On Perceived Size

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Abstract

It is a well-known that under certain circumstances one and the same object may be perceived as having different sizes. A common example of this phenomenon is the so-called moon illusion. In this paper a model is presented which is based on the Shannon theorem which appears to reproduce the data available for this type of observation very well. This theorem states that, for any data processing system, there is an upper-limit to the channel capacity. Assuming this to be valid for neurooptical systems, this means that there is a limited number of pixels available for image production; these pixels may be, however, distributed over a larger or smaller area of the retinal surface. Based on this assumption, a function is developed which determines the fraction of the total number of pixels available for the overall image which actually lie within the bounds of the object´s image. This function thus gives a numerical value for the perceived size of the object of interest. In order to be able to apply this function it was calibrated by fitting the experimental data available from an early investigation (12) of subjective perceived size. The result is another function which allows the prediction of the expected perceived size for situations similar to those which cause the real moon illusion and has been shown to fit two sets of experimental visual data.

1. Perceived Size

An observation which is frequently made is that when the the sun or the moon are just above the horizon they may appear to be twice as large as when they rise higher in the sky. This change in the perceived size of objects like the sun or the moon is an example of an illusion which cannot be photographically reproduced. This type of phenomenon has been discussed in the literature and has given rise to more than a dozen different hypothesis (1,2,3,4 and literature cited therein). A similar, but far less frequently made observation, is that the rising or setting moon appears to be exceptionally large although it is in the same position above the horizon, where for weeks or even months, it was its usual size. A similar effect is sometimes observed with the sun, with it appearing as a huge red ball on, or near the horizon. There was, however, only a very limited number of reports about this second phenomenon (5).

There is general agreement that the source of this type of illusion lies with the image processing in the brain. It also appears that a special property of the image is required to trigger this illusion. This trigger has been most frequently identified as a particular geometric property of what is observed as being the sky. Explanations have been proposed which have to do with perspective (3). By analogy to another geometrical illusion, the sky is assumed to take on an elliptical shape. Other authors have reasoned that the angle of observation, or angle of regard, is responsible for the moon illusion (2) and the effects of color and diffraction have also been discussed as the potential source (5). Another hypothesis is the adaption level theory (F. Restle; (8)). However, the most promising explanation, which we will discuss further in this paper, appears to lie with an entity which is related to what we now call information density (5,6,7).

There are several optical and spectroscopic effects which may change the properties of the light which ulimately produces the retinal image. For example, the wavelength dependent scattering which causes the setting sun to appear red and the sky to appear blue. Refraction in ice crystals in the atmosphere (halo effects) or diffraction at the pupil of the eye can induce specific effects. It is possible to measure these and to determine parameters (e.g., the real colour, contrast, resolution or lightness and brightness) which, in turn, can be related to properties of the image which the brain uses to extract information.

The question immediately arises, is the illusion under discussion dependent on some of these parameters? Properties such as contrast and resolution are closely related to a quantity known as the maximum achievable information density which we propose as being the unterlying cause of the moon illusion.

2. The Shannon Model

In order to make later arguments clearer, at first a simple model related to maximum achievable information density will be discussed.

If we consider a spacecraft transmitting images of a planet´s surface to earth. Its ability to do this is ultimately limited by the law of conservation of energy since the amount of power (Joule/s) available from its internal storage is limited. This determines the maximum channel capacity C (bit.s^{-1}) of the transmitter and, as a consequence, the maximum number of bits or pixels which can be transmitted per unit time (Shannon theorem, (9,10)). The available number of pixels may be concentrated on a small area to achieve high resolution or they may

be spread over a large area, resulting in a low resolution, wide-angle view. In other words, the achievable resolution is inversely proportional to the size of the area selected.

In data systems other than the one of our simple example, the limiting factor may not be the power available, but never-the-less other parameters limit the channel capacity. An increase in resolution always has to be compensated for by a sacrifice in image size. If the visual imaging process is considered to consist of data acquisition followed by data processing, a similar relationship between size and resolution should also hold.

In order to produce a model (11), which describes the perceived size of a particular object based on the Shannon theorem, several assumptions will be made:

1. Since the time required for neuroptical system to produce a conscious image is relatively short ($\approx$ 80 ms), the number of pixels which can be processed in this time to produce an image is limited (channel capacity).

2. The brain defines a solid angle of optimum perception, from which those pixels are selected. The size of this solid angle determines resolution. The pixels are assumed to be fairly evenly distributed within this angle and this may be varied continously when visually fixing an object (size constancy) or held constant (angle constancy). At first, pixels located outside this angle are assumed not to contribute to the image under consideration.

3. The size of this solid angle of optimum perception depends on a variety of external and subjective parameters (e.g. personal interest in an object).

4. The maximum achievable resolution may be either limited by atmospheric visual conditions, or by the resolving power of the eye.

5. The image based on all the information extracted and processed from the solid angle of optimum perception is transfered to what one can effectively describe as an internal visual memory screen and it is the content of this screen which one later recalls as the actual image.

6. Since the same model should be equally suitable for very small and very large objects, all distances are measured in multiples of a length unit, d_0. This is defined as the distance at which the object of interest fills the entire angle of optimum perception. For simplicity, it will also be assumed that this distance is the same for horizontal and for vertical observation (which, in practice, may not always be the case).

7. If, for some reason, the total angle of optimum perception is smaller than usual, a certain object will subtend a larger portion of this the angle and therefore it will appear larger than usual. In other words, perceived size is defined as the fraction of the angle of optimum perception subtended by the object of interest.

The situation arising when the image of an area with diameter R which contains the object of interest with diameter r, is projected on to the retina is shown in figure 1. The model which allows the perceived size of an object to be calculated is based on ratios of angles. Therefore, the angles measured in the real world (e.g., the angle subtended by the object, (r/d)) are

assumed to also apply to the retinal image. (See caption of figure1). The upper limit for the angle of optimum vision is ≈ 0.2 rad = 11.5^0. Solid angles are approximated by the squares of the respective angles, e.g., $(R/d)^2$. Individual pixels are indicated by small squares in this figure. Their density (pixels per unit sterad) varies, depending on what visual image is required. Visually fixing a particular object causes the angle of perception to decrease continuously while, simultanously, increasing the pixel density. This is the process known as size constancy, which is in effect, a substitute for non-existent zoom properties of the eye lens. In the other visual mode, known as angle constancy, the angle of perception is held constant while regarding objects at different distances. In this mode differences in perceived size furnish information over distances (perspective).
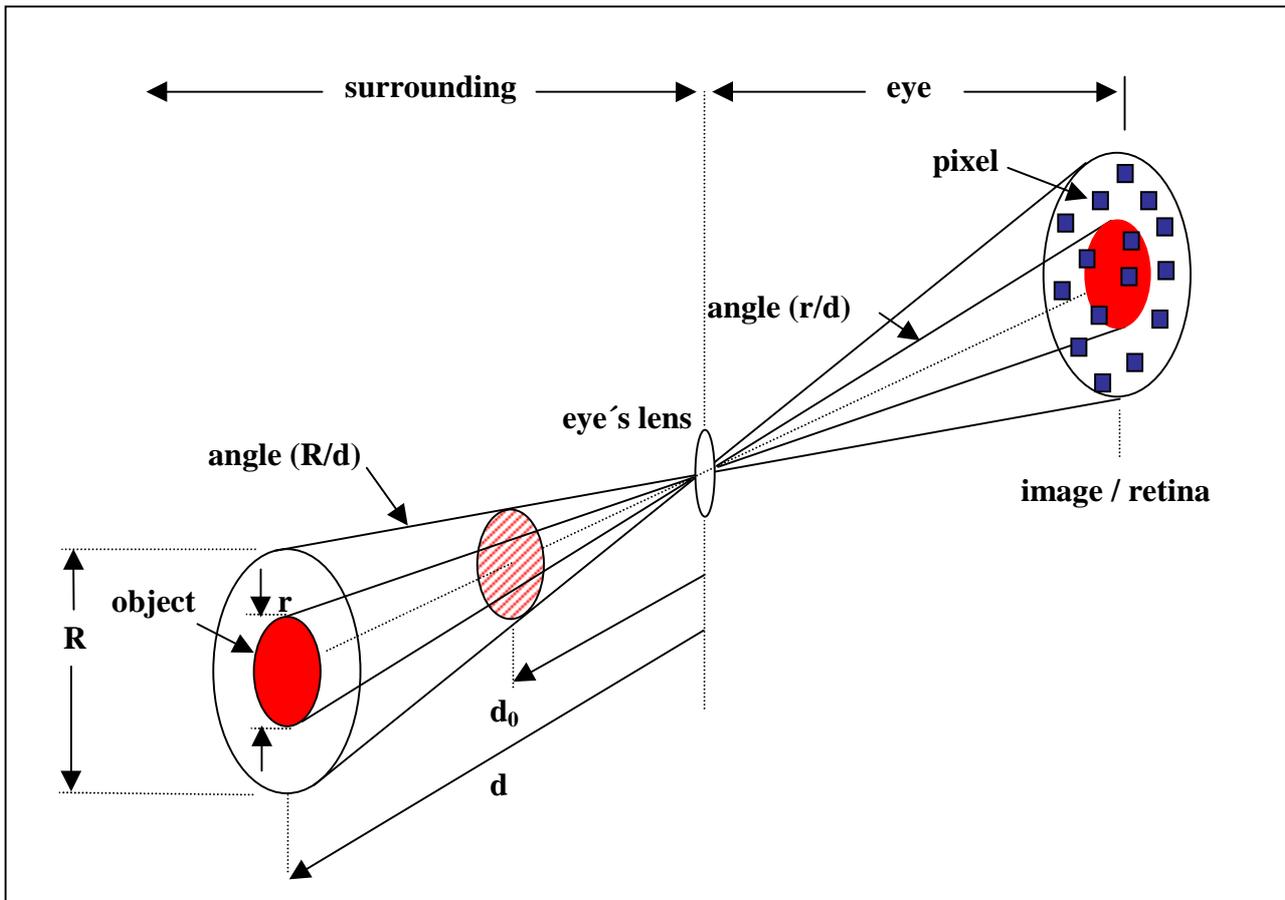

Fig. 1. The projection of a circular object with diameter r on to the retina. R is the diameter of the area of optimum perception. The distance d is given in units of d_0 , the distance at which the object subtends the full angle of optimum perception. In this case R/d = r/d = α. The maximum value of α is ≈ 0.2 rad or 11.5^0. When the object moves away from the observer, r/d becomes a fraction of R/d. The corresponding solid angles are assumed to be $\approx (r/d)^2$ and $(R/d)^2$, respectively. Although this approximation is some 20% in error, since the perceived size of the object depends on the ratio of two such angles the result is correct. For the same reason the refractive index within the eye has been neglected.

$(R/d)^2$ is the solid angle which corresponds to that section of the visual field which has been selected for maximum attention. This will be referred to as the "angle of (optimum) perception". The corresponding retinal area is proportional to $(R/d)^2$. The area on the retina subtended by an object´s image is proportional to the solid angle $(r/d)^2$. The solid angle $(R/d)^2$, multiplied by the pixel density P(d) (pixels per unit sterad) gives the total number of pixels N processed by the visual system resulting in one image:

$$\left(\frac{R}{d}\right)^2 P(d) = N \tag{1}$$

Assuming that the angle of perception is adjusted more or less proportionally to the dimensions of the object of interest, it seems reasonable to choose the pixel density (pixels per unit solid angle) as a function of d, i.e., as $P(d) = p.d^{2n}$, where n is a parameter and p is a constant. All lengths and diameters are measured in units of d_0.

It is assumed that the object has been moved to a position corresponding to d =1. It now subtends the full angle of optimum perception and all the pixels processed are concentrated in the object´s image only.

In this case $R/d = r/d = \alpha$; $(d = d_0)$. Setting $d = 1$ $(= d_0)$ one obtains:

$$\left(\frac{r}{1}\right)^2 P(1) = N \;; \qquad \left(\frac{r}{1}\right)^2 p.1^{2n} = N \;; \qquad N = r^2 p \tag{2}$$

Combining eqs. (1) and (2) the angle of perception can be derived as

$$\left(\frac{R}{d}\right) = \sqrt{\frac{N}{p.d^{2n}}} = \sqrt{\frac{r^2.p}{p.d^{2n}}} = \frac{r}{d^n} \qquad \text{(in units of rad)} \tag{3}$$

This leads to an expression for the relative angle AR(d) subtended by the object as a fraction of the total perceived angle:

$$AR(d) = \frac{(r/d)}{(R/d)} = \left(\frac{r}{d}\right) \cdot \left(\frac{d^n}{r}\right) = d^{n-1} \tag{4}$$

AR(d) can be defined as the perceived size of the object. Setting n = 0, one obtains $AR(d) = \frac{1}{d}$; the perceived size of the object decreases proportionally to the distance (like the image on the retina) while the total angle of perception is kept constant. Setting n = 1 leads to $AR(d) = d^0 = 1 = $ constant, which corresponds to (ideal) size constancy. All other cases can be described by choosing an intermediate value of n, $0 < n < 1$.

The parameters, α and d_0, are defined via the distance from the observer at which the object subtends the entire angle of perception. In addition, it is assumed that this particular distance d_0 is the same for both horizontal and vertical observation.

The perceived size of an object as a function of d for different values of n is shown in figure 2. At d =1 $(d = d_0)$ the object subtends the entire angle of optimum vision. If now the object is moved away from the observer, its image shrinks with increasing d. If, however, the object is visually fixed by the observer, the angle of perception will also shrink. Therefore, the object usually will appear larger than one would expect it to be from consideration of the retinal image alone. However, in practice, ideal size constancy does not exist.

Three different values have been chosen for the parameter n; n = 1 corresponds to size constancy (horizontal straight line), n = 0 (lower curve of figure 2, which is a hyperbola) corresponds to angle constancy. The curve between the two extremes, for n = 0.579(22), represents a realistic value. At d = 1, due to definition (equ. 4), all functions approach unity, irrespective of the value of the parameter n.
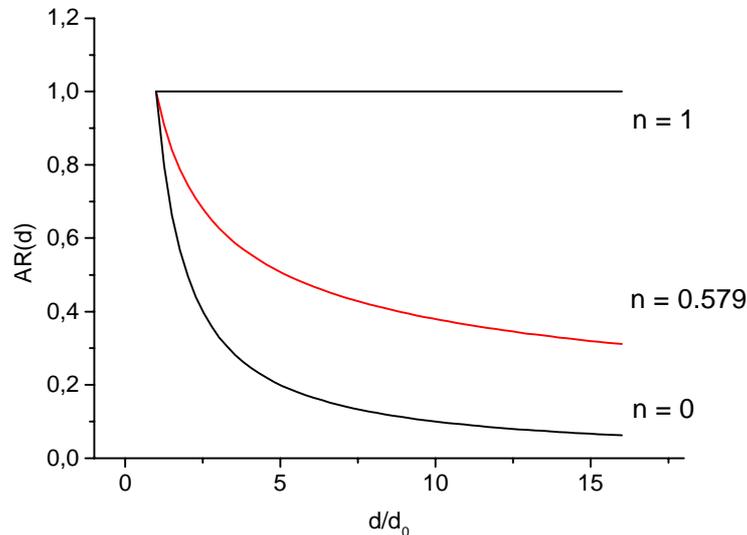

Fig. 2. Functions AR(d), which give the angle subtended by the object relative to the angle of optimum vision. This can be interpreted as the perceived size of the object as a function of distance. Three different values have been chosen for the parameter n: n = 1 corresponds to size constancy (horizontal line), n = 0 (bottom curve, showing a hyperbola) corresponds to angle constancy. The intermediate curve is calculated for n = 0.579, which is a realistic value. Due to definition, the functions are normalized to their values at d = 1 (= d_0). This is the distance at which the object fills all the angle of optimum perception. At d_0 the perceived size of the object should match for horizontal as well as for vertical direction of regard.

3. Applications

3.1 The Schur Experiment

Perceived size as a function of d, for both horizontal and vertical observation has been investigated experimentally by Erna Schur (12). In this work a bright circle, 17.5 cm in diameter, was projected on a screen in the dark at a distance varying between 4.80m and 16.00m. The subjects were required to compare the size of this circle to a disc of the same diameter at a distance of 4.00 meters. The perceived size in both directions, horizontal and vertical, was arbitrarily set to be 100% at a distance of 4 meters, although there is no reason to assume that the perceived sizes really match at this distance.

In order to fit the experimental data (12) to equation (4) developed above, a value for d_0 has to be selected. Its value has no influence on the size of the parameter n which is to be determined from the data. As was the case in the original experiment, all data were normalized to d = 4m. This means that d_0 is 4m and abscissa values should really be given in multiples of this unit. However, in order to faithfully reproduce the distances actually used in the experiments (12), they are still indicated in Figures 3 and 4 in meters. At $d_0 = 4$m the angle subtended by the disk amounts to $\alpha = 0.0347$ rad or $2^0 30´$. This is also the total angle of optimum perception.

Fitting the experimental data (12) to the function $AR(d/d_0) = (d/d_0)^{n-1}$ one finds $n_H =$ 0.579(22) and $n_V = 0.319(34)$ for horizontal and vertical n, respectively (Figs. 3 and 4).
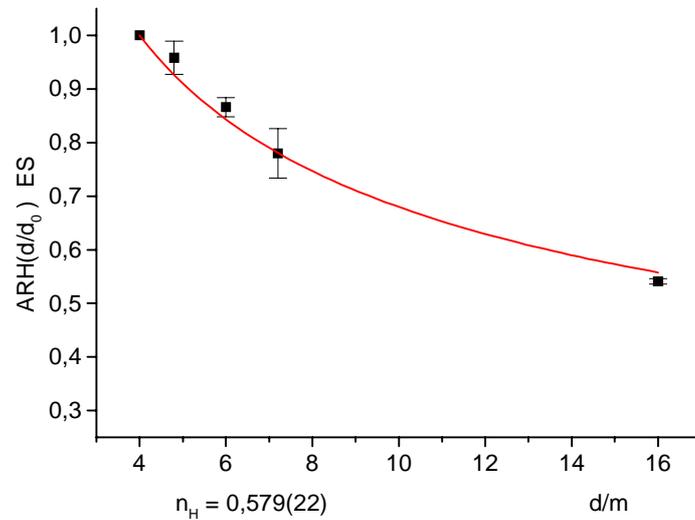

Fig 3. The perceived size of a circle of 17,5 cm diameter seen from a horizontal distance between 4m und 16m normalized to its perceived size at 4m distance. The abscissa values are given in meters. Seen from a distance of 4m the circle subtends an angle $\alpha = 0.0347$ rad or $2^0 30´$. Data points from (12).
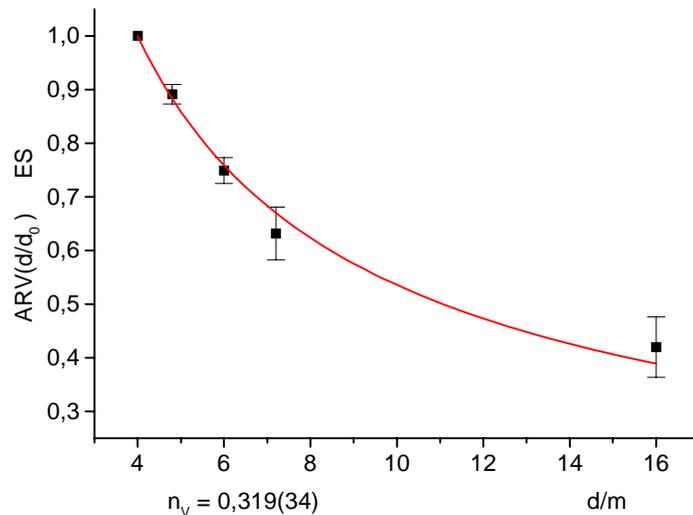

Bild 4. The perceived size of a disc, 17,5 cm in diameter, at a vertical distance between 4.00m and 16.00m normalized to the perceived size of an identical object at 4.00m . Data points from (12).

The result shows that, as expected, the parameter n differs significantly for the two directions of observation. For comparison, both functions are plotted together in Fig. 5. Both curves have been extrapolated to a distance of 33m.

One finds that there are different degrees of what is called size constancy: At greater distance an object viewed horizontally appears considerably larger than one above, while, at short distances the two functions approach each other. The distance at which they converge is defined as the correct d_0, and this has to be determined experimentally. If, for example, one would choose a different d_0, say 2 m, the curves would converge at this value and,

simultanously they would be shifted vertically with respect to each other, resulting in a larger difference at d = 33 m, which would correspond to a more pronounced moon illusion.
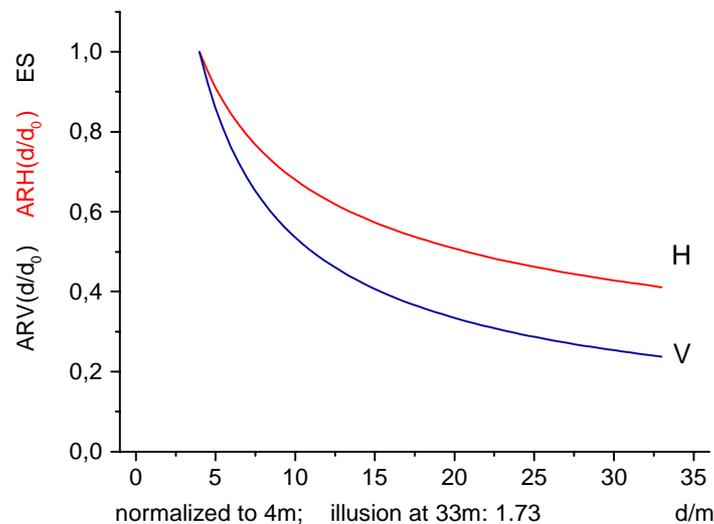
Fig. 5. The perceived size for horizontal and vertical directions of regard, plotted together for comparison. At 33 m an object straight ahead appears considerably larger than an identical object at its zenith. Notice that because of the normalization to d_0 = 4m the functions intersect at this value. If a different value of d_0 were chosen, say 2 m, the curves would meet at this value and they would be shifted vertically with respect to each other and exhibit a larger difference at d = 33 m.

The ratio of the two functions, $ARH(d/d_0)$ and $ARV(d/d_0)$, should give the relative perceived size of the object in an horizontal direction relative to its perceived size in a vertical direction as a function of d, i.e., the moon illusion. The corresponding function, $AM(d/d_0)$, is

$$\frac{ARH(d/d_0)}{ARV(d/d_0)} = AM(d) = (d/d_0)^{\Delta n} \qquad \text{with } \Delta n\ n_H - n_V = 0.260(40) \qquad (5)$$

However, so far $ARH(d/d_0)$ and $ARV(d/d_0)$ are based on an arbtirary assumption of d_0. In order to determine the correct d_0, a direct comparison of the perceived size in vertical and horizontal direction is needed at least for one value of d.

Relevant experimental data have also been reported by Erna Schur (12). In this work, a bright disc projected at the zenith had to be compared with an identical disc at the same distance (varying between 3m and 33m) in the horizontal plane. The latter disk was then reduced in diameter until the subject considered a match to have been achieved. The ratio of the real diameters is a direct measurement of the illusion. In contrast to the size constancy experiments, the angle subtended by the object was kept constant in this case. The experiments were performed at two different angles (1^0 18´ and 30´, respectively). Since similar results were achieved in both cases (12), all the data available have been averaged.

For distances up to a few meters, the ratio of the real diameters (the illusion factor) was found to be just slightly above unity. Between 5m and 10m a rapid increase in the ratio was observed and at more than 10m a more moderate slope was registered. However, even at 33m there was no indication that an asymptotic value (Fig 6, experimental values (12)) has been

reached. The maximum illusion factor, $AM(d/d_0)$, still lies below a value of two This corresponds very well to observations made on the real moon (1,2).
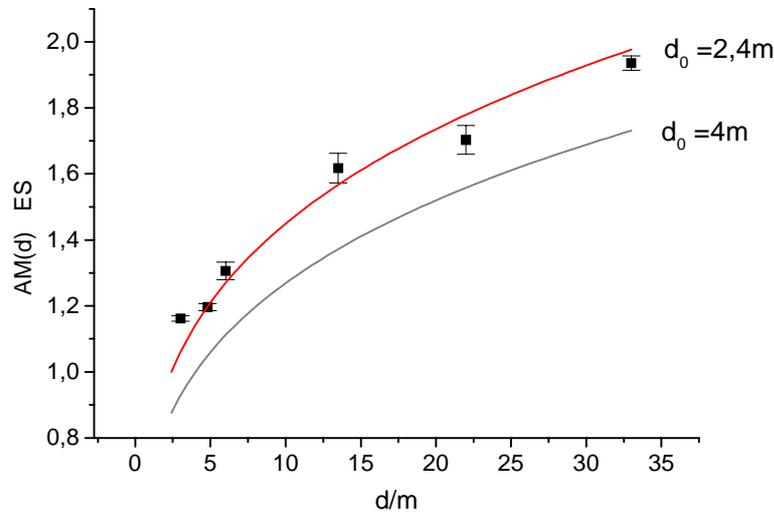

Fig. 6. Experimental data (perceived size of an object viewed horizontally relative to the size of one viewed vertically) at a distance between 3 m and 33 m. The curve shown is $AM(d/d_0) = (d/d_0)^{\Delta n}$ [with $\Delta n = n_H - n_V = 0.260(40)$]. The abscissa scale is given in meters. The lower curve refers to $d_0 = 4.00$ m which was chosen arbitrarily in the course of fitting the size constancy observations. This corresponds to a starting angle α of optimum perception of $0{,}0437$ rad $= 2^0\,30'$. The upper trace gives the result of the fitting procedure. If the object (with diameter 17.5 cm) were positioned at a distance of $d_0 = 2.42$m the angle subtended would be that of optimum perception, $\alpha = 0.0722$ rad or $4^0\,08'$.

The calculated function $AM(d/d_0)$ for two different values of d_0 is shown in Fig. 6. The initial value chosen, $d_0 = 4$m, leads to a function $AM(d/d_0)$ which lies slightly below the experimental data. From a direct fitting to the experimental values one obtains $d_{0\,exp} = 2.42$ m.

This should be the true distance, where, due to definition, the object should appear the same size in both directions. This agrees with the observation that the illusion starts to become noticeable at a distance of 3–5 m. It corresponds to a starting value for the effective angle of perception $\alpha = 0.07224$ rad or $4^0\,08'$ of arc. This is a reasonable value, when one recalls that the maximum angle of optimum vision is 0.2007 rad or 11.5^0. (It seems unlikely that the visual system should select for the maximum angle when there is no obvious need, since the object is fairly small and the surroundings are in the dark.)

It should be mentioned that the function $AM(d)$ reproduces the results of experiments on the moon illusion pretty well up to a distance of 33 m, although the fitting is based on n parameters obtained from experiments on size constancy covering a maximum distance of only 16 m.

Inserting n_H and n_V into Eq.(4) and normalizing it to $d = 2.42$ m instead of 4 m, produces the curves for the perceived size shown in Fig. 7. Compared to the results shown in Fig.5, the illusion factor $AM(d/d_0)$ has increased and now reaches to a value of 1.97 at a distance of 33 m.
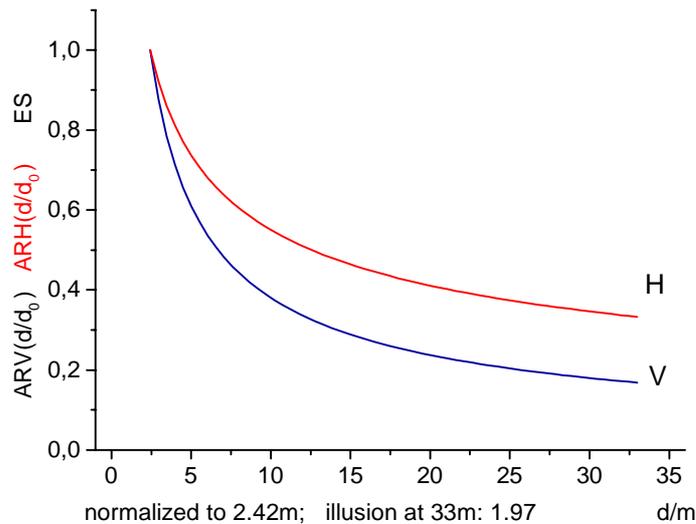
Fig. 7. Perceived size of a circle with a diameter of 17.5 cm, normalized to its size at a distance $d_0 = 2.42$ m. At this distance, due to the model, it should exhibit the same size for both directions of regard. Comparison with Fig. 5 indicates that, at a distance of 33m, the illusion has increased.

3.2 The Gilinsky Experiment

Alberta Gilinsky´s experiment (13, 14) investigated the perception of size under two contrasting observational sets: one for matching objective size and the other for matching retinal or projected size.

The subjects were required to match the size of a standard stimulus object (a white isosceles triangle, base equal altitude) placed at various distances directly ahead of them. This was achieved by altering the size of a variable triangle at a constant distance of 100 feet. As a standard, triangles of different size (between 44 and 78 inches in base and altitude) were presented at six distances, ranging from 100 to 4000 feet.

In one set of experiments "objective" instructions were given. The purpose was to determine the subject´s estimate of the absolute size of the standard triangel when it was shown to them at various distances.

In another set of experiments "retinal" instructions were given. First it was mentioned that an object appears to be smaller the farther away it is. Then the subjects were asked to imagine the field of view as a scene in a picture or photograph. They were reminded that every image in a picture is fixed in size. Now, if they were to cut out the fixed image of the standard triangle and paste it on the image of the variable triangle, would the two images be just the same size?

Using the experimental data of Gilinsky, Eq. (4) can be used to determine the size constancy parameter n. This was done for four different cases (Figs 8 and 9). In Fig. 8a the altitudue of the triangle is 54 inches. The results in the left diagram refer to retinal instructions. Curve fitting leads to a parameter n = 0.472(43) which is not too far away from the result one obtains from Schur´s (12) experimental data (n = 0.579(22)). The difference may be explained as resulting from the quite different conditions of observation.

The estimated size of the standard triangle following the objective instructions (13, 14) are shown in figure 8b. The data show that when required to make an estimate of the absolute size a somewhat surprising result was produced. The value obtained from a fit to the data was n = 1.074(6) >1, which one may term a "size overconstancy". This may indicate that, when taking into account distance, the visual system may overcompensate it.
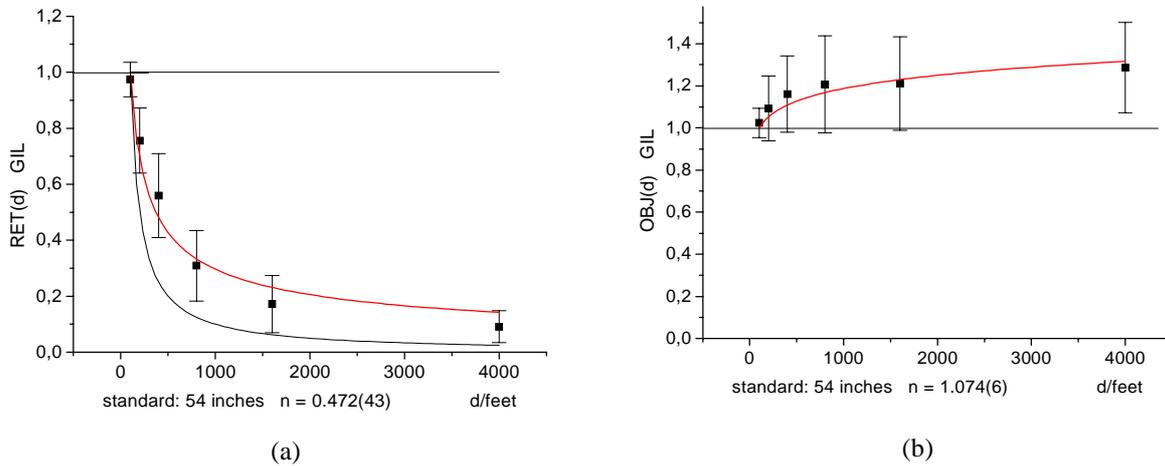

Fig. 8a. Perceived size of a triangle (size 54 inches) as a function of distance. Left curve: Estimate of size following retinal instructions. The straight horizontal line indicates size constancy, the bottom curve corresponds to angle constancy. Fig. 8b: Estimate of the absolute size leads to a size constancy paramater n >1, which may be described as "size overconstancy".

The results for a 66 inch standard triangle (13, 14) are shown in figure 9. In this case n was determined to be 0.515(41) and 1.014(4) for a and b. In the case of retinal instructions, the perceived size seems to be slightly larger for the 66 inch triangle, although the results agree to within their error limits.
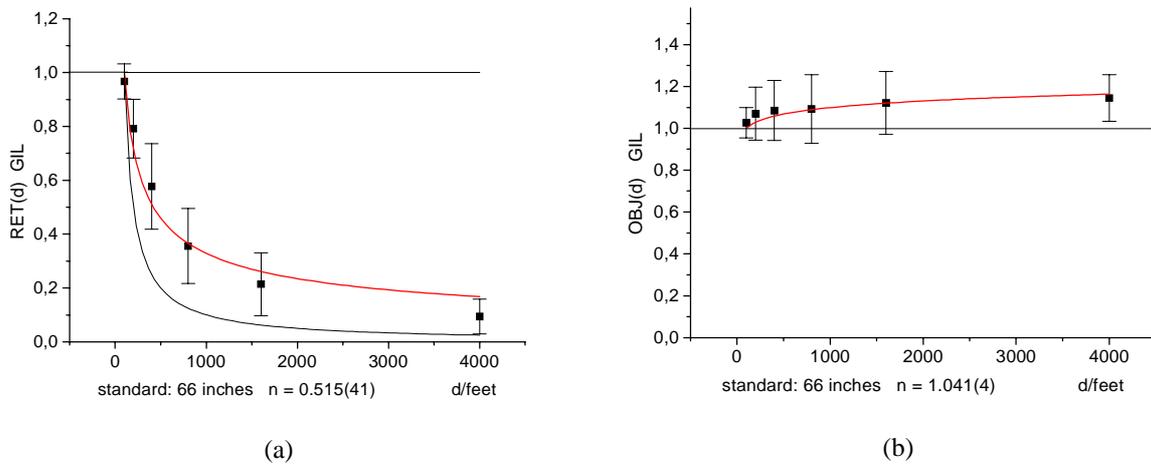

Fig. 9a. Perceived size of a 66 inch triangel at distances ranging from 100 to 4000 feet. The straight horizontal line indicates size constancy, the bottom curve corresponds to angle constancy. Fig. 9b. Subjects were required to estimate the absolute size. The results of the fit may be described as "size overconstancy".

3.3 The Moon Illusion

The model presented here was developed in order to fit the experimental data on the ratio of the perceived sizes of circular discs which were viewed in horizontal and vertical directions. Although it is based on rather simple assumptions, the function AR(d) derived from this model, seems adequate to fit the experimental data on perceived size for both directions of observation with only *one parameter*, n. The function AM(d), obtained in this way, reproduces the illusion observed in the model experiment quite well. It reproduces the main characteristics of the observed behaviour: The effect is very small at short distance (in units of d_0), rises steeply at intermediate distances and then flattens out at higher d values. However, the model AR(d) is not defined for $d < 1$ and there is a singularity at $d = 0$. Also, at $d/d_0 = 1$ one would expect the function AM(d) to be flat and not steep. Therefore, it is questionable if the curvature of AM(d) derived from ARH(d) and ARV(d), corresponds to reality at very small values of d ($1 < d/d_0 < 2$).

Despite these shortcomings, it seems resonable to apply this model to observations on the real moon, although the absolute distances involved are necessarily large in this case.

Based on Schur´s experimental data (12) shown in Fig.6 we derive a value $d_0 = 2.42$m for a disk with a diameter of 17.5cm. Seen from this distance, the disk would subtend the entire angle of optimum perception. Therefore one can calculate this angle. The result is $\alpha = 4.139^0$. (At larger distances this angle is reduced, but because the angle does not shrink to the same extent as the image of the object on the retina an increasing part of the surroundings will be perceived.)

The advantage of introducing d_0 is that all objects subtending the same angle of vision are, on the d_0 scale, at exactly the same distance from the observer. Only the value of d_0 differs for objects of different absolute size.

Schur´s experimental data (Fig.6) were obtained with visual angles not too far away from the angle subtended by the real moon. Assuming that these results hold approximately for the real moon, one can calculate $d_{0/moon}$. This is the distance, at which the moon, seen from the earth, would subtend an angle of $\alpha = 4.139^0$. One obtains $d_{0/moon} \cong 48\,000$ km. Its distance d_{moon} on the $d_{0/moon}$ scale is

$$d_{moon} = \frac{tg(\alpha/2)}{tg(\delta_{MOON}/2)} = \frac{tg\,2.070^0}{tg\,0.259} = 7.99 \quad \text{(in units of } d_0)$$

Therefore, on its own d_0 scale the moon is not at infinite distance at all. The approximate 8 units of d_0, calculated for this distance, apply to any other object which subtends the same visual angle as the moon, e.g., a terrestial object in front of the moon. Only the *actual* values of d_0 are quite different.

According to the model developed here, the size illusion is given by the function AM(d/d_0). At this distance AM(7.99) = 1.73. This result is quite close to that found by Kaufman and Rock from observations where an artificial moon (an illuminated iris) was seen above a natural landscape (3) an lies well within the range given by other authors (1,2,4, and literature given therein).

However, the question remaining is why is the perceived size of the moon at the horizon significantly different from its size at its zenith. Taking into account the basic facts of information theory from which this model is derived, one can argue that the effect may arise as a result of an evolutionary development in the visual system, providing considerable advantage in a real life situation: When observing any object on the horizon (including the sun or the moon), a smaller angle of perception would result in an increase of resolution.

In addition, it is usually observed that the sun or the moon look particularly huge and impressive when visibility is good and objects in the foreground provide details which can be resolved well. This is especially the case when, in addition, the surroundings are dark or lacking in contrast. In this case the information density supplied by the planet´s area relative to its surroundings is extremely high. In order to take advantage of the good optical conditions, i.e., to resolve fine structure, for example the sharp edge of a silhouette, a high pixel density is required to produce the necessary resolution. This forces the visual system to sacrifice solid angle. As a consequence, the object appears exceptionally large.

At the other extreme, it appears to be the case that the sun or the moon never seem to be extraordinarily large when their contours and that of the entire foreground are diffuse. This is also compatible with our model, which is based on information critera. Effects arising from optical considerations such as resolution, brightness, contrast and color play a prominent role here, but the effects of subjective interest are also considerable.

The effects of the variation of the perceived size of terrestial objects can be interpreted in a similar way. Variation of the perceived size would also be expected, even if the object does not change its distance at all, but only its size. This would also seem the case when neither its distance nor its size are altered, but the interest in the object is suddenly increased, thus requiring an increase in the information to be gained from it (i.e. an increase in resolution).

4. Conclusion

Based on the Shannon theorem, it is assumed that the number of pixels processed by the visual system in order to synthesize an image is limited by the channel capacity C. It is further assumed that the visual system has the ability to select pixels from a smaller or larger area of the retinal image, depending on whether it is more interested in details or in a survey. Independent of the size of this area, all the information collected from this area is projected on what one may describe as kind of internal visual memory screen or frame of constant size. Elevated interest in an object produces the tendency to select the pixels from a smaller retinal area in order to increase resolution. The smaller this retinal area, the larger the objects appears to be. The moon illusion is interpreted as resulting from neurobiological developments which have origins way back in evolution, which made it especially important to be able to resolve fine details of objects near to or on the horizon.

The observation that the sun or the moon occasionally seem to be exceptionally large may be triggered by the fact that then the optical conditions are such that it enables one to resolve structural details in front of the celestial object much better than in the surroundings.

A simple function has been derived which can be used to fit the data obtained in early experiments which were performed in order to measure perceived size as a function of distance. This model allows experimental data to be fitted by adjusting a single parameter. One function for each of the two directions of observation (horizontal and vertical) was

derived and combination of them in a third function allows the moon illusion to be predicted to within considerably better than a factor of two. Fitting one more parameter reproduces data obtained from a model experiment simulating the moon illusion.

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