and Discussion: Data obtained from the present experiment are expressed in terms of the average values of seven Os and shown in Table 10. Values in parentheses indicate the *SDs*. In Fig. 8 perceived size was plotted against physical distance in log-log coordinates. Determination of the law of the visual angle, as is evident from Fig. 8, is based on a reference point; the normal cigarette-box at distance of 150 cm. We shall assume again the Equation (2) can be applied to the data in Experiment V. The exponent n' values, the corresponding $1-n'$ values and coefficients of correlation r are given in Table 11.

It is apparent from Fig. 8 that perceived size is almost held invariant under the change of distance. The effect of variation in observational conditions is surprisingly small. All perceived size is below the law of size constancy except one value. Otherwise expressed, "over-constancy" is found. This finding is consistent with Makino's results (1954). The obtained n' 's are approximately equal to zero, as shown in Table 11. Since perceived size as a whole exhibits a tendency to increase with increasing distance, calculation of n' yields positive values. The calculated $1-n'$ values indicate that perceived size shows nearly perfect constancy, though perceived size under monocular observation suggests slightly lower constancy than that under binocular observation.

The following can be found by comparing the data obtained in this experiment (single stimuli data) with those of cigarette-box in Experiment III (two stimuli comparison data): The degree of constancy of perceived size in single stimuli situa-

FIG. 7. The functional relation between perceived size and physical distance when using large white cardboard box.

tion is higher than that of two stimuli comparison situation: the effects of change in observational conditions is predominant with respect to perceived size in two stimuli comparison situation, but not in single stimuli situation. These findings support the results obtained in Experiments I and II.

DISCUSSION AND CONCLUSIONS

1. From the point of view of methodology, it is of importance to distinguish clearly between two types of size constancy. In the present study, one type of constancy is referred to size constancy by the method of two stimuli comparison, and another to that by the method of single stimuli. As already stated, the former is concerned with the size constancy demonstrated in traditional laboratory-experiments since Martius and the latter is related to constancy of familiar objects seen in our everyday life.

2. The data of Experiments I-V indicate that there are some interesting differences between two types of size constancy. The degree of constancy of perceived size obtained by the method of

TABLE 10 (Exp. V)
Perceived size (in cm) as a function of distance under two
sets of observational conditions

Observational conditions	Distance			
	150 cm	250 cm	350 cm	450 cm
Binocular	6.7 (0.36)	6.9 (0.55)	6.8 (0.57)	7.0 (1.17)
Monocular	6.7 (0.89)	6.8 (1.14)	6.9 (1.13)	7.3 (1.97)

TABLE 11
Exponents (n') of perceived size, values of $1-n'$ and coefficients of
correlation (r), which are calculated from the data in Table 10

Observational conditions	n'	$1-n'$	r
Binocular	0.032	0.968	0.943
Monocular	0.069	0.931	0.905

FIG. 8. The functional relation between perceived size and physical distance.

single stimuli (Experiments II and V) is in general higher than that by the method of two stimuli comparison (Experiments I, III and IV). The former is relatively invariant under the change of observational condition, but not the latter. Of particular interest is the fact that the findings obtained in single stimuli situation coincide with our own perceptual experience in ordinary life.

3. When considering the problem of size constancy, the concept of size is impor-

tant. A great deal of analysis, logical as well as experimental, has been aimed at clarifying the term 'size' (e.g., Helson, 1936; Boring, 1942; Joynson, 1949; Hastorf, 1950; Edwards, 1950; Ittelson, 1951, 1960; Gilinsky, 1951). The results of Experiments III and IV are linked closely with the concept of assumed size. In these experiments, it was demonstrated that constancy of cigarette-box was in general higher than that of white cardboard box. This interesting tendency, as an inference, is directly attributable to an effect which occurs as to the *assumed size* (Hastorf, 1950; Ittelson, 1951, 1960) or *subjective true size* (Gilinsky, 1951). The result may be regarded as an experimental analysis on assumed size.

4. One of the most fundamental problems on size constancy is the functional relationship between apparent or perceived size and viewing or physical distance. It is known that the power function expressed by Equation (1) fits well for two stimuli comparison data (e.g., Makino, 1956; Makino & Ueno, 1959; Kuroda, 1961; Ueno, 1962). The results in Experiments II and V also suggest that the power function expressed by Equation (2) holds for single stimuli data. This fact is important in deriving general function to express

the relation between perceived size and physical distance.

5. The essential difference between size constancy in two stimuli comparison situation and that in single stimuli situation is concerned with the problem of perceptual dimensions. As to what kinds of dimension refer to size constancy, no accurate determination can be made at present. It is quite certain, however, that according to Brand's system (1954), size constancy in two stimuli comparison situation refers to lower dimensions (e.g., the dimension Discrimination) than size constancy in single stimuli situation.

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(Received June 20, 1963)