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The National Aeronautics and Space Admini-

stration, entitled "Interrelations of Per-

ceived Size and Distance"

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The research conducted under this grant has been directed toward the basic processes involved in the size cue to distance and toward the effect of perceived distance on perceived size. At the time of the initiation of this research program a number of important problems concerning the relation between perceived size and perceived distance were unanswered. One of these was the question of the adequacy of familiar size as a cue to the distance of an object from the observer (perceived egocentric distance). Two of the papers resulting from the research program concerned with this question are entitled "The effect of set on perceived egocentric distance" (Gogel, 1968) and "Equidistance effects in visual fields" (Gogel, 1969a). These studies demonstrated that the perceived distance from familiar size could be modified by the set of the observer and by the equidistance tendency. Neither of these studies augur well for familiar size as a precise determiner of perceived distance. On the other hand, the former study (Gogel, 1968) demonstrated that as an average response, the retinal size of a familiar object was a determiner of reported egocentric distance and in some instances the average responses from this cue system could approach veridicality. However, it was also substantiated that the familiar size cue to distance consisted of two not one cue system. One of these, the absolute size of a familiar object, although rather variable between observers, was able to support the perception of egocentric distance. The other, the relative size cue occurring between either simultaneous or successive presentations of a familiar object was a

cue to a difference in perceived depth, i.e., a perception of eccentric distance. The perceived distance of a familiar object as determined by each of these two cue systems was not always the same and under the circumstances in which both types of distance cues were available the relative rather than the absolute size cue determined the perception.

It was noted also (Gogel, 1969b) that a familiar size, contrary to expectations, sometimes did not determine perceived size. In order to understand this puzzling result, it was decided to examine the perceived size and perceived distance associated with non-familiar (geometrical) objects presented under reduced conditions of observation. It was found by presenting different retinal sizes of the geometrical object to different observers that the perception of the size of the object on first presentations varied directly with its retinal size with the perceived distance of the object tending to be invariant. This suggested that some factor was present to make the objects appear at a near distance and as a result of appearing at this near distance the objects acquired an apparent size proportional to their retinal size (Gogel, 1969d). Two additional experiments verified the existence of a tendency in the absence of visual information to perceive objects at a near distance. This factor was termed the specific distance tendency. It was hypothesized further that the specific distance tendency was important not only in determining the perceived distance (and thus the perceived size) of non-familiar objects but also of familiar objects. Such an hypothesis however seemed to be contrary to the previously obtained result indicating that familiar size was a cue to reported distance.

This problem was investigated in two additional studies using familiar objects presented one at a time under otherwise reduced conditions of observation. In one of these studies (Gogel & Newton, 1969) it was found that the

(3)

Familiar objects having simulated distances beyond the distance defined by the specific distance tendency usually were perceived as small off-sized versions of familiar objects. On the other hand, familiar objects simulating distances less than that defined by the specific distance tendency often were perceived as large off-sized versions of familiar objects. The simulated distance is the physical distance which a normal-sized object of that particular kind would have to be placed in order to produce the particular retinal size presented to the observer. In the second study (Gogel, 1969a) the off-sized results obtained in the previous study were confirmed. In addition, the observers reported the apparent distance of the objects. It was found that the reports of distance increased with the simulated distance but that these reports increasingly underestimated simulated distance as the simulated distance increased.

From these studies, the process underlying familiar size as a cue to distance appears to be as follows. When presented with a familiar object under otherwise reduced conditions of observation, the observer will perceive the object at a near distance as defined by the specific distance tendency and as a result will perceive the object to have a size at this distance that is proportional to its retinal size. This perceived size will be greater or less than the familiar size depending upon whether the simulated distance is less or greater than the distance defined by the specific distance tendency. Thus the familiar object will often be perceived as an off-sized version of a normal object. It has been demonstrated by other researchers that a distant object is expected to look smaller than a near object of the same physical size. It seems therefore that when the familiar object appears to be a small off-sized object the observer will judge (infer) that the object is far away with the magnitude of this inference increasing as the object

(4)

appears increasingly small-sized. It is suggested that familiar size because of its failure to determine perceived size also fails to determine perceived distance. As a consequence of the specific distance tendency resulting in off-sized perceptions, however, an inference of distance will usually occur. Although this inference increases with the simulated distance of the object, the magnitude of the reported distance is usually less than the simulated distance. It seems that the addition of familiarity to an object does not affect substantially the perceived size and perceived distance of the object but does increase the observer's ability to make inferences concerning the object distance.

Although it is clear that the above description of the process underlying the familiar size cue to distance is also concerned with the effect of perceived distance on perceived size less attention has been given in these studies to perceived distances as a determiner of perceived size. In another study, however, (Gogal & Marchon, 1968) an additional aspect of this relation was investigated directly. In this study the perception of a size illusion in an Ames distorted room was considered. It was proposed that a distorted room was not essential for the illusion. An analysis of the illusion suggested that the essential factors were the equidistance tendency and the context theory of perceived size. The equidistance tendency states that, in the absence of visual information of distance, objects will appear equidistant. The context theory of perceived size states that the perceived size of an object is determined by the requirement that the perceived size (S') per unit of retinal size (θ) of the object is the same as the S'/θ value of objects in its perceived vicinity. Using these two factors simultaneously it was demonstrated that a size illusion identical to that expected from a distorted room could be obtained from a normal (rectangular) room. These two factors,

particularly the context theory of perceived size, has application to the perception of size in a variety of situations.

The results of this research program has two general consequences. First it has revealed some of the important factors determining size as a cue to distance. The understanding of these factors would be important, for example, in any effort to reduce the errors in judged distance from this cue system. Second, the examination of the relation between perceived size and distance has indicated general organizational factors that may be significant in other cue systems. The application of these organizational factors to the processing of visual information is being developed in an article presently in draft form (Gogel, 1970b). Also, a systematic account of the results from the present research program and their relation to previous studies is in preparation (Gogel, 1970a). This latter paper will also include a discussion of the experimental results relating the specific distance tendency and errors in reported distance obtained from the research conducted this past summer. In summary, this research program has contributed substantially to the understanding of the interrelation of perceived size and distance and has identified principles of visual organization that are applicable to a variety of visual judgments.

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Hogel, W. C. The effect of set on perceived egocentric distance. Acta Psychologica, 1968, 28, 283-292.

In this study, the set of the observer to perceive the distances of playing cards was modified by providing experiences which would suggest that relatively far distances were being observed. One group of observers threw darts down a visual alley while viewing the alley, prior to observing the cards. When observing the cards, this group threw darts to the apparent distance of the cards and gave verbal reports of apparent distance. The other group of observers gave verbal reports of the apparent distance of the cards without throwing darts or viewing the throwing alley. The 'Dart Group' gave verbal reports of the distances of the cards which were approximately twice those from the 'No Dart Group.' In this experiment, the ratio of the perceived distances of the cards on the first presentation was considerably less than the simulated ratios. A second experiment was designed to investigate the effect of a prior presentation of a 'full cue' field upon the subsequent perceived distance of the cards. This objective was not achieved in that a 'control group' who were first presented with the cards, closely approximated veridicality in perceived distance using the absolute size cue.

The study supports the following conclusions: (1) Perceived egocentric distance from the familiar size cue can be affected by the experiences of the observer occurring prior to the presentations of the cards. (2) The distinction between relative and absolute size cues to distance from familiar objects is valid. (3) Although the perception of egocentric distance from familiar size shows considerable observer variability, it can occur (Experiment I) and under some conditions can approach veridicality in terms of average (or median) responses (Experiment II).

Hogel, W. C. The sensing of retinal size. Vision Research, 1969, 9, 3-24 (a).

This study examines the interpretation that under reduced conditions of observation the perceived size of an object is the result of a direct response to retinal size. In opposition to this interpretation is the size-distance invariance hypothesis stating that a perceived size results from a retinal size only when an appropriate perceived distance is also present. Four experiments were conducted. The first two experiments indicate that in the absence of distance cues perceived size is proportional to retinal size. The last two experiments suggest that this result is a consequence of the tendency, under reduced conditions, to perceive the objects at a common (specific) distance perception of retinal size. The possible significance of the specific distance tendency is discussed for binocular as well as monocular conditions of observation.

Gogel, W. C. Equidistance effects in visual fields. American Journal of Psychology, 1969, 82, 342-349 (a).

The image of a playing card was presented in an otherwise dark visual field or apparently suspended above the floor of a visual alley. The perceived size and perceived distance of the card were judged by 40 Os. In agreement with the expected effect of the equidistance tendency, the playing card appeared to be more distant and larger in the visual alley than in the reduced visual field. The results suggest that familiar size was a valid, but not a very effective, cue to perceived size and perceived distance. It seems that the equidistance tendencies occurring between simultaneous presentations of experimental objects and comparison fields can distort the perceived size and the perceived distance of an experimental object presented in the comparison field. Optical contact along a visual surface as a cue to depth was discussed as a limiting case of the equidistance tendency.

Gogel, W. C. The absolute and relative size cue to distance. American Journal of Psychology, 1969, 82, 228-234 (b).

A differentiation between absolute and relative size as cues to distance was applied as an explanation to the difference in perceived egocentric distance which can occur between first and successive presentations of different retinal sizes of a familiar object. It was assumed that the absolute cue would be heavily weighted in the first presentation (a presentation following some time in the dark) and that the relative cue would be heavily weighted in the simultaneous presentation of the two retinal sizes. Both of these cue systems were assumed to operate in combination in determining the perceived distance associated with a second presentation of the familiar object. It was found that although in the first presentation, on the average, the perceived distance of the familiar object increased with a decrease in retinal size, this increase was considerably less than that shown between second presentations. This change was predicted by considering the data resulting from both the first and simultaneous perceptions together. It was suggested that the method of using different groups and different orders of presentations would also be useful in differentiating between absolute and relative cues in other cue systems than that of familiar size.

Gogel, W. C. The effect of object familiarity on the perception of size and distance. Quarterly Journal of Experimental Psychology, 1969, 21, 239-247 (c).

The perceived sizes and perceived distances of familiar objects were investigated in two experiments in which images of familiar objects were presented monocularly, one at a time, in an otherwise dark field of view. It was found that the angular size of the objects as well as their familiar size determined reported size. Reported distances were increasingly underestimated as a function of increasing simulated distances of the objects. The results are consistent with the conclusion that, as a function of the retinal size of the objects, the observer perceives the familiar objects as off-sized, and, that as a consequence of these off-sized perceptions, the observer's judgments of the object distances reflect inferential rather than perceptual processes.

Gogel, W. C. & Marshak, D. E. The perception of size in a distorted room.

Perception & Psychophysics, 1968, 4, 26-28.

This study was concerned with determining the factors important in the size illusion occurring with respect to extraneous objects introduced into an Ames' monocular distorted room. It was asserted that the distortion in the room was unnecessary in order for the size illusion to be present. A rectangular room plus the extraneous objects produces the same stimulus conditions found in the Ames' room and, hence, should produce the same illusion in perceived size. In an experiment using a rectangular room, 24 Os judged the size and distance of objects at the same or different distances behind the windows. As in the case of the Ames' room it was found that the objects of physically equal size were perceived to be in the plane of the windows with the more distant objects appearing to have the smaller size. These results are explained in terms of the action of the equidistance tendency making the objects appear at the distance of the windows and the concept that objects in the same apparent fronto-parallel plane must have equal values of perceived size per unit of retinal size.

Gogel, W. C. & Newton, R. E. Perception of off-sized objects. Perception &

Psychophysics, 1969, 5, 7-9.

Stimuli simulating familiar objects were viewed monocularly, one at a time, in an otherwise dark visual field. Thirty-two Os indicated the apparent size relative to the familiar size of the objects. Many of the objects appeared to be off-sized, i.e., larger or smaller than normal. The results suggest that the perceived sizes of the objects were strongly influenced by the angular sizes. It is concluded that familiar size only partially determines perceived size when the objects are viewed under otherwise reduced conditions of observation.