THE BENUSSI EFFECT IN A KINETIC FIELD

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1. *The Benussi effect*

In almost every study on visual perception (and even in the well-known manual by [Osgood 1953]), a figure can be seen consisting of a grey ring that lies half on a black surface and half on a white surface. Its origin is uncertain but I attribute it to [Benussi 1916], if for no other reason than family (scientific and academic). In such a figure, it can be seen that the colour of the ring is relatively uniform. However, such uniformity is, in a certain sense, inexplicable because the half which is on the black surface should appear, by virtue of the simultaneously brightness contrast (or lateral inhibition as we may say today), lighter than the half which is on the white surface. Benussi had the idea of physically separating the two halves of the ring with a black thread stretched vertically on the border between the two surfaces. In doing so, he observed that the difference would have been expected from simultaneous contrast was immediately re-established. Figure 1 shows a variant of Benussi's device in which the ring is replaced by a small rectangle. The reader can reproduce the effect by placing a pencil vertically on the border between the white and black surfaces.

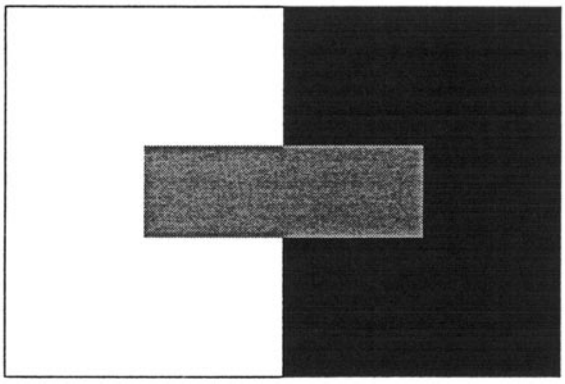

Fig. 1 The Benussi effect: placing a pencil vertically between the black area and the white area (see also the text).

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The explanation of the phenomenon discovered by Benussi - at least the one that I usually give - is as follows: the rectangle is basically unitary (in the sense that it is not visibly divided into more than one part) and all its characteristics, such as length, height and spatial setting are unitary. Thus it is not surprising that the colour is also unitary and is therefore seen as uniform. However, as soon as the rectangle as a whole is split up, by dividing it vertically into two sub-wholes, two distinct parts are formed, the left part and the right part which both acquire a certain independence within the whole. Each one of the two parts lies entirely on a surface of different brightness and so there is no longer any reason (unitariness) why the contrast should not be visibly displayed, therefore the left part appears darker and the right part lighter.

The same result is obtained by reducing the horizontal coaxiality of the two halves of the rectangle, as seen in figure 2.

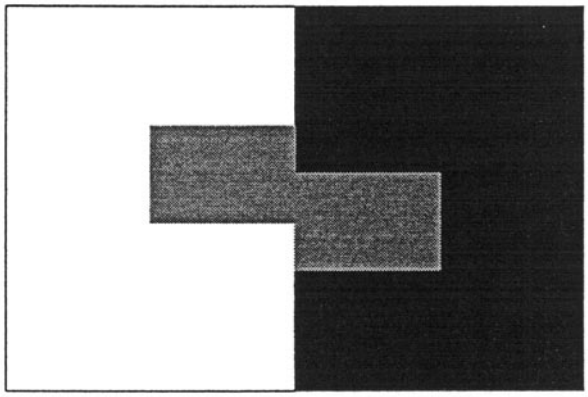

Fig. 2 Even a slight breakdown of unitariness of a rectangle leads to a differentiation in colour between the two halves.

The grey figure (which is not even a rectangle any more) has clearly visible "parts" and therefore nothing prevents a sharp simultaneous contrast occurring with the surrounding white and black surfaces given that, in a certain sense, each part "speaks for itself."

Therefore, the Benussi effect consists of this: that every intervention that causes a certain unit to break down into parts results in the same parts assuming independence, thus becoming different in certain properties. In the case in question their colour changes.

2. *The slow motion tunnel effect*

Figure 3 below represents a special type of tunnel effect ([Wertheimer 1912], [Burke 1962]) that I studied together with Yoshie Kiritani of Chiba University (the work will be published shortly). A vertical, black rectangle (1.5 × 4.5 cm.) is displayed against a white background on a computer monitor. There is also a light grey horizontal rectangle, of 1.7 cm height and varying length (about 10 cm, the reason for this will become clear further on), that moves from left to right at a low velocity (about 1 cm/sec).

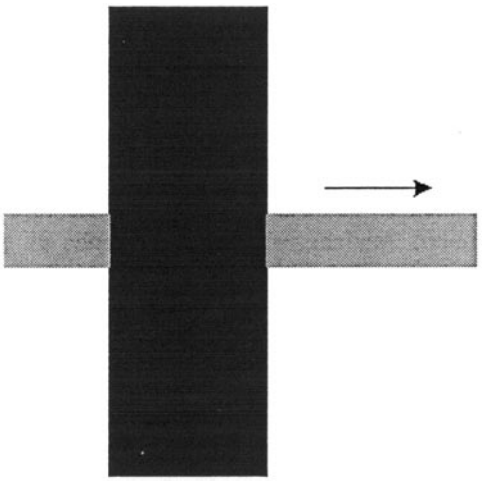

Fig. 3 Illustration of the slow-motion tunnel effect (Vicario and Kiritani): a grey rectangle moves slowly (1cm/sec) behind a black screen.

While I refer to the original work for the detailed description of the stimulation conditions, for the account of the experiments and for their theoretical interpretation (regarding the horizontal and vertical organisation of the events), here I mention only the fact that the perception of a rectangle in movement is connected also to the width of the vertical screen. If the screen is too wide, instead of just a single rectangle in motion, two small, independent, rectangles are seen in movement: one that enters from the left side of the screen and another which exits to the right. If, instead, the screen remains the same but the velocities of the two surfaces in motion are altered, then the unitariness of the rectangle is connected to this difference in velocity. If the ratio between the velocities is less than 1:2.5 (or 2.5:1), a single unit continues to be seen but if

the ratio is greater than 1:3 (or 3:1), two rectangles start to be seen, one slower (or faster) that enters and another faster (or slower) that exits.

3. *Chromatically homogeneous surfaces whose contours move at different velocities*

Ms. Kiritani and I proceeded to reduce the width of the vertical screen until it became an extremely thin line and we verified that, even in this case, it was possible to see two rectangles in movement, provided that the ratio between the velocities was sufficient. In such circumstances, it is a little difficult to speak of the tunnel effect because the simple line covers nothing and consequently cannot be defined a "screen." The perceptual effect is somewhat paradoxical because the line exists as a slit into which a rectangle coming from the left vanishes and another rectangle appears in motion to the right.

It was just a simple step to remove the vertical line too, thus obtaining a chromatically homogeneous surface, the vertical sides of which moved at different velocities. What we did ascertain is that, as long as the ratio of velocities between the left and the right sides was less than 1:1.5, it was not at all apparent whether the rectangle in motion lengthened or shortened. At this point, it is sufficient to place a line, a pencil or a finger vertically across the moving object in order to see the different velocity of contraction (to the left) and expansion (to the right), or even to see two rectangles moving independently of each other on either side of the separator.

This is explained as follows. The rectangle in motion is an event (on this subject see my deliberations in [Vicario 1989] and [1996]), whose parts possess different developing modalities: the left side goes at one velocity and the right side at a different velocity. Alternatively, the situation can be described as an object whose extremities "fish" in different fields which are characterised by differing kineses. Up to a certain point, the tendency of the event is to present itself as a rectangle whose movement is uniformly distributed in all parts of the object and we are not aware of the extremities moving at different speeds. I say "up to a certain point" because, as long as they come to a ratio of 1:2, the difference can be perceived. In my opinion, the situation is perfectly comparable with that in figure 1, in the sense that the tendency of the static rectangle to be perceived as having a uniform brightness exploits the difference of the brightness of the fields on which the two extremities lie.

Now let us introduce a "separator." In the static example, the rectangle becomes divided into two parts, thus giving rise to the brightness contrast, the left part is seen as having a different colour from that possessed by the right

part. In the kinetic example, the separator highlights the fact that the rectangle has a "head" and a "tail" that establish themselves as independent parts. It follows that each part reaches a certain autonomy and thus it can be seen that the tail moves at a different velocity from that of the head. In other cases, using higher ratios of velocity, the "rectangle movement" event splits into two events: (i) "a rectangle that moves from the left and disappears under the separator" (the pencil, the finger, etc.) and (ii) "a rectangle that appears from under the separator" (the pencil, the finger, etc.). Since the transformation of the event takes place when a separator is introduced into the field, which is the same device that Benussi used to demonstrate that the colours can also depend on the figural properties, it can be truly said that the Benussi effect manifests itself in the kinetic field too.

4. *Considerations of the Benussi effect*

The situation in figure 1 is characterised by the following facts or hypothetical mechanisms: (a) the distal stimulus, that is, the small rectangle as a physical object is uniform in all its parts; (b) the proximal stimulus, that is, whatever takes place on the retina, is uniform for all parts because the reflectance of the parts of the physical objects is identical; (c) the processes corresponding to the projection of different parts of the small rectangle on the retina are unequal because the lateral inhibition increases the brightness of the parts surrounded by black and diminishes the brightness of those surrounded by white; (d) a process of homogenisation of the signals arising from the areas undergoing lateral inhibition takes place; (e) the small rectangle appears to be of uniform brightness; (f) the phenomenal object corresponds exactly to the physical object; (g) the separator eliminates the homogenisation process.

A slightly different example is illustrated in the classroom when the students' attention is directed to a wall illuminated by a side window. As we well know, the intensity of the light reflected from the wall is not uniform but gradually diminishes from the areas nearest to the window to those furthest away from the window. The wall appears uniformly bright and we have no difficulty in demonstrating the opposite. By taking a stick and placing it vertically against the wall, it can be demonstrated that the surface between the separator and the window is brighter than the surface between the separator and the centre of the room (see figure 4). (This phenomenon was studied experimentally by [Koffka 1923], though in a different form.)

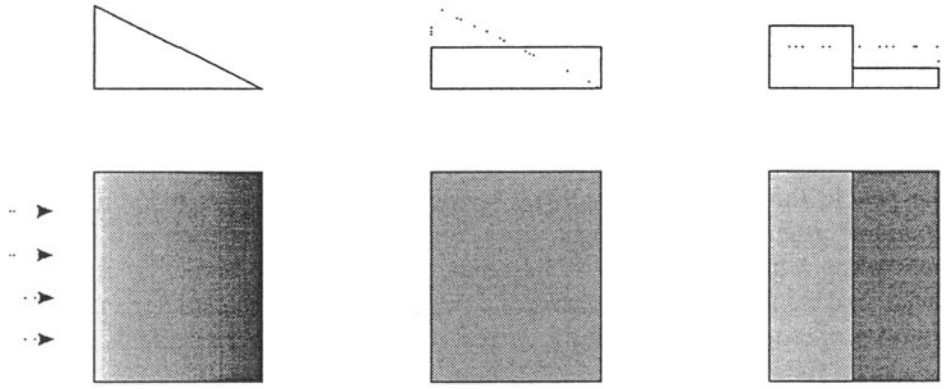

Fig 4 Illustration of the wall case seen with lateral illumination: on the left the distribution of light; in the centre the perceived brightness, on the right the brightness perceived as a consequence of the separator being introduced. In the small figures above: on the left the distribution of light, in the centre and on the right the pattern of perceived brightness.

As it is, the example of the wall can be analysed as follows: (a) the distal stimulus, that is, the wall as a physical object, is uniform in all its parts; (b) the proximal stimulus, that is, that which is projected on the retina is unequal in all its parts because the light which comes from one side is more intense than that coming from the other; (c) the processes corresponding to the projection of different parts of the wall on the retina are unequal; (d) a process of homogenisation of the signals coming from different parts of the retina takes place; (e) the wall appears to be uniformly bright; (f) the phenomenal object corresponds exactly to the physical object; (g) the separator eliminates the homogenisation process and two areas are seen, one lighter and the other darker; (h) the homogenisation process is reproduced on either side of the separator because the parts on the right and the parts on the left are not illuminated to the same physically uniform extent.

At this point, I must mention a case that has always intrigued me. Let us imagine being in front of a vertical brick wall as shown in figure 5. The bricks are perceived as perfectly identical, in the sense that those visible in the line of sight are just as large as those seen out of the corner of the eye: the brick wall is perfectly uniform in all its parts. The fact may appear to be taken for granted by the casual observer: the bricks *are* all equal!

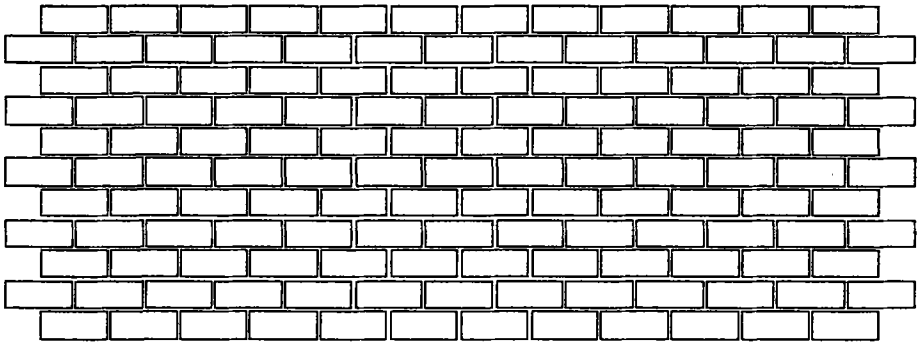

Fig 5 A brick wall with elements that are equal and are perceived as equal.

However, this fact is not taken at all for granted by the student of vision, who knows that, for projections of equal areas, phenomenal objects become smaller and smaller on moving from the fovea towards the periphery of the retina. This statement of fact is usually illustrated by figure 6, in which demonstrates that in order to obtain objects of equal size the retinal area concerned must be increasingly greater as one gradually proceeds towards the periphery of the retina.

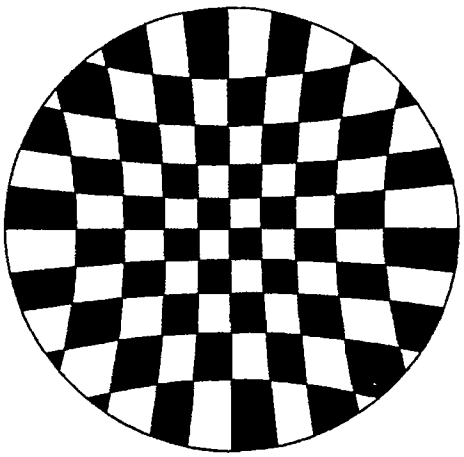

Fig 6 Representation of the fact that in order to have perceptually equal surfaces, stimuli must be applied to an increasingly larger area so as to increase the eccentricity of the stimulation. (With the paper in contact with the tip of the nose and observing the figure with one eye, the black surfaces look very must like squares both at the centre and at the periphery).

And so, how is it that all the bricks are seen to be equal, from those in the fovea to those at the periphery? My hypothesis is that, in this case, the same homogenisation process that we have already discussed is at work, which would cause an equalisation of the sizes of the objects: objects which are clearly identical in all other characteristics.(Unlike the case of the texture gradient that produces an abatement in the third dimension, see [Metzger 1975], figures 506 and 507, that I would discuss separately.)

The example of the brick wall seems to lead back to that of the laterally illuminated wall, given that (a) the distal stimulus, that is the brick wall, is uniform, (b) the proximal stimulus is not uniform because the projections of bricks appear to become smaller and smaller with their eccentricity in relation to the fixed point and (c) the processes taking place on the retina are probably not uniform either. However, with regard to (d), the homogenisation process, there exists an indication of its presence. I am referring to the phenomenon of apparent rarefaction that I examined some time ago ([Vicario 1971a], [1971b], [1972], [1981]; [Chapman and Cavonius 1974]; [Bressan, Masin, Vicario and Vidotto 1985]; [Vardabasso and Zanuttini 1980], [1985], [1987]). As can be seen in figure 7, if one part of a homogenous composition is figurally circumscribed, the elements present in the circumscribed area appear slightly "larger," and more widely spaced and also possibly appear to exhibit a greater chromatic contrast in relation to the background.

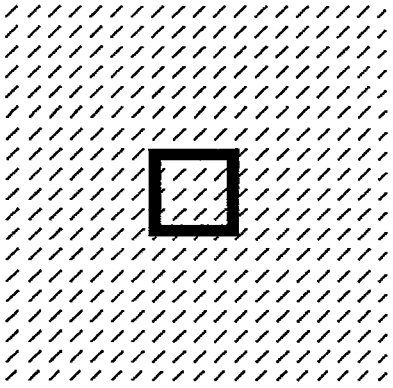

Fig 7 Inside the central square, the lines appear more widely spaced and the background seems a little brighter than outside the central square.

My opinion is that (g) the presence of a figural instrument of separation causes the breakdown of the probable compromise that exists between the size response for the stimuli placed in front of the fovea and those situated at the periphery of the retina. In this way both areas acquire a certain independence

and the difference in size is seen, just as in Benussi's example, the difference in brightness is seen. The importance of all this is that, in the absence of a separator that we introduced purely for experimental purposes, one sees (e) the totally uniform wall, (f) exactly corresponding to the physical object.

It must be added that (h) the same process of homogenisation, which develops on the whole of the visible surface in the absence of a separator, is reproduced in the two areas which are created by the introduction of the same separator, so that both areas appear individually homogenous. It would not surprise me if the introduction of more separators led to more *Felderfüllungen,* with the result that the invisible size gradient of the composition (gradient at the level of primary neural processes) would be transformed into a juxtapositioning of surfaces of visibly different composition.

5. *Concluding remarks*

My impression is that the Benussi effect is much more than just a simple optical curiosity and far more than a simple device to demonstrate, on a perceptive level, the interdependence of heterogeneous elements such as colours and outlines of figures. Examples of such can be given in the works of [Kanizsa 1954], for colour and marginal gradients, or those of [Koffka 1962], pages 288-298, for size, brightness and velocity.

To my mind, it shows the existence of balancing or homogenisation processes, operating in the perceptive system that function in the same way as constancies. When two elements of the field have one or more important characteristic in common, they become equalised, obscuring or transforming their dissimilar characteristics.

There is, however, one problem: at what point between the stimulus and perception do such processes occur? It is precisely this question that differentiates Benussi's case from that of the wall (white or brick does not matter). In the former, these processes seem to intervene at a relatively high level when the uniformity becomes defined after (at least logically if not temporally) the figure is formed. In the latter, they appear much earlier when it is a question of balancing the results of stimulation at lower levels, that is, those of the simple assessment of brightness (the white wall example) or of size (the brick wall example).

References

[Benussi 1916] V. Benussi, "Versuche zur Analyse taktil erweckter Scheinbewegungen," *Archiv für die gesamte Psychologie* 36, 59-135.

[Bressan, Masin, Vicario, Vidotto 1985] P. Bressan, S.C. Masin, G.B. Vicario, G.A. Vidotto, "A functional-measurement study of apparent rarefaction," *Bulletin of the Psychonomic Society* 23, 415-17.

[Burke 1962] L. Burke, "On the tunnel effect," in A. Michotte et collaborateurs, *Causalité, permanence et réalité phénoménales*, Publications Universitaires, Louvain, 374-406.

[Chapman and Cavonious 1974] F.A. Chapman and C. Cavonius, "The influence of stimulus area on visual acuity, effect of observer criterion," *Psychologische Forschung* 36, 329-34.

[Kanizsa 1954] G. Kanizsa, "Il gradiente marginale come fattore dell'aspetto fenomenico dei colori," *Archivio di Psicologia, Neurologia e Psychiatria* 15, 251-64.

[Koffka 1923] K. Koffka, "Über Feldbegrenzung und Felderfüllung," *Psychologische Forschung* 4, 176-203.

[Koffka 1962] K. Koffka, *Principles of Gestalt Psychology*, Routledge & Kegan, London.

[Metzger 1975] W. Metzger, *Gesetze des Sehens*, Kramer, Frankfurt am Main.

[Osgood 1953] C.E. Osgood, *Method and Theory in Experimental Psychology*, Oxford University Press, New York.

[Vardabasso and Zanuttini 1980] F. Vardabasso and L. Zanuttini, "Diradamento apparente e acuità visiva," *Giornale italiano di Psicologia* 7, 475-84.

[Vardabasso and Zanuttini 1985] F. Vardabasso and L. Zanuttini, "Variabili fenomeniche e discriminazione visiva," *Giornale italiano di Psicologia* 12, 123-34.

[Vardabasso and Zanuttini 1987] F. Vardabasso and L. Zanuttini, "Rarefaction and Resolution, Stimulus Area and Detection: an Order of Priority," *Perceptual and Motor Skills* 65, 447-52.

[Vicario 1971a] G.B. Vicario, "Un fenomeno di diradamento apparente in campo visivo," *Archivio di Psicologia, Neurologia e Psichiatria* 32, 515-42.

[Vicario 1971b] G.B. Vicario, "Visual Acuity and Stimulus Area," *Psychologische Forschung* 35, 17-26.

[Vicario 1972] G.B. Vicario, "Phenomenal Rarefaction and Visual Acuity under 'Illusory' Conditions," *Perception* 1, 475-82.

[Vicario 1981] G.B. Vicario, "Diradamento apparente e acuità visiva," *Atti dell'Istituto Veneto di Scienze, Lettere ed Arti* 139, 347-53.

[Vicario 1989] G.B. Vicario, "Forma ed eventi," in O. Longo, ed., *Forma, rappresentazione e struttura,* Laboratorio Servizio Tecnologia, Naples, 115-29.

[Vicario 1991] G.B. Vicario, "L'ipotesi della costanza in psicologia," *Rivista di Psicologia* 66, 9-18.

[Vicario 1996] G.B. Vicario, "La percezione di eventi," in P. Boscolo, F. Cristante, A. Dellantonio and S. Soresi, eds., *Aspetti qualitativi e quantitativi nella ricerca psicologica. Scritti in memoria di Albina Lucca,* Il Poligrafo, Padua, 291-98.

[Vicario and Kiritani 1999] G.B. Vicario and Y. Kiritani, "Slow-Motion Tunnel Effect: an Enquiry into Vertical Organization of Perceptual Events" (in preparation).

[Wertheimer 1912] M. Wertheimer, "Experimentelle Studien über das Sehen von Bewegung," *Zeitschrift für Psychologie* 61, 161-265.

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