varied in degree and kind according to the postoperative time elapsed, and among individuals of the same time group, so that a single description of autopsy findings would not fit all cases. The gall bladders were frequently empty and colorless, and in some cases could not be identified on gross examination. In other cases they had increased in size, some being otherwise normal, some discolored. The surface of the liver adjacent to the gall bladder was sometimes stained a bright green, suggesting that bile had passed through the gall bladder wall. Microscopic examination revealed a tendency for the gall bladder wall to become thickened and for its epithelium to undergo metaplasia to stratified columnar.

Some of the livers showed varying degrees of damage according to elapsed time and the success or failure of bile duct restoration. A marked increase in the amount of pigment was sometimes present, but evidence from other experiments indicates that this phenomenon is associated with prolonged starvation as well as with obstruction of the bile duct. Discernible jaundice, in the sense of obvious discoloration of body fluids, was encountered in only one instance.

I have recently given attention to interruption of only the bile duct at a point between its emergence from the pancreas and its insertion on the duodenum. The methods include ligation, severing, and removal of a segment of the duct. After such a treatment the continuity of the bile duct is restored sooner and with greater frequency than where ligation is done on the hepatoduodenal ligament.

In some cases an artery and a vein could be traced past the ligature directly into the liver whether the continuity of the bile duct had been restored or not. The presence in the hepatoduodenal ligament of these vessels, if correctly identified, suggests that the afferent vasculature had been restored.

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29 November 1963

Vision and Touch: An Experimentally Created Conflict between the Two Senses

Abstract. *Observers were presented with an object whose visual shape, because of optical distortion, differed considerably from its tactual shape. After simultaneously grasping and viewing the object, the observers were required to indicate their impression of it by drawing it or by matching another object to it. The results reveal that vision is strongly dominant, often without the observer's being aware of a conflict.*

The experiments in this report are designed to answer the question: If contradictory information is given to two senses of an observer about the properties of an object, what will be his experience? By means of optical distortion, an observer can be given a visual impression of an object which is at odds with his tactual impression of that same object. Will the observer be aware of this contradiction or will one unified impression be experienced? If a unified impression is experienced, will it be a compromise between the visual and tactile sensations or will one sense dominate? Although analogous experiments have been carried out on the problem of localization and on the perceived upright, the conflict between vision and touch concerning properties such as shape or size has not been investigated.

Several experimental procedures were used. In all experiments, the subject viewed a standard object through a transparent plastic optical element which compressed the image along its horizontal axis only, thus changing the object's visual shape. While the subject was looking at the object, he was also instructed to reach behind and to grasp it through a black silk cloth, which prevented the subject from seeing his hand, since any distortion in the visual appearance of his hand could lead to a loss of experimental naivete. The subject viewed the object through an eye piece set into the front of a box. He saw it within the small field provided by a circular opening in front of the optical element. The subject placed his right arm around to the rear of the box which was 40.6 cm deep and, through a large opening (and through the cloth hanging directly behind) grasped the object, a 25 mm white square, 1 mm thick, made of a hard plastic material, attached to a thin black metal stem set vertically in a hole in the bottom of the box. The image of the width was optically reduced by a transparent piece of plastic, 0.6 cm thick, with parallel sides, which served as an optical lens element. The element could be bent around a vertical axis only, by turning a dial to the desired degree of reduction; thus it formed a portion of a thick-walled cylinder. Rays striking the plastic at an angle of incidence other than 90° were displaced. This effectively compressed the image of the object along one axis only. In these experiments the plastic was bent to reduce the width of the image by approximately one half. The plastic was placed 15.2 cm in front of the standard square and 25.4 cm from the observer's eye.

The question of how to measure what the subject experienced was an interesting one. After viewing and grasping the standard, the subject could be asked to select a comparison object which he judged to match the standard. But how should the comparison object be presented, visually or tactually? Eventually we decided on three different experiments: (i) visual comparison only, (ii) tactual comparison only, and (iii) a quite different method in which the subject was asked to draw a picture the same shape as the standard. In this last method, the subject utilized both visual and tactual senses in making his reproduction. Different subjects were used for each experiment. In all experiments, the subject was instructed either to draw or to match in accordance with his "impression" of the standard. In this way no bias was introduced for vision or touch, as would be the case if we asked him to match what he had "seen," or what he had "felt."

In each experiment there were three conditions. In the experimental condition, the subject viewed the standard and at the same time grasped it manually. Pains were taken to insure that he viewed and grasped the standard simultaneously and that he never performed one maneuver without the other. He then selected or drew a rectangle which seemed to correspond in shape to the standard. This was the main condition in which vision and touch yielded conflicting information. The subject was not told what his task was to be afterward until after he had been exposed to the standard. This was to prevent him from using his fingers to measure or otherwise engage in judgmental efforts at accuracy. Such efforts, in the preliminary experiments, had often led to awareness of the experimental conflict situation. In the vision-control condition, the subject only viewed the standard. This afforded an empirical check on the distortion produced by the optical element. It was also an indication of what was expected in the drawing or matching task when the standard was perceived only visually. In the touch-control condition, the subject only grasped the standard. This gave a measure of the central tendency and accuracy of shape discrimination by touch alone and, also, indicated what was expected when the standard was experienced by touch only. In all conditions, 5 seconds were allowed in which to perform the experiment. Only one judgment was obtained from each subject because additional judgments could not have been made with the desired naivete. Separate subjects served in each of the two control conditions so that they too would be naive as to what the task would entail until the object had been experienced.

In the first experiment the subjects made drawings of their impression of the shape of the standard. The drawings were carefully measured at the top and bottom for width and the two values were averaged. The two sides were then measured in the same way for the length. The proportion of the length to the width was the measure used to represent the perceived shape. The mean proportion of length to width for the ten subjects in this experiment was 1.85; the vision-control subjects yielded a mean of 1.9, and for the touch control subjects, the mean proportion was 0.98. In this experiment, the same subjects served as controls for both touch and vision after the conflict condition, the order of the two being counterbalanced among the ten subjects. The order did not seem to make any difference. Since the objectively correct drawing should have been a square, the fact that the experimental subjects were drawing a rectangle of almost a 2 : 1 ratio (which was exactly what they did, on the average, in the vision-control condition) indicates that vision was completely dominant. The absolute length and width were both considerably underestimated, but they were not asked to attend to the absolute size of the standard, only to its shape.

In the second experiment the method of selecting a comparison match by vision alone, under one experimental and two control conditions, was utilized. Selection was made from a rack which had a series of rectangles on stems set in holes in its base, with dimensions ranging from 8.6 to 31.8 mm in width; the height was constant at 25 mm. The rectangles were varied in steps representing a constant fraction of approximately 12.5 percent of the width. In the experimental condition, the subject selected a comparison stimulus which he considered to be the same width as his impression of the width of the standard. He only looked at the comparison object; he looked at and grasped the standard but he only viewed the comparison. This procedure may be thought to be biased in favor of a visual resolution since the subject selected by using vision alone. However, he was not aware that he would have to make a match from vision, and therefore he could not be said to be concentrating more on vision in his perception of the standard because of the comparison task. It could also be argued that it should not make any difference what comparison technique was used, since the subject received a unitary impression and would communicate this impression by whatever type of comparison he made. That is, once he "decided" what he had experienced, it should not be crucial which method or modality he employed to tell us what he had experienced. The mean ($N = 10$) for the experimental condition was a width of 14.1 mm; for vision alone the mean width obtained was 13.4 mm; and for touch alone the mean width was 23.1 mm. The results clearly show a favoring of a visual resolution. There is not too much difference between the average vision-control match and the experimental (or conflict) match. Two subjects who gave experimental matches in the direction of touch account for the slight difference obtained.

A word should be said about the method of computing the means in this and the following experiment. Since the absolute magnitude of steps increases in size as the series increases, computing a mean directly from the variable selected by each subject would bias the results in an upward direction. Hence the mean of the step-ranks was used in the actual computation. This was then converted back to a metric value by interpolation so that it would be more meaningful.

In the final experiment, comparison with the standard was made by touch alone. One experimental and two control conditions were used. The rack used in the second experiment was also used for this one. The subject could grasp the first rectangle and then move his hand along the rack, feeling each rectangle in turn. The rack was so placed that selections were made in an ascending order for half of the subjects and in a descending order for the other half of the subjects. If the previous experiment can be considered biased toward a vision resolution then this experiment should, if anything, be biased toward a touch resolution. Again, however, it could be argued that matching by touch or vision should give the same results.

For ten subjects the means for the conflict condition was a width of 14.5 mm, for vision alone the mean width was 14.1 mm, and for touch alone the mean width was 20.5 mm. It will be noted that in all of our experiments the vision-control outcome indicates that the phenomenal effect of the optical compression was not fully one-half. Also, in the second and third experiments the touch-control outcome was, on the average, less than the objective size of the standard. Hence, predictions based on dominance of touch or vision are not quite as far apart as originally desired.

The results of all three experiments show that, with few exceptions, the visual impression is completely dominant. Analogous experiments were conducted in which the visual "size" of an object is altered by means of a lens. The conflict between visual and tactual size is also resolved more or less completely in favor of visual size. An experimental procedure added at the end of some of the experiments on size will serve to illustrate another important point about the dominance of vision. The subject was asked to look at and grasp the standard. While still grasping it, he was then told to close his eyes and open them again. He was then asked if the standard felt any different when his eyes were open or closed; 23 out of 38 subjects tested in this way reported that the object "felt" larger when their eyes were closed. The remainder did not report any definite impression.

In other words vision is so powerful in relation to touch that the very touch experience itself undergoes a change. The object actually feels the way it looks and this is why we believe that most subjects were unaware of a conflict in these experiments.

Although about one subject in five did become aware of the conflict, it is remarkable that there were so few. There was a tendency for these subjects to resolve the conflict more in the direction of touch than naive subjects do. Reporting a conflict does not necessarily indicate a spontaneous registration of contradictory perceptions. The subject may have been suspicious of the apparatus or (and this occasionally did occur despite efforts to prevent it) looked away or up, giving him an uncontaminated tactual impression so that he became aware of the conflict. In any event, the answer to our starting question as to whether a unified impression would be experienced in the conflict condition is a qualified "yes". Generally the subject is unaware of the conflict, which means he does have a unified impression. Further, that impression is dominated by what he sees. It seems clear that it is possible to study this type of sensory conflict experimentally and this is an important first step.

At this stage of the work no attempt has been made to differentiate the various aspects of touch perception, that is, whether based on tactile or kinesthetic sensations, passive or active components, simultaneous or temporal integration, and the like. We are using the term "touch" in the broadest possible way to stand for any and all aspects of sensory experience based on the mechanical contact of the observer with objects which can yield information as to the properties of such objects (*1*).

The results have implications for theories of the genesis of visual perception (for example, the visual shape derives from tactual shape) and for theories concerning spatiality in general. Bishop Berkeley had said, "Visible figures are the marks of tangible figures; and . . . it is plain that in themselves they are little regarded or upon any score than for their connection with tangible figures, which by nature they are ordained to signify" (*2*). Our results point in a very different direction.

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17 September 1963

Radiocarbon Dating: A Case against the Proposed Link between River Mollusks and Soil Humus

In a recent report, Keith and Anderson (*1*) conclude that "Modern mollusk shells from rivers can have anomalous radiocarbon ages mainly owing to incorporation of inactive (C^{14}-deficient) carbon from humus probably through the food web, as well as by the pathway of carbon dioxide from humus decay." A necessary consequence of their hypothesis is that appreciable oxidation of the humus takes place within the water body rather than in the soils of the drainage basin. Although the possibility that this hypothesis is true cannot be completely eliminated, a far more reasonable hypothesis exists which explains their observations equally well. Their hypothesis cannot be verified by isotopic data alone.

Table 1. Approximate isotopic composition of carbon from various sources.

Source	δC^{13} (per mil)	C^{14}/C^{14}_{atm} *
Atmospheric CO_2	0†	1.0
Soil Co_2	−25	1.0
Soil humus	−25	0.6‡
Limestone	0	0.0
Typical river	−12	0.8
Typical lake	−5	0.9
Surface ocean	0	1.0

* Ratio of C^{14} in source to C^{14} in atmosphere. † Composition of dissolved CO_2 at equilibrium with atmospheric CO_2. ‡ Equivalent to an age of 4100 years.

The observations upon which Keith and Anderson's conclusions are based are (i) a correlation exists between C^{14} and C^{13} deficiencies (relative to the surface ocean) in the carbon of shells formed in terrestrial waters; and (ii) river mollusks show greater deficiencies than those from lakes. They explain the first observation by assuming that both the C^{13} and C^{14} deficiencies in mollusks formed in terrestrial waters are largely the result of humus oxidation. The greater the contribution of CO_2 derived from humus (compared with the contribution of atmospheric CO_2) the greater the deficiency of both isotopes. The second observation is explained by postulating a lower concentration of humus in lake water relative to river water as the result of settling. Oxidation of humus would then, presumably, contribute a smaller fraction of carbon to lake mollusks than to river mollusks. The isotopic composition of the various types of carbon referred to here are summarized in Table 1.

Table 2. Percentage of carbon from various sources required to give the concentrations of C^{13} and C^{14} found in the shells of typical river mollusks and typical lake mollusks. A, According to the Keith-Anderson hypothesis (extreme case, no contribution from limestone); B, according to the generally accepted hypothesis.

Source	River		Lake	
	A	B	A	B
Atmospheric CO_2	50	30	80	70
Soil CO_2		50		20
Soil humus	50		20	
Limestone		20		10

In my estimation, the generally accepted explanation (*2*) that the C^{13} deficiency should be attributed to the uptake of soil CO_2 by ground water (oxidation of humus in the soil, rather than after it has been transported into streams) and the C^{14} deficiency to the solution of limestone is far more plausible. In this case both the apparent correlation between the C^{14} and C^{13} deficiencies and the difference between rivers and lakes would be attributed to exchange with atmospheric CO_2 (relatively rich in both C^{14} and C^{13}). A water initially deficient in both C^{13} and C^{14} would gradually lose both deficiencies as it exchanged its carbon with the atmosphere. For lakes the exchange would, as shown by Broecker and Walton (*3*), be more extensive than for rivers, and on the average, lakes might be expected to show smaller deficiencies in both isotopes.

Quantitatively, the explanation given here is far more acceptable. Table 2 shows the ingredients necessary to make a typical lake and river shell by each hypothesis. As indicated in Table 1, soil CO_2 has a C^{14} concentration approximately equal to that in the atmosphere rather than that in the humus of the soil itself. By using bomb-produced C^{14} as a tracer, it has been shown that most soil CO_2 originates from the decay of the previous year's vegetation (*4, 5*). It should also be noted that whereas humus of about 4000 years in age is needed to yield the observed composi-