'Berkley´s Touch'
or:
Is only one Sensory Modality the Basis of the Perception of Reality?

Alf C. Zimmer

... I believe whoever will look narrowly into his own Thoughts, and examin what he means by saying, he sees this, or that thing at a Distance, will agree with me that, what he sees only suggests to his Understanding, that after having passed a certain Distance, to be measur´d by the Motion of his Body, which is perceivable by Touch, he shall come to perceive such, and such Tangible Ideas which have been usually connected with such and such Visible *Ideas*. (George Berkeley, An Essay towards a New Theory of Vision, Dublin, 1709), Zitat XLV.

In this quote Berkeley proposes the dogma[1], that space is perceived by touch and that only secondarily by associating tactual with visual perceptions the perceiver grows accustomed to the notion of visual perception of space. This claim that touch is the primary sense organ for perceiving reality has determined much of the discussion about perception in the age of Enlightenment and still influences popular theories of perceptual development (see Piaget, 1969).

[1] Why vision and audition seem to be the sensory basis of higher cognitive functions explains Locke (1694; LI): "No sooner do we hear the Words of a familiar Language pronounced in our Ears, but the *Ideas* corresponding thereto present themselves to our Minds. In the very same instant, the Sound and the Meaning enter the Understanding. So closely are they United, that ´tis not in our Power to keep out the one, except we exclude the other also. We even act in all respects, as tho´ we heard the very Thoughts themselves. So likewise, the Secondary *Objects*, or those which are only suggested by Sight, do often more strongly affect us, and are more regarded than the proper *Objects* of that Sense; along with which they enter into the Mind, and with which they have a far more strict and near Connexion, than *Ideas* have with Words. Hence it is, we find it so difficult to discriminate, between the immediate and mediate *Objects* of Sight, and are so prone to attribute to the former, what belongs only to the latter. They are, as it were, most closely twisted, blended, and incorporated together. And the Prejudice is confirm´d, and riveted in our Thoughts, by a long tract of Time, by the use of Language, and want of Reflexion. However, I doubt not, but any one that shall attentively consider what we have already said, and shall say upon this Subject before we have done, (especially if he pursue it in his own Thoughts) may be able to deliver himself from that Prejudice. Sure I am, ´tis worth some Attention, to whoever wou´d understand the true nature of *Vision*."

The very core of this argument is captured in Dr. Molyneux´s question as quoted by John Locke (1694): "I agree with this thinking Gent ... and am of opinion, that the Blind Man, at first sight, would not be able with certainty to say, which was the Globe, which the Cube, whilst he only saw them: though he could unerringly name them by his touch, and certainly distinguish them by the difference of the Figures felt "(pp. 67-68). In John Locke´s theoretical framework, the complex idea of space relies on tactual sensations leading to the ideas of objects. Despite his objections against Locke´s empiricism, Berkeley answers Molyneux´s question in the negative: "... a Man born Blind and made to See, wou´d, at first opening of his Eyes, make a very different Judgment of the Magnitude of Objects intromitted by them, from what others do. He wou´d not consider the Ideas of Sight with reference to, or as having Connexion with, the *Ideas* of Touch." (p. 93)

The question if someone born blind will be able to identify known objects by looking at them after he has been operated has later motivated Condillac (1754) to develop an empiristic theory of perception based upon touch as the primary sense organ. "It is true that we do not notice the judgments we make in order to grasp the whole of a circle or square...." (Also see Diderot (1749): "It follows ... that we owe to experience the notion of permanent objects; that by touch we acquire that of their distance; that perhaps the eye must learn to see as the tongue to speak").

Upon this theoretical background one has to regard the development of psychophysics in beginning of the 19th century starting with Ernst H. Weber´s investigations "de tactu" of 1834 and "Der Tastsinn und das Gemeingefühl" of 1846. In a similar fashion the development of empiristic theories of space perception by Lotze (1989), Helmholtz (1860), and Wundt (1896) have been influenced by Berkeley´s dogma of the primacy of touch. The quintessence of these theories starts from the notion that only by touching objects or being touched by them, by moving objects or moving our bodies and limbs towards them we experience reality directly. Associating these direct experiences with the sensory data given by eye or ear, spatial vision or hearing becomes possible; insofar they can be regarded as a symbolic – because indirect – representation of the touchable reality similar to language[2].

[2] Fodor & Pylyshyn (1981) in their critique of Gibson´s (1979) 'Ecological Perception' have reiterated this position very clearly but without relating it to its Empiristic roots by refuting Gibson´s core concept of 'direct perception' with the argument that any theory of perception has to be structured according to transformational grammar.

The primacy of touch as understood by Weber had direct consequences for his experimental methods and their generalization to other sensory channels: "My results on the perception of weights by the tactual sense are therefore valid for the visual perception of length, too." Especially J. Piaget´s "The mechanism of perception" (1969) has popularized Berkeley´s dogma with direct consequences for the education of young children; according to his claims e.g. young children born blind should not be able to make short-cuts in their explorations of space because making short-cuts without visual information depends on the formal operation of computing the cosine. Contrary to this claim, these children are able to make short cuts: a result which either contradicts Piaget´s stage theory of cognitive development or implies that tactual space perception cannot be the basis of geometric space.

Berkeley´s argument concerning the epistemological primacy of touch radicalizes the Stoic point of view on the criteria of reality (Sextus Empiricus, Pyrrhonic scepsis I, 228); according to which "real knowledge" relies on touching and manipulating object. In many Indo-European languages this epistomological point of view is implicit: see for instance the English words 'concept' or 'percept' which both derive from the latin 'capere', it is even more obvious in Germanic languages e.g. in German *Begriff* (concept) from *Greifen* (grasp or catch) und *Wahrnehmen* (perceive) from *wahr* (true) und *nehmen* (take): Taking as true or 'grasping reality' this corresponds well to the fact that real size can only be perceived by touching; the seen size in contrast depends on the distance between the perceiver and the object; especially the Ponzo illusion shows how variable the vision impression of size is. However, the phenomenon of visual dominance as shown in the Ames room reveals that in the case of discrepancies between haptics and visus the visual perception prevails over the (correct) haptic perception.

Aristotle vindicated visual perception as a medium for grasping reality by claiming that not isolated sensations but the invariance of the relative motions of objects and perceivers constitute the veridicality of visual perception, a point of view which became focal in Gibson´s ecological perception (1979). Aristoteles attacked the Stoic reliance on touch even directly by reporting a stunning illusion of touch: If one crosses the index and the middle finger and touches **one** object, **two** objects are perceived. This indicates that tactile perception relies on top-down processes too, insofar as the act of perceiving relies on representations of the world in the mind of the perceiver.

Aristoteles´ observation constitutes an argument against classifying touching as a "lower" sense modality in comparison to seeing or hearing because this classification of senses divides them according to be criterion of complexity: "lower" sense modalities are directly and entirely tuned to changes in a single physical dimension, in contrast "higher" sense modalities allow the identification of objects (in vision: forms and symbols, and in audition: melodies and phonemes which a turn stand for symbols). If the Aristotelian illusion indicates that tactual experiences rely on internal representation as much as hearing or seeing, touch has to be classified as an object-oriented sense modality, however, in this case touch lacks the immediacy of perception which Locke and Berkeley presuppose when postulating the primacy of touch. Furthermore the apparent "wisdom of language" and even self observations relying on verbal reports have to be regarded with caution, as a remark by Katz (1924) shows, namely that the strong parallelism between perceiving and acting might go back to one feature of Indo-European languages where perceptions "rule the accusative" as actions do; in contrast the Khartvelian languages (e.g. Georgian) differ just in this feature but are compatible in most other syntactic constructions with Indo-European languages. As postulated by Whorf (1950) in the so-called Sapir-Whorf hypothesis of the determination of perception by language, the notion of perceiving as a mental **act** might be result of the linguistic background of European philosophy.

Since the times of Molineux a couple of cases have been documented where congenitally blind have gained vision; all these cases indicate that these people are able to visually identify objects which up to then they have only experienced tactually (see Gregory 1970, Morgan 1977). The limits of the intersensory coordination become apparent in the drawings of this people which show that – at least in the beginning – these people are only able to depict those parts of object which are accessible by touch (see Fig. 1); for instance, they cannot 'comprehend' shadows.

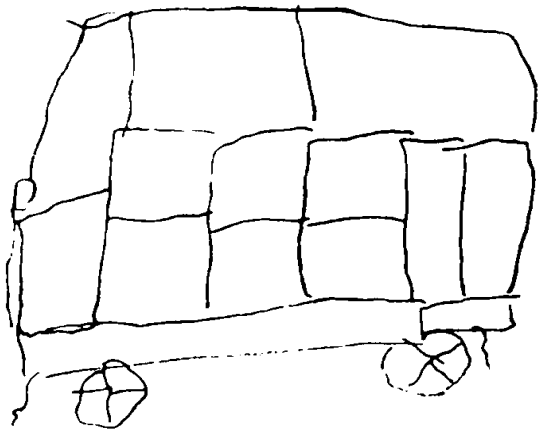


Fig. 1 a

Fig. 1 b

Fig. 1 c

Fig. 1: Drawings of congenitally blind people after an operation giving them vision.

A further neuropsychological argument for the coordination of vision and touch constitute the results of the research group of Bach y Rita (1972) they show that congenitally blind people are able to identify objects the picture of which has been transformed into a vibration pattern on their back (see Fig. 2).

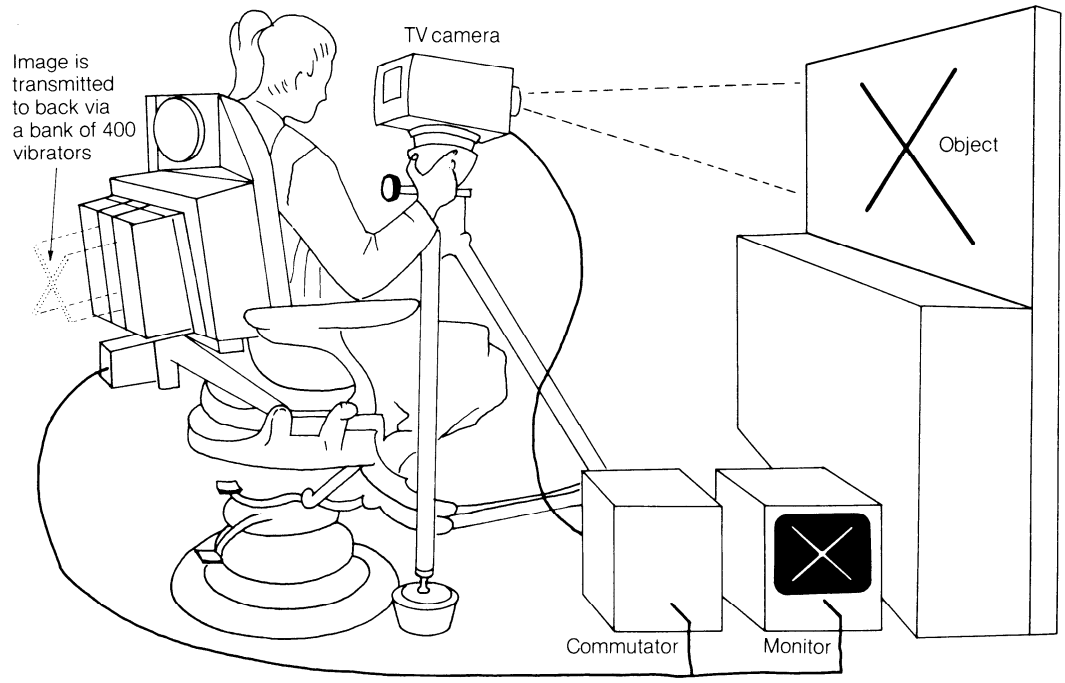


Fig. 2: The apparatus used by the research group of Bach y Rita

On this principle rely assistive instruments for blind people as e.g. the Optacon (Bach-y-Rita, et al. 1969).

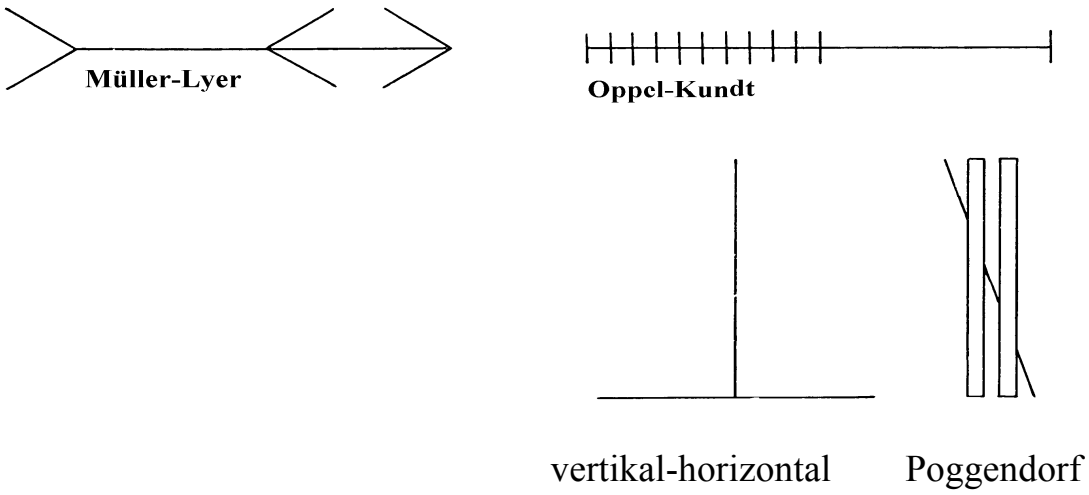
This example of the coordination of different sense modalities supports the Gestaltist postulate of perception as an objects-directed process. Graziano & Gross (1995) found a bi-modal cells in the parietal lope of monkeys; that responds both to the tactile and corresponding visual stimulations but most important is that in contrast to the standard Hubel & Wiesel-type of receptive fields the visual response of these neurons is not related to the position of the retina but to the position the body of the perceiving animal.[3]

Well before these neuropsychological and neuroanatomical results in favor of perception as the result of intersensory cooperation and not of a hierarchical order, functional analyses and comparisons of the tactual and visual sense modalities have been undertaken. The epistemological motivation behind these analyses has been on the one hand the refutation of Berkeley´s dogma and on the other hand the notion of perception as an aggregation of sense data. Using a similar chain of argumentation as Aristotle in his critique of the stoic position, by showing the parallelism in of vision and touch in regard to perceptual illusion, Berkeley´s dogma of the priority of touch was put into question.

Starting with Volkmann (1858) and – probably not – ending with Franz, V.H., Gegenfurtner, K.R., Bülthoff, H.H. and Fahle, M. (2000) the following classes of illusions have been analyzed for the parallelism between vision and touch:

1. The Oppel-Kundt-Illusion: Parrish (1895), Robertson (1902), Volkmann (1858);
2. The Müller-Lyer-Illusion: Over (1968), Patterson & Deffenbacher (1972), Rudel & Teuber (1963), Tsai (1967), Wong (1975a);
3. The vertical-horizontal-illusion: Frey & Craven (1972), Künnapas (1975), Reid (1954), Tedford & Tudor (1969), Wong (1975b), Wong (1977);
4. The Poggendorf-Illusion: Fisher (1966), Pasnak & Ahr (1970);
5. The Ponzo-Illusion: Leibowitz & Pick (1972);
6. Illusory motion: Benussi (1916);
7. The Bourdon-Illusion: Day (1990);
8. The Ebbinghaus (Titchener) illusion: Franz, Gegenfurtner, Bülthoff, Fahle (2000)

[3] This result shows that the apparent plausibility of the constructivist approach to the perception as suggested by Müller (1838) or more recently by Tarr & Bülthoff (1995) is not really stringent because the retinotropic projections are not the only information upon which the brain can construct object perceptions.



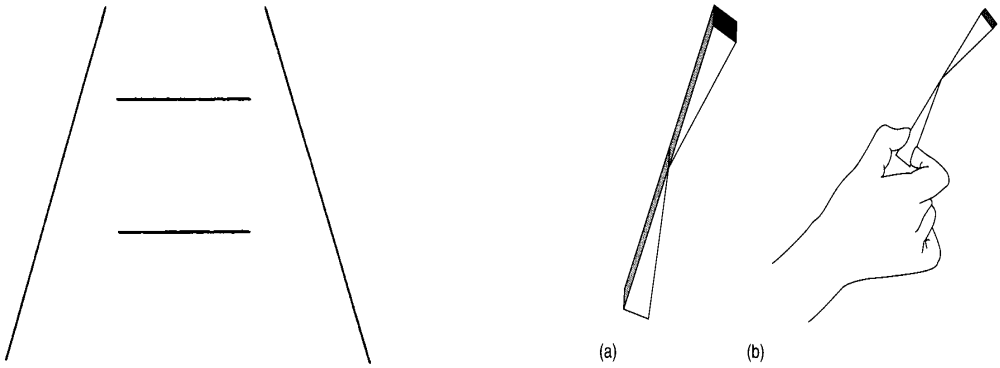
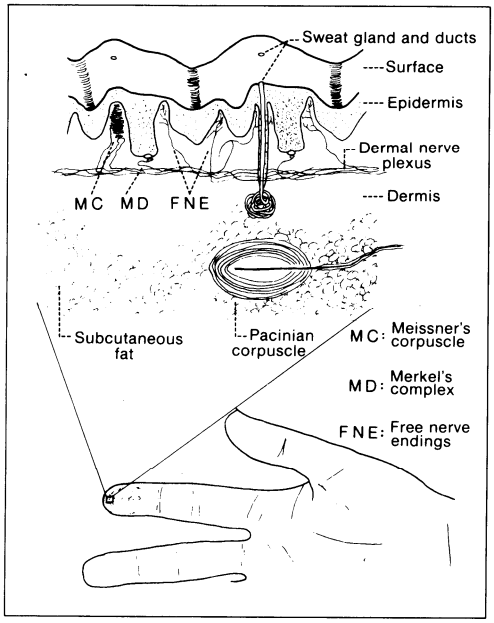


Abb. 3: Geometric-optical illusions having an analogous effect on touch.

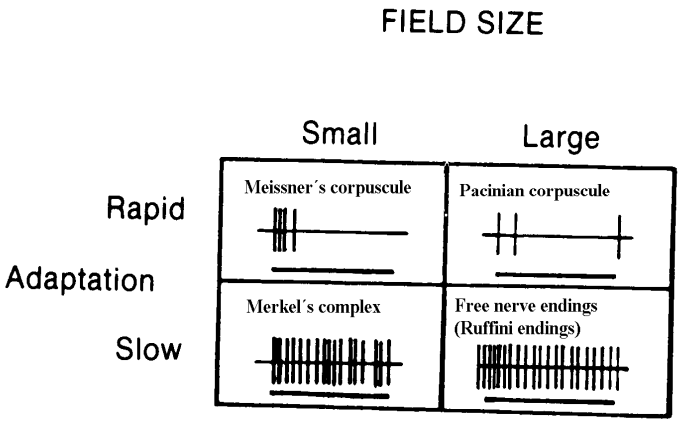
Overviews and epistemological interpretations of these experiments can be found in: Fechner (1860), Sobeski (1903), Rieber (1903), Jaensch (1906), Révész (1934), Hippius (1937), Révész (1938), Révész (1953), Scholtz (1957/58), Hatwell (1960), Over (1966), Katz (1969), Huntley & Yarus (1973), Frey (1975).

Gregory´s argument (1970) that all geometric optical illusions are due to the experiences of the spatial environment and their representation in pictures and that the effect of illusion-inducing patterns should vanish if these experiences are lacking, have been refuted by the

experimental results of Leibowitz and Pick (1972) showing that the Ponzo-illusion can be shown in cultures without a carpentered environment, and other results, e.g. those of Jungnitsch, who has analyzed these illusions with congenitally blind. Loomis (1990) has shown that tactile perception has the characteristics of a low-pass-filter and a closer inspection of the mechano-receptors which transform physical forces into neural signals supports this view at least for passive tactile perception (see Fig. 4).



a)



b)

Fig. 4: The anatomical and functional features underlying haptic perception.

a) The structure of glabrous skin, as illustrated by a section through the finger pad (adapted from Vallbo & Johansson, 1978)

b) The neuronal responses to an indentation (⎍) in the four haptic receptors which can be classified according to fieldsize and speed of adaptation.

In a similar fashion optical illusions can be accountered for low-pass-filtering which might be differentially tuned to the dimension of the – body related-dimensions of the perceptual space. For this reasons the apparent parallelism between visual perception and passive tactile perception can be caused by the same physiological process of low-pass-filtering and therefore the analyses of tactual illusions are irrelevant for the critical appraisal of Berkeley´s dogma or at least non not conclusive.

Gestalt Theory, starting with Ehrenfels (1890)[4] referring to Mach´s phenomenon of the perceptual identity of melodies under transpositions regarded perception in general as object-oriented despite the above mentioned linguistic cautelae of Katz. The "Graz School" and the "Berlin School", however, differ in the postulated processes for bridging the gap between perceived objects and sense data. According to the "Graz School" and especially for Benussi (1916) invariants, that is, relations of relations, constitute the perceptual objects, this reminds of the Aristotelian approach. In contrast, the Berlin School (especially Köhler (1920) and Koffka, 1935) postulate processes of self-organization analogous to the properties of the electro-magnetic field; the driving force behind the self-organizing processes is the minimum principle which has motivated Attneave (1981) to coin the expression "soap bubble psychology". Both Gestaltist accounts results in a positive answer to Molineux´s question and have motivated many Gestalt psychologists to experiment in the field of inter-sensory processes.

The fixation to the epistemological question in combination with the classification of touch as a passive sense modality has allowed only few researches to go beyond the analysis of illusions: Metzger (1954), Witte (1975) as well as their students Färber (1980) and Jungnitsch (1984) have analyzed the spontaneous active form of touch in the exploration of forms. In

[4] Ehrenfels refers directly to Mach (1886), however similar arguments for the solution of a problem posed by Molyneux´s question appear as early as 1759 when Porterfield argues: "..... I have already demonstrated, that the Judgments we form of the Situation and Distance of visual Objects depend not on Custom and Experience, but on an original , connate and immutable Law, to which our Minds have been subjected from the Time they were first united to our Bodies; and therefore the blind Person, immediately upon receiving his Sight, must, by virtue of this Law, by his Eyes alone, without any Assistance from his other Senses, immediately judge of the Situation of all Parts of the Globe and Cube" (pp. 414-415). A similar train of arguments can be found in Kant´s "Critic of pure reason" (1781) for the visual space as a-priori-representation underlying all other kinds of perception. The first mathematical treatment of perceptual invariants has been gone by Vieth (1818) when constructing the Horopter. Müller (1838) derived a constructivistic approach for object perception on the foundation of Vieth´s analyses; he argues that the experience of a rigid body or all other bodies in three dimensions is only possible due to mental activity which constructs this experience from multiple two-

parallel, J. J. Gibson has demonstrated the veridicality of "Active Touch" (1962), an analysis influenced by Katz (1924). These experimental results and especially Gibson´s approach of considering perception as a system tuned to object recognition is more important in shattering Berkeley´s dogma of the primacy of touch than the experimental results comparing visual and haptic effects of comparable illusion producing patterns.

If instead of passive tactile perception active touch is used for investigating three-dimensional objects and spatial arrangements, the comparison with the parallel visual processes makes the critique of Berkeley´s dogma even more conclusive. Metzger, Vukovich-Voth, Koch (1970) have investigated the perception of the relative magnitude of parts of three-dimensional objects and have found consistent bias effects. Jungnitsch (1984) has shown how the "exploratory patterns" of congenitally blind and seeing subjects determine the amounts of illusion in a complex symmetric pattern. Congenitally blind and seeing subjects spontaneously use the following strategies of exploration (and even the relative proportion in both groups are similar): a) global touching, b) utilizing the finger width gliding with constant speed, and c) applying the bi-manual distance between fingers. Only the later strategy leads to differences between the two groups of subjects: congenitally blind use this strategy more often probably due to the fact that it is part of the training in rehabilitation centers for blind people. In general, Jungnitsch (1984) shows that especially the contradictory results regarding touch in the Oppel-Kundt-Illusion are the result of the different exploratory modes applied in the different experiments. For instance, the results of Volkmann (1858) rely on experiments allowing subjects to explore freely and to compare patterns in parallel, in contrast James (1890) or Robertson (1902) obtained their contradicting results (favoring Berkeley´s dogma) when requiring subjects to perceive passively.

The above mentioned low-pass-filtering characteristic of skin receptors can be partially over come by active sequential exploration. Thus, only those comparisons of illusion in vision and touch bear on the question of Berkeley´s dogma which either are both active or both passive (the passive perception approach, however, generates further problems because it prevents subjects to apply the normal, that is, investigative perceptual processes). However, active exploration, that is, moving the hands in active touch or changing the point of view in seeing, reduces the effects of illusions, sometimes they even disappear. In both modalities not only object perception is possible but corresponds in such a way that cross-modal object

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dimensional projections when the object or the perceiver in relation to the object is moved (p. 1176); this conception has been revised by Pinker (1997) and Tarr & Bülthoff (1995).

recognition is possible as shown in the results reported by Gregory (1970) and of the research group of Bach y Rita. As early as in 1966 J. J. Gibson has postulated that if perception is object-oriented then the senses interact in order to achieve this task by functioning as a unitary, albeit complex system. His postulate that perception is the result of a systemic interaction of senses makes the question of the priority of a non-question.

Molyneux´s question as well as Berkeley´s dogma refer to the **origin** of experience. However, from a pragmatic point of view it might be even more interesting to investigate how the development of experience is shaped by modality-specific or modality-independent effects. Jungnitsch (1984) was able to show that the more intense the experience of a subject with a specific pattern is and the more freely this subject is able to explore, the weaker the effects of tactual or visual illusions are. These results open the way for a more application oriented or pragmatic approach to Berkeley´s dogma.

Loomis (1983) has investigated the performance data (precision of recognition) across both modalities with different symbol systems. Figure 5 shows six systems of symbols corresponding in complexity).

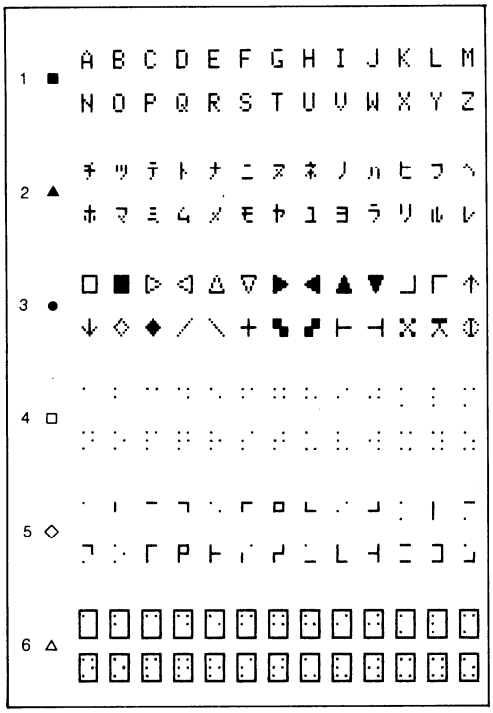

Fig. 5: Patterns for tactile and visual form recognition (the symbols beside the numbers are used in the display of the data in Figure 6)

Loomis (1983) presented his subjects these different symbol systems either in haptic or in visual exploration conditions and tested them afterwards in the other sense modality. Fig. 6 shows the relation between haptic (abscissa) and visual recognition performance (ordinate) for the different groups of symbols.

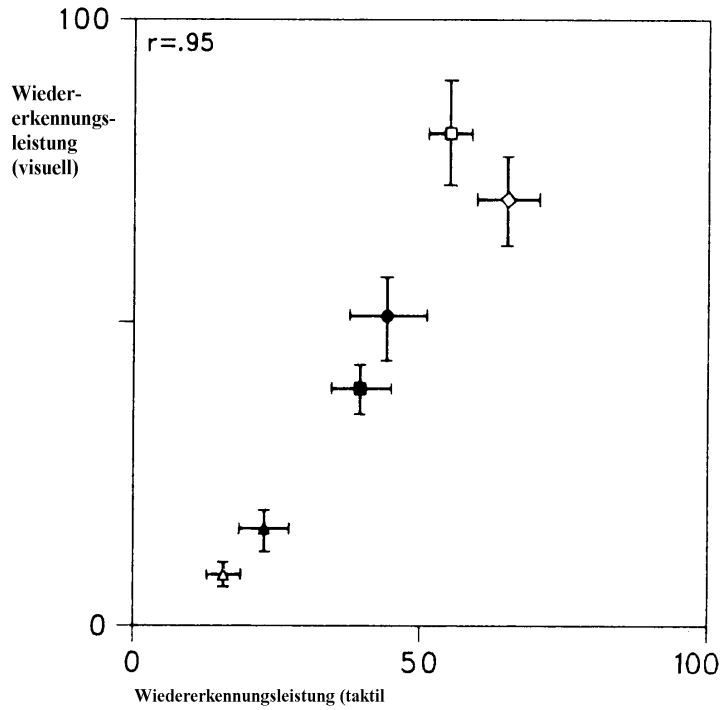

Fig. 6: Recognition performance (abscissa haptic and ordinate visual) for the six symbol systems in Fig. 5.

The data show the superiority of the Braille patterns (open square or open diamond) in comparison to other symbol systems (black circle, square, and triangle, open and black triangle). The difference between Latin (black squares) and Japanese (black triangle) letters is apparently due to the subjects´ better knowledge of Latin letters. The extreme problems subjects had with the Braille symbols in frames shows that spatial masking reduces the recognition performance in both sense modalities equally. Despite the increasing variances of the data of the different sense modalities, the results in Fig. 6 show a substantial parallelism between visual and haptic information processing. The tendency for slightly better visual recognition performance might stem from the effect that people with intact visus tend to use primarily visual symbol systems which makes them more easily learnable.

In conclusion: Experiments comparing haptic and visual performance have shown that not only perceptual illusions can be found in both sense modalities but that the effects in general are commensurable. This result is taken as strong empirical argument against Berkeley´s dogma. At the same time it supports the claim of Gestalt psychologists and Gibsonians that there are perceptual organizing principles independent from sense modalities in the domain of object recognition (D. Deutsch (1997) reports acoustic illusions in the perception of 'acoustic objects'). Gibson (1979) has summed up these results in the claim that from the point of view of the perceiver the world of objects does not consist of a multitude of sensations in different modalities but is a unitary percept having systems characteristics. The identification of receptive fields consisting of bi-modal cells, reacting both to visual and to tactual stimulation (Graziano & Gross, 1995), which are invariant against eye-movements show that the parallelism of visual and haptic perception cannot be reduced to an acquired hand-eye-coordination as claimed by activity psychologists (Zinchenko and Lomov, 1960).

On the background of these results, Berkeley´s dogma as well as the directly opposed position of visual superiority might be reduced to the same basal assumptions concerning cognition, namely to regard perception as the endproduct of processing sensory information (Helmholtz´ 'unconscious inferences') and not taking into account that an organism interacting with objects of the world can only survey if it perceives the **objects: Any** sensor achieving this goal gives the organism with this sensory equipment a better fitness. That in the evolution different sensors for the same physical variables have developed shows that Berkeley should not have posed the dogma about the priority of touch over vision in object perception but should instead have concentrated on the constraints of the physical environment upon the development of sensors: That is, his 'esse est percipi' would have adressed the question which parts of the physical world demand to exist in the world of the perceiver in order to allow him/her to survive. From a Gestaltist point of view 'being perceived' (percipi) is not accidental but the result of the evolution of perceptual processes timed to the object with interact with the perceiver (Koffka, 1935)

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