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The influence of object familiarity on magnitude estimates of apparent size

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Abstract. Three magnitude-estimation experiments were used to determine the exponents of the power function relating size judgments and physical size for two-dimensional familiar and unfamiliar stimuli. The exponent of the power function was used to index the effect of familiar size on perceived size under a variety of conditions, from full-cue to reduced-cue viewing conditions. Although the value of the exponents varied across the three experiments, within each experiment the exponent of the familiar stimulus was not significantly different from that of the unfamiliar stimulus, indicating that familiar size does not influence the rate of growth of perceived size. The results of a fourth experiment excluded a possible explanation of the findings of experiments 1–3 in terms of subjects responding to relative angular size as a consequence of the successive presentation of the different-sized representations of the familiar stimulus. Taken together, the present findings are consistent with the hypothesis that the influence of familiar size on estimates of size mainly reflects the intrusion of nonperceptual processes in spatial responses.

1 Introduction

The influence of the familiar or assumed size of an object on estimates of object size is typically investigated by using off-size versions of familiar objects. In full-cue and, to a lesser extent, in reduced-cue viewing situations, such off-size familiar objects provide a conflict between familiar size, on the one hand, and the available visual and oculomotor information, on the other. With this design an effect of familiar size is demonstrated if size estimates of the off-size familiar object, relative to size estimates of an unfamiliar object of the same size as the off-size object, regress towards the normal size of the familiar object.

In general, the results of these cue-conflict studies (for reviews, see Epstein 1967; Sedgwick 1986) indicate that under a wide range of conditions familiar size can influence estimates of size. For example, in addition to the well documented familiar-size effects found under reduced-cue conditions (eg Fitzpatrick et al 1982; Gogel 1969; Higashiyama 1984; Schiffman 1967), in a number of studies (eg Franklin and Erikson 1969; Higashiyama 1984; Predebon 1979, 1987; Predebon et al 1974; Slack 1956) familiar-size effects have been obtained under binocular, full-cue, viewing conditions. It should be noted, however, that in a few studies an effect of familiar size has not been obtained under either full-cue (Fillenbaum et al 1965; Schiffman 1967) or monocular (Mershon and Gogel 1975) viewing conditions, and in some studies (eg Gogel 1969; Gogel and Da Silva 1987; Gogel and Newton 1969; Higashiyama 1984) conducted under certain reduced-cue conditions only weak familiar-size effects have been reported.

In the cue-conflict studies subjects are usually required to estimate the size of only one version of a particular familiar object, either a smaller-than-normal or a larger-than-normal sized object. A different approach to assessing the effect of object familiarity on perceived size is to determine the form of the function relating perceived size and physical size. Psychophysical judgments of many perceptual characteristics, including size, can be described by a power function of the form $J = kS^n$, where J is the psychological magnitude (eg apparent size), S is the physical magnitude (ie physical size), k is a constant defining the scale unit, and n is the exponent indicating the curvature of the function. In a number of studies (for reviews, see Baird 1970; MacMillan et al 1974) it has been shown that for unfamiliar two-dimensional stimuli the exponent for apparent size is in the region of 0.7 – 0.9, indicating that apparent size grows at a slower rate than physical size. No study, however, has examined the form of the power function for familiar two-dimensional stimuli.

In the first three of the four experiments reported here the exponent of the power function was used to index the effect of familiar size on perceived size. Specifically, if familiar size does not influence perceived size the exponent of the power function should be within the range of exponent values (0.7 – 0.9) for unfamiliar two-dimensional stimuli. Conversely, if perceived size is influenced by object familiarity the exponent of the power function should approach zero since perceived size will tend to be independent of the actual size of the familiar object, that is, the perceived sizes of smaller-than-normal and larger-than-normal size representations of the familiar object should regress towards the normal size of the object. In these three experiments the method of magnitude estimation popularized by Stevens (1957) was used to scale perceived size. The last experiment was similar to the cue-conflict studies in that subjects viewed only one representation of the familiar object. Taken together, the results of these experiments indicate that the function relating perceived size and physical size is unaffected by object familiarity and, more generally, that familiar size does not influence magnitude estimates of size.

A number of aspects of the procedure and data analyses of the first three experiments require clarification. First, in these experiments the method of magnitude estimation with a modulus (standard) was used. In a number of studies it has been reported that the absence or presence of a standard does not affect the exponent of the power function for a number of stimulus dimensions (eg distance; Da Silva 1985). Even so, since familiar but not unfamiliar objects have an internalized standard (ie a remembered size), it seemed prudent to use an explicit standard, as otherwise a difference in the exponents of the familiar and unfamiliar stimuli might be attributed to the presence/absence of an internalized standard rather than to an effect of familiar size on perceived size.

Second, the apparent size instructions used in these experiments were those typically used in the magnitude-estimation literature, and requested a judgment of the perceived size of the stimuli. There was an additional reason for obtaining apparent-size estimates rather than judgments of the physical or actual (objective) size of the stimuli. Teghtsoonian (1965) found that magnitude estimates of the size of circles are markedly influenced by instructions; apparent-size and objective-size instructions yielded exponents of 0.76 and about 1.00, respectively. The unity exponent under objective-size instructions was attributed to subjects' strategy of estimating the linear dimension of the stimuli. Since the main purpose of the present investigation was to scale perceived size, and not to evaluate subject's ability to estimate linear dimensions, apparent-size instructions were used. For this reason also, the data from those subjects who reported using a linear-dimension strategy were excluded from the data analysis.

Third, although the exponents of the power function were the data of primary interest, I also investigated possible differences between conditions in the multiplicative constant or scaling factor (k) of the power function. Since k is determined by the absolute size of numbers assigned to the stimuli (Gescheider 1988), it is possible that systematic differences between conditions might exist in the assignment of numbers and, hence, in the multiplicative constant, even though familiar size does not affect the exponent of the power function. Finally, the characteristics of the power function of each subject's magnitude estimations formed the basis for the statistical analyses reported here. However, to provide a descriptive indication of the shape of the function, I also present graphical plots of the group or average magnitude-estimations for each experimental condition.

2 Experiment 1

The purpose of experiment 1 was to assess the effect of object familiarity and viewing conditions on the exponent for size. Four different groups of subjects made magnitude estimates of the size of either a familiar or an unfamiliar patterned stimulus series under either monocular or binocular viewing conditions. In addition, all subjects made magnitude estimates of a control (unpatterned) stimulus series. The data from the control series condition were used to evaluate possible sampling differences among the four groups of subjects. Because large individual differences in the exponents for size and for other perceptual attributes have been noted by some investigators (eg Teghtsoonian and Teghtsoonian 1983) in the absence of the control condition data, any difference in the exponent values of the familiar and the unfamiliar patterned stimulus series could be attributed to sampling differences rather than to an effect of familiar size.

2.1 *Method*

2.1.1 *Subjects.* Forty undergraduate students served as subjects. All had normal or corrected-to-normal vision.

2.1.2 *Stimuli.* The stimuli were three sets of nine rectangular figures prepared from the same white photographic paper. The familiar stimuli were nine photographic reproductions of a nine-of-spades playing card, and the pattern stimuli were nine photographic reproductions of a white rectangle which had nine irregularly positioned and oriented black rectangles on its surface; the control stimuli were uniform white rectangles. Relative to a normal-sized card, N, (8.9 cm high and 5.7 cm wide), the sizes of the card, pattern, and control stimuli were $0.4N$, $0.55N$, $0.7N$, $0.85N$, N, $1.15N$, $1.3N$, $1.45N$, and $1.6N$. The standard figure for all three stimulus sets was the middle figure in the series (size N).

The stimuli were attached, one at a time, to a black painted wall, 2.5 m from the subject. For the binocular viewing condition, subjects viewed the stimuli with free-regard whereas for the monocular condition the subject's head was restrained in a head-rest and chin-rest device, and the stimuli were viewed (with the right eye) through a circular reduction tube which restricted the field of view of the black wall to a circular area approximately 1.5 m in diameter. Both for the binocular and for the monocular viewing conditions, the stimuli were viewed under normal fluorescent room illumination.

2.1.3 *Design.* There were four groups of ten subjects; two groups viewed the stimuli binocularly, and two monocularly. Each subject was tested twice over two sessions, once with either the pattern or the card stimulus series, and once with the control series. The interval between the two sessions was approximately 30 min. For each of the two binocular and two monocular viewing groups, one of the groups was presented with the card series in one session and with the control series in the other session, and the other group was presented with the pattern series in one session and the control series in the other. Within each group, the order of presentation of the two series was counterbalanced across the two sessions.

2.1.4 *Procedure and instructions.* The procedure and instructions were similar to those of Teghtsoonian's (1965) magnitude-estimation study on the apparent size of two-dimensional figures. In each session, subjects were first shown the standard. Subjects then made two judgments for each of the nine figures in the series including the standard figure; the standard was not identified in the test session. The figures were presented in random order, with the restriction that the standard could not be the first figure presented and that the same figure could not immediately follow itself. Thus, in each session, each subject made a total of eighteen judgments.

The apparent-size instructions were as follows:

"I am going to show you a series of patterns (cards), and I want you to tell me how big they look to you. First, I shall show you a pattern (card) whose size will be called 100, arbitrarily; then I'll show you others, and to each one I want you to assign a number which is proportional to its size as it appears to you. For example, a pattern (card) which looks twice as large as the one called 100 would be called 200, one which looks half as big would be called 50, and so on. Don't worry too much about being consistent or trying to remember what you assigned to a previous pattern; just judge each one as it comes along. Obviously there are as many numbers above 100 as you want to use, but there are also as many number below 100. Do you have any questions? (The standard was then displayed). This is the pattern (card) whose size is called 100. (The standard was then replaced by the first stimulus in the series.) If the first pattern (card) was 100, what would you call this one?"

After each judgment, the experimenter attached the next stimulus to the wall. During this time, subjects in the binocular conditions were required to close their eyes and face sideways; in the monocular condition, a screen in front of the reduction tube occluded the subject's view.

Preliminary work indicated that some subjects were likely to interpret the apparent-size instructions to mean judgments based on the linear dimensions (eg *height*, *width*) of the rectangular figures. Since the exponent for magnitude estimates of linear extent is close to 1.0 (eg Stevens and Guirao 1963; Teghtsoonian 1965) a finding that the exponent of the familiar (card) series is smaller than the exponent of the pattern series cannot necessarily be interpreted as an effect of familiar size on perceived size; rather, it might be attributed to the greater likelihood of an unfamiliar stimulus eliciting a linear-dimension judgment. Postexperimental interviews indicated that none of the subjects in the two binocular-viewing groups reported using a linear dimension strategy, whereas four subjects in the monocular card/control condition and three subjects in the monocular pattern/control condition did use this strategy. These subjects were replaced by an additional group of seven subjects.

2.2 *Results and discussion*

For each session, each subject's two judgments for each of the nine figures were averaged. The exponent (n) and the scaling constant (k) of the individual subject's power function were estimated from the slope and the y intercept, respectively, of the

Table 1. Means ± SE of the exponents (n), constants (k), and coefficients of determination (r^2) of individual best-fitting power functions: experiment 1.

Condition	k	n	r^2
Binocular			
Group 1: card/control			
Card series	5.71 ± 1.945	0.82 ± 0.072	0.962 ± 0.007
Control series	6.19 ± 1.601	0.78 ± 0.070	0.961 ± 0.006
Group 2: pattern/control			
Pattern series	5.65 ± 0.872	0.80 ± 0.086	0.964 ± 0.010
Control series	4.97 ± 1.024	0.81 ± 0.062	0.950 ± 0.013
Monocular			
Group 3: card/control			
Card series	3.67 ± 1.334	0.87 ± 0.067	0.960 ± 0.008
Control series	3.74 ± 0.815	0.83 ± 0.076	0.947 ± 0.009
Group 4: pattern/control			
Pattern series	5.85 ± 1.354	0.77 ± 0.076	0.956 ± 0.035
Control series	5.73 ± 1.451	0.79 ± 0.059	0.932 ± 0.014

best-fitting straight line relating log magnitude estimates to log stimulus area. Table 1 shows the means and standard errors of the exponents, constants, and coefficients of determination of the individual power functions of each of the eight experimental conditions. The exponents are well within the range of those obtained by other investigators for apparent size (MacMillan et al 1974; Teghtsoonian 1965) and apparent area (eg Da Silva et al 1987; Vogel and Teghtsoonian 1972), and the values of the mean coefficients of determination indicate, as is consistent with visual inspection of the individual functions, that the power functions are reasonably good fits to the data from individual subjects' judgments.

The means of the exponents of the four subjects in the monocular card/control condition who reported using a linear-dimension strategy were 1.01 and 0.948 for the card and control figures, respectively, and for the three subjects in the monocular pattern/control condition the mean exponents were 0.95 and 0.89 for the pattern and control figures, respectively.

To determine whether the type of figure series influences either the exponents or the scaling constants of the power function, two sets of t-test analyses were performed on these data. One set—paired t-tests—compared for each group the means of the exponents and the means of the scaling constants, for the control series with those for the companion figure-series (ie either the card or pattern series). For all four groups, neither the mean exponent nor the mean scaling constant of the control figure differed significantly from the corresponding values of the companion figure-series: the t values (criterion $t_9 = 2.62$, $p = 0.05$, two-tailed) for the exponent data for groups 1-4 (table 1) were 1.59, 0.07, 1.16, and 0.71, and for the scaling constant data they were 0.82, 0.91, 0.06, and 0.05, respectively. The second set—unpaired t-tests—compared the exponents and constants of the card and pattern series of the two binocular groups with those of the two monocular groups. Again, for neither the exponent nor for the scaling constant data was the difference significant: the t values (criterion $t_{18} = 2.10$) of the exponent and scaling constant data for the binocular groups were 0.11 and 0.01, respectively, and 1.05 and 1.16, respectively, for the monocular groups.

It might be objected that the preceding analysis does not exclude an effect of familiar size on magnitude estimations. Specifically, it is possible that magnitude estimates deviated from the power function such that estimates of the large cards and small cards tend to be smaller and greater, respectively, than values predicted by the power function. Such an S-shaped function relating magnitude estimates to physical area can be fitted by a power function, although the r^2 values will be moderate. Given that some of the r^2 values are not especially high, an effect of familiar size on magnitude estimates will not be revealed in either the exponent or the scaling constant of the power function. Inspection of the individual functions, however, did not suggest any systematic differences between the card and control conditions in the shape of the function. Furthermore, if the effect is systematic and reliable then it should be evident in the average or group functions. Figure 1 shows the average magnitude-estimation data separately for each of the eight stimulus series: For each series, geometric means were computed for each of the nine stimuli (based on eighteen scores per stimulus) and these are presented in figure 1 as a function of physical area, on logarithmic coordinates. The straight line in each graph represents the power function whose multiplicative constant (k), exponent (n), and coefficient of determination (r^2) are shown in the top left of each graph. As is indicated by the high r^2 values, the power function provides a very good fit to the group or average judgments, and, as can be seen, from the graphical plots of the power functions in figure 1, the two card conditions (binocular and monocular) do not appear to differ systematically in the shape of the function from those of the control conditions.

The results of these analyses indicate that neither the exponent nor the scaling constant of the power function for apparent size is affected by the familiarity of the stimulus under either binocular or monocular viewing conditions. Furthermore, to the extent that the control and pattern figures differ in the dimension of surface complexity, the present results are consistent with Verrillo and Graeff's (1970) finding that the surface complexity of an area does not influence the rate of growth of apparent size.

The results of the t-tests imply that the exponents of the control stimuli did not vary across the four groups of subjects, suggesting that sampling variations are unlikely to have masked possible differences in the exponents for size across the four conditions. For this reason, in the following experiments only the card and pattern series were used.

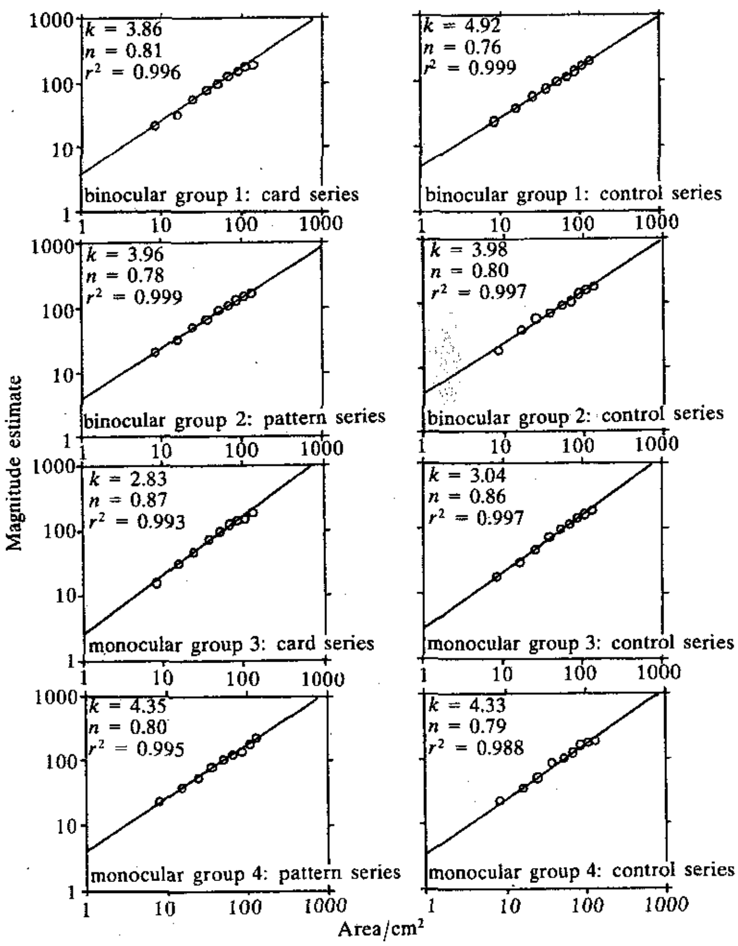

Figure 1. Magnitude estimations of stimuli as a function of physical area for the conditions in experiment 1. Each data point is the geometric mean of the magnitude estimates of ten subjects. The straight line is the power function relating magnitude estimates and physical area: k, n, and r^2 values refer to the multiplicative constant, exponent, and coefficient of determination, respectively, of the power function. Group numbers refer to the corresponding conditions in table 1.

2.3 *Supplementary experiment*

A possible reservation with the findings of experiment 1 is that subjects were exposed to two different figure series, either the card and control figures or the pattern and the control figures. Exposure to the first series of figures may have influenced subjects' estimates of the second series of figures. Arguably, this procedure may have eliminated or minimized the differences between the exponents for size of the familiar and unfamiliar figures. To examine this possibility, two independent groups of subjects, nine subjects in each, made magnitude estimates of the apparent size of either the card series or the pattern series used in experiment 1. The subjects, none of whom had participated in the previous experiment, viewed the stimuli monocularly and, after first viewing the standard figure, made two judgments of each of the nine figures. In all other respects, this experiment (experiment 1a) was identical to the monocular conditions of experiment 1. Two subjects in the card condition and one subject in the control condition reported using the linear-dimension strategy: The exponents of these three subjects were 0.97, 0.85, and 0.77, respectively. These subjects were replaced by three more subjects.

The means, with standard errors in parentheses, of the individually determined exponents, scaling constants, and coefficients of determination were 0.78 (0.058), 7.34 (1.92), and 0.955 (0.023), respectively, for the card-series group and 0.71 (0.044), 8.93 (2.101), and 0.943 (0.017), respectively, for the pattern-series group. For neither the exponent nor for the scaling constant data was there a significant difference between the two conditions (ie card or pattern series). The results of this experiment suggest that in experiment 1 the failure of familiar size to affect the exponent for size is unlikely to have resulted from subjects being exposed to the two different figure series.

3 Experiment 2

In experiment 1, the card series, the sizes ranged from smaller-than-normal to larger-than-normal with the middle figure of the series being the normal-sized card. Although in normal viewing environments familiar objects are frequently perceived as smaller-than-normal, they are rarely experienced as larger-than-normal (Predebon 1990). Given this asymmetry in experiencing large and small off-sized familiar objects, the aim of experiment 2 was to determine whether a stimulus series consisting of smaller-than-normal sized versions of a playing card and a stimulus series consisting of larger-than-normal sized playing cards produce similar or different values for the exponent of size.

3.1 *Method*

3.1.1 *Stimuli.* The stimuli were two series of photographic reproductions of playing cards and two series of photographic reproductions of pattern figures. Relative to a normal-sized card, the sizes of the small series were $0.4N$, $0.5N$, $0.6N$, $0.7N$, $0.8N$, $0.9N$, and N, and for the large series the sizes were N, $1.1N$, $1.2N$, $1.3N$, $1.4N$, $1.5N$, and $1.6N$. The normal-sized card and the pattern of the corresponding size served as the standard for the two card series and the two pattern series, respectively. Thus, unlike in experiments 1 and 1a, the standard was either the smallest or largest figure in the series.

3.1.2 *Procedure and subjects.* There were two groups of eleven subjects. None had participated in the previous experiments and all had normal vision.

As in experiment 1 subjects participated in two sessions with a break of 30 min between sessions. One group made magnitude estimates of the playing cards and the other group estimated the sizes of the pattern stimuli. For each group the order of presentation of the large and small series was counterbalanced across sessions. In each session, the standard was shown first followed by two presentations of each of the seven figures in the series, including the standard figure. Thus, in each session each subject made a total of fourteen judgments. Viewing was monocular. In all other respects, experiment 2 was identical to the monocular conditions of experiment 1.

Three subjects in the card condition and two subjects in the pattern condition reported adopting a linear-dimension strategy. The mean exponents of these subjects were 0.77 and 0.70 for the large-card and small-card series, respectively, and 0.73 and 0.82 for the large and small pattern series, respectively. These subjects were replaced by another five subjects.

3.2 *Results and discussion*

Table 2 shows the means and standard errors of the individual exponents, scaling constants, and the coefficients of determination for each condition. The exponents are higher than those obtained in the previous experiments. It is not clear how this discrepancy can be explained; perhaps it reflects differences in the positions of the standard in the range of stimuli (middle versus extreme), or it may reflect the smaller range of stimuli in the present experiment compared with in the previous experiments.

The paired *t*-tests performed on the difference between the means of the exponents of the large-stimulus and small-stimulus series were not significant either for the card or for the pattern stimuli (t_{10} = 0.79, 0.90, $p > 0.05$, respectively); nor were the corresponding differences between the means of the scaling constant of the large-stimulus series and of the small-stimulus series significant (t_{10} = 0.62, 0.68, respectively, $p > 0.05$). The unpaired *t*-tests performed on the difference between the means of the exponents of the large-card and of the large-pattern series and between the

Table 2. Mean ± SE of the exponents (n), constants (k), and coefficients of determination (r^2) of individual best-fitting power functions: experiment 2.

Condition	n	k	r^2
Cards			
Large series	0.91 ± 0.096	3.05 ± 1.843	0.908 ± 0.085
Small series	0.99 ± 0.096	3.55 ± 1.301	0.938 ± 0.022
Patterns			
Large series	1.03 ± 0.161	4.34 ± 1.581	0.944 ± 0.016
Small series	0.94 ± 0.115	5.09 ± 1.876	0.912 ± 0.052

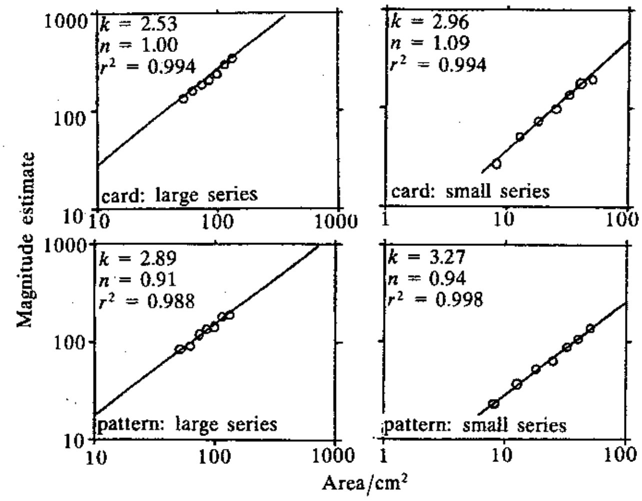

Figure 2. Magnitude estimations of stimuli as a function of physical area for each of the four conditions of experiment 2. Each data point is the geometric mean of the magnitude estimates of eleven subjects. The straight line is the power function relating magnitude estimates and physical area: k, n, and r^2 values refer to the multiplicative constant, exponent, and coefficient of determination, respectively, of the power function.

small-card and small-pattern series were not significant (t_{20} = 0.65, 0.36, respectively, $p > 0.05$), and neither were the unpaired t-tests performed on the scaling constant data from these two conditions significant (t_{20} = 0.62, 0.68, respectively, $p > 0.05$).

Figure 2 shows the average magnitude-estimation data separately for each of the four conditions. As is indicated by the high r^2 values, the power function provides a very good fit to the average magnitude estimations.

4 Experiment 3

The results of experiments 1 and 2 demonstrated that object familiarity does not affect the exponent for size. One obvious qualification to this conclusion is that even under the monocular viewing conditions of experiments 1 and 2 there were sufficient visual cues for observers to perceive the actual size of the cards. On this view, these experiments have merely identified some of the conditions under which object familiarity does not affect magnitude estimates of size. The purpose of experiment 3, therefore, was to determine whether familiar size affects the exponent for size under reduced-cue conditions, that is, under conditions in which familiar size usually influences estimates of size (eg Park and Michaelson 1974).

4.1 *Method*

4.1.1 *Subjects.* There were two groups of ten subjects. All were unaware of the purpose of the experiment, and none had prior experience with the method of magnitude estimation.

4.1.2 *Stimuli and apparatus.* The stimuli were seven transparencies of playing cards and seven transparencies of the pattern figures used in the previous experiments. Relative to a normal-sized card, the size of the card and pattern figures were $0.55N$, $0.7N$, $0.85N$, N, $1.15N$, $1.3N$, and $1.45N$. The standard stimuli were the normal-sized card and the corresponding pattern figure. The stimuli were presented in an enclosed visual alley, 2.5 m long and 1.2 m wide. The transparencies were mounted individually on the surface of a milk glass screen of a light-tight box containing the light source for transilluminating the transparencies. The transparencies were presented at eye level and were viewed from a distance of 1.2 m. Subjects viewed the stimuli monocularly (with the right eye) in a visual field that was otherwise dark. The luminance of the stimuli were 0.55 cd m^{-2}.

With the subject's head in a chin-rest and head-rest device, the stimuli were viewed through an aperture in a screen positioned 30 cm in front of the subject. When the experimenter replaced the stimuli, the aperture was closed, thereby occluding the subject's view of the visual alley. At no stage were subjects given information as to the distance of the objects in the alley from themselves.

4.1.3 *Procedure.* One group of subjects made magnitude estimates of the sizes of the playing cards, and the other group estimated the sizes of the pattern stimuli. The standard was shown first, followed by a single presentation of each of the seven stimuli. The order of presentation of the stimuli was randomized across subjects.

In pilot work it was found that under the conditions of the present experiment subjects were frequently confused by the magnitude estimation instruction. On the first presented stimulus of the card series, many subjects claimed that although the card seemed to be of a different size to that of the standard card it was in fact the same card but at a different distance. For this reason the second sentence of the instructions was replaced by the following: "... These patterns (cards) may or may not appear to be at different distances from you; I am not interested in that. I want you to tell me how big they look to you, that is, the size they appear or look to you on your first visual impression. First, ...".

4.2 *Results and discussion*

Surprisingly, no subject reported adopting a linear-dimension strategy. The means, with standard errors in parentheses, of the exponents, scaling constants, and the coefficients of determination of the individually determined power functions were 0.95 (0.112), 0.504 (2.128), and 0.956 (0.010), respectively, for the card series, and 0.87 (0.89), 5.18 (1.37), and 0.955 (0.001), respectively, for the pattern series. Neither the difference between the means of the exponent nor between the means of the scaling constant values was significant (t_{18} = 0.56, 0.05, respectively, $p > 0.05$), indicating that under reduced-cue conditions, familiar size does not affect the characteristics of the power function relating magnitude estimates of size to physical area. Figure 3 shows the average or group power-function for the two conditions of this experiment: the high r^2 values indicate that the power function provides a very good fit to the average magnitude-estimation data.

An alternative interpretation of the present findings is that subjects may have based their magnitude estimations on the relative angular size of the stimuli, that is, on their relative 'phenomenal extensity' (Rock 1977). Arguably, the presentation of the visual standard in the test field and the successive presentations of the different-sized stimuli of the series may have encouraged an angular size response. In this event, the failure of familiar size to influence magnitude estimates of size is irrelevant to the issue of whether familiar size influences perceived size; it merely demonstrates that familiar size does not affect angular-size responses.

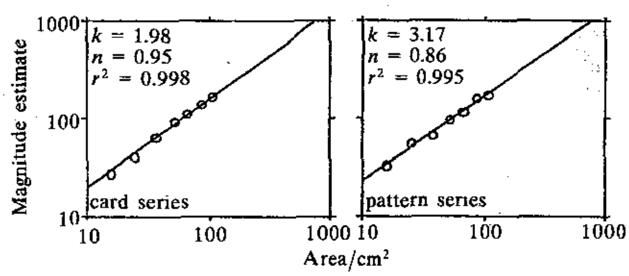

Figure 3. Magnitude estimations of stimuli as a function of physical area of the card-stimulus and pattern-stimulus series in experiment 3. Each data point is the geometric mean of the magnitude estimates of ten subjects. The straight line is the power function relating magnitude estimates and physical area: k, n, and r^2 values refer to the multiplicative constant, exponent, and coefficient of determination, respectively, of the power function.

5 Experiment 4

In this experiment the effect of familiar size on magnitude estimates of perceived size was further examined under conditions which excluded an angular-size response arising from the successive presentation of different-sized stimuli. Unlike experiment 3, subjects made magnitude estimates of only one version of the familiar object. A somewhat similar study has been reported by Gogel and Da Silva (1987). They had independent groups of subjects judge the size and distance of a normal-sized playing card viewed at distances of 56, 107, and 149 cm under reduced-cue conditions. In addition to obtaining haptic estimates of size, they also obtained from each subject a single magnitude estimate of the size of the card relative to a normal-sized card which was presented under full-cue conditions and assigned a value of 10. The magnitude-estimation data suggested that the playing card was perceived as a small off-sized object with the perceived size of the card decreasing as the physical distance of the card increased. Unfortunately, since the magnitude judgment was obtained after the haptic judgment, it is possible that the latter influenced the former. For this reason, it seemed worthwhile to examine Gogel and Da Silva's finding under the conditions of experiment 3.

5.1 *Method*

5.1.1 *Subjects.* The subjects were twenty-four students, none of whom had participated in the previous experiments. All had normal or corrected-to-normal vision.

5.1.2 *Stimuli.* The stimuli were three transparencies of a playing card. Relative to the normal-sized version, the size of the cards were 1.4*N*, *N*, and 0.7*N*. The standard stimulus was a normal-sized card.

5.1.3 *Procedure and instructions.* Independent groups of eight subjects made magnitude estimates of one of the three cards, either the 1.4*N*, *N*, or 0.7*N* card. Subjects were first shown the standard, that is the normal-sized card, under normal room illumination, and told to assign to it a value of 10. They were then told that during the course of the experiment they would be seeing a series of playing cards and that some of the cards might appear larger, some smaller, and some of the same size as the standard card (in fact, only one-sized card was presented during the test session). The instructions were similar to those for experiment 3: subjects were to assign a number corresponding to how "big the card looks to you on your first visual impression" relative to the size of the standard. Subjects were then positioned in the observation booth, and after a period of dark adaptation, the aperture was opened after which subjects made a single magnitude estimate of the playing card viewed in a visual field that was otherwise dark.

5.2 *Results and discussion*

The means of the magnitude estimations of the 1.4*N*, *N*, and 0.7*N* playing cards were 13.3, 8.9, and 5.5, respectively. The results of the *t*-tests on the log transformation of the magnitude-estimate data indicated that the difference between the means of the transformed estimates of the large and normal-sized cards was significant, as was the difference between the means of the transformed estimates of the normal-sized and small cards (t_{14} = 2.17, 1.95, respectively, $p < 0.05$). The pattern of these results suggests, in agreement with the findings of experiment 3, that, to a substantial degree, familiar size does not affect magnitude estimates of size. Given that the standard was not presented under the same conditions as the test stimuli and that only one estimate was obtained from each observer, it neither seems plausible nor warranted to interpret subjects' magnitude estimates in this experiment and in experiment 3 as reflecting a response to the relative angular size or extensity of the cards.(1)

5.3 *Supplementary experiment*

The failure of familiar size to influence magnitude estimates of size in experiment 4 might be attributed to the operation of residual cues to the actual size and distance of the cards. This seems unlikely, however, since under similar conditions in a number of cue-conflict studies (eg Fitzpatrick et al 1982; Higashiyama 1984; Park and Michaelson 1974) it has been shown that familiar size affects direct estimates of size. The results of an unpublished study conducted in a different context is relevant to this issue. The viewing conditions were virtually identical to those of the present experiment except that the playing card transparencies were viewed from a distance of 1.35 m and had a luminance of 6.2 cd m^{-2}. Two independent groups of eight subjects verbally estimated (ie in inches or centimetres) the metric size (vertical dimension) of either a 1.5*N* or a 0.7*N* sized card (actual size = 13.3 or 6.2 cm, respectively).

The objective-size instructions requested estimates of the physical or actual size of the card. Objective-size instructions were used since there is evidence to suggest that under reduced-cue conditions, the effect of familiar size on direct judgments (eg verbal estimates) of size is more likely to occur with objective-size than with

(1) This finding is not specific to playing cards. Similar results were obtained with a normal and a smaller-than-normal (0.7*N*) \$5 bank note.

apparent-size instructions (see section 6). If, under the reduced-cue conditions of this study, familiar size does not influence objective verbal-metric estimates of size, it cannot be concluded from the null finding of experiment 4 that familiar size is an ineffective determinant of perceived size.

The mean size estimates of the $1.5N$ and $0.7N$ cards were 10.2 cm and 9.0 cm, respectively: the difference between these two means was not significant ($t_{14} = 1.21$, $p > 0.05$), indicating that objective-size metric estimates were influenced by familiar size. This finding suggests that the failure in experiment 4 to obtain an effect of familiar size on magnitude estimates is unlikely to result from the effects of residual size and distance cues in the display.

6 General discussion

In the present investigation the novel procedure for determining the form of the power function relating perceived size and physical size was used to assess the effect of object familiarity on perceived size. The results of the first three experiments demonstrated that under a variety of viewing conditions neither the exponent nor the scaling constant of the power function relating perceived size to physical size is affected by the familiarity of the stimuli, indicating that familiar size does not influence the rate of growth of perceived size. Although inconsistent with the results of some of the cue-conflict studies (eg Fitzpatrick et al 1982; Park and Michaelson 1974), these findings are in agreement with those cue-conflict studies (eg Gogel 1969) which have shown either a small or nonexistent effect of familiar size on estimates of size.

In experiment 4, it was found that under comparable viewing conditions and stimulus presentations, verbal-metric estimates, but not magnitude estimates, of size are influenced by object familiarity. These findings are not inconsistent with each other, however. In experiment 4 verbal-metric estimates were obtained under objective-size instructions whereas in experiments 1, 2, and 3 the instruction requested magnitude estimates of the apparent size of the stimuli. There is now evidence to suggest that the familiar-size effects found in the cue-conflict studies are contingent on the instructions, that is, on whether the instructions require estimates of objective (physical) size as distinct from estimates of apparent (perceived) size. In particular, the results of three studies (Gogel and Da Silva 1987; Higashiyama 1984; Predebon 1978) have confirmed Gogel and Newton's (1969, page 9) speculation that "... if O perceives a large- or small-sized rather than a normal-sized familiar object, it is unlikely that his response will reflect this perception, if his instructions were to estimate real or physical size". Higashiyama (1984), under conditions similar to those used in the present investigation, found that apparent size instructions minimized familiar-size effects whereas instructions (assumptive) which encouraged subjects to utilize the familiar-size information produced substantial effects of familiar size on verbal size-estimates even under full-cue conditions. Similarly, Gogel and Da Silva (1987) found that under reduced-cue conditions haptic estimates of physical or objective size were independent of the visual angle of a playing card whereas haptic estimates of apparent size decreased with decreasing visual angle of the card. Similar instruction effects have been found with verbal-metric estimates of size (Predebon 1978). To the extent that apparent-size instructions elicit reports based on the perceived size of the target, the pattern of results in these studies are consistent with the view that, to a large extent, familiar size does not affect perceptions of size.

The magnitude-estimation instructions in the present experiments directed subjects to base their estimates on how the stimulus 'appeared', and are similar to the apparent-size instructions used in the studies cited above. The failure of object familiarity to affect the exponent for size (experiments 1, 2, and 3) and its failure in experiment 4 to influence magnitude estimates of the size of the playing card provide converging evidence for the claim that familiar size may not be an important determinant of perceived size. Taken together with the results of experiments 1-4, the most parsimonious explanation of the objective metric-estimate results of the supplementary experiments of experiment 4 is that subjects interpreted the objective-size instructions to mean a judgment based on their memory of the normal size of cards. In particular, the results of the supplementary experiment are consistent with Gogel's (1969, 1973, 1974; Gogel and Da Silva 1987) theory of off-size perceptions which asserts that the perspective belief [the belief that perceived size decreases with perceived distance of the target (Carlson 1960)], together with the perception of a familiar object as being either larger or smaller than its normal size, allows observers to make cognitive judgments of the size of the object. Thus, an observer who views an off-size familiar object and correctly perceives it as off-size may, if the perspective belief is elicited, attribute this discrepancy to the inferred distance of the object. In this event, a smaller-than-normal sized object will be estimated to be normal sized and will be cognitively judged to be at a far distance. According to Gogel's theory, such cognitive-size and distance responses are more likely to occur with the objective-size instructions used in the supplementary study of experiment 4 than with apparent-size instructions.

A possible qualification to the above interpretation of the present findings is that since subjects were shown a standard figure, the unfamiliar (pattern) series acquired a 'familiar' or an assumed size, and for this reason, the similarity of the pattern and card exponents cannot be interpreted as indicating that familiar size does not affect perceived size. However, if familiar-size effectiveness increases with a decrease in conflicting visual and oculomotor cues, as is widely supposed, this qualification implies that the exponents for both the card and the pattern stimuli should be smaller under reduced-cue than under either the binocular or the monocular viewing conditions of the present investigation: this obviously did not occur.

Finally, one aspect of the analysis of experiments 1, 2, and 3 requires comment. The means of the coefficients of determination (r^2) of the individually determined power functions, although indicating a reasonably good fit to subjects' judgments, are not sufficiently high to exclude alternative models to the power function. In particular, a simple linear model in the form of $J = nS + c$ is similar to a power function with an exponent less than 1, and it is possible that the effect of familiar size might be evident in the additive constant (c) of this model.[(2)] A reanalysis of the data of experiments 1, 2, and 3 indicated that the linear model does provide a reasonably good fit to the magnitude-estimation data. However, its fit is generally lower than that of the power function model. The r^2 of the linear model for the average magnitude-estimation data of each of the fourteen conditions in experiments 1, 2, and 3 ranged from 0.958 to 0.995, compared to the range of 0.980 to 0.999 for the power function (see figures 1, 2, and 3), and in only one condition (experiment 3; small-pattern series) were the r^2 values of the two models equal. In any event, the analyses of the individual subject's magnitude-estimation data in terms of the linear model indicated that the differences between the means of the additive constant of the card conditions and of the relevant control conditions were not significant, suggesting that familiar size does not systematically influence the additive constant of the linear model.

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(2) I am grateful to John C Baird for suggesting this analysis of the data.

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