Clinical history and visual assessment of diagnostic tests in radiology

In this issue of the *Cleveland Clinic Journal of Medicine*, Williams and associates analyze the effects of certain variables on the interpretation of electroencephalographic (EEG) tracings. They found that the presence or absence of a clinical history led to substantial variations in EEG interpretations, in the number and type of additional tests requested, and in the rationale for suggesting those additional tests. Similar results have been obtained in studies of the diagnostic performance of radiologists.

■ *See Williams and associates (pp 437–440)*

The process of visual diagnosis involves several closely related components: recording, display, perception (detection), recognition, and interpretation, with each step dependent on the previous step. Recording and display may be considered "technologic factors," while perception, recognition, and interpretation are classed as "human factors."

The effect of clinical history on the assessment of diagnostic imaging procedures and how the history relates to each of these steps is not completely understood.

TECHNOLOGIC FACTORS

Because technologic factors related to image assessment are relatively easy to quantify and analyze, radiology has devoted much attention to improving the recording and display of a diagnostic image.

This concern with technologic factors has a sound basis in the physiology of the visual process: Detection of an image is directly related to the level of contrast and the characteristics of its borders, but only indirectly related to its size or area.[1] Therefore, the nature of the radiographic shadow itself influences whether the observer will perceive it or miss it.

In the last two or three decades, advances in imaging techniques, materials, and technology have led to substantial improvement in the quality of diagnostic images. The most dramatic advances occurred with the advent of computed tomography and digital imaging methods. Digitization makes possible the precise control of contrast, and special software allows us to enhance the edges of shadows. These advances help in the detection of abnormalities and lesions. Although overlying shadows can decrease contrast and obscure edges, it appears that only a small portion of misses and interobserver variability are related to the limitations of recording or display.

HUMAN FACTORS

In the 1950s and 1960s, the role of the radiologist in the interpretation of films was scrutinized. Garland[2,3] and Yerushalmy[4] showed that lesions frequently missed by experienced radiologists are obvious in retrospect. Over the years, other investigators[1,5,6] reached similar conclusions.

Clearly, the missed images were not caused by lack of visibility. If the abnormalities were visible in retrospect, some other process must be responsible. Furthermore, there has been no evidence to suggest that improved technology has reduced observer error rates within the expanding group of potentially detectable lesions. Thus, it appears that observer error is only minimally related to the limits of technology. Most errors are related to human factors.

Detection

For the observer, the first step in visual assessment is to *see* those structures that can be perceived in an image.

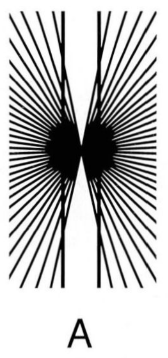

FIGURE 1. Kerling's illusion. A and B both have parallel vertical lines. In A they appear to bow outward. In B the lines are perceived as converging or diverging.

FIGURE 2. If we had never seen an elephant, or if these lines were more fragmentary, it is possible that we would not reconstruct these fragments into the image of an elephant. Similarly, information from a clinical history can help to generate a diagnosis from an image that might at first appear to be "fragmentary."

This process begins with a visual search. Radiologists have described and advocated a variety of orderly search patterns; but studies of search patterns using eye movements in practicing radiologists found that few radiologists actually employ an orderly and reproducible pattern.[1] In fact, the more orderly patterns were associated with higher miss rates.

The studies also showed that all readers displayed marked lack of uniformity in their visual coverage of test radiographs. Certain portions of the film were excluded from visual coverage, and the areas excluded varied from observer to observer. The readers showed a frequent tendency to return to areas of previously recognized abnormality. This lack of uniformity in coverage may account for some of the misses as well as the interobserver variability encountered in studies of diagnostic performance. Also, areas of abnormality may serve as distractors.

Recognition

The radiologist's next job is recognition of what is perceived. The observer analyzes each shadow or pattern of shadows in an attempt to discern its nature. Studies of search patterns of the eye reveal that the experienced observer almost immediately focuses on the abnormal region, while the inexperienced observer scans the image with no apparent pattern.[1] However, experienced radiologists show no better ability than laymen in detecting low-contrast test objects in phantoms.[7] These findings suggest that recognition is not fully determined by sensory input but that the ability to perceive is related to recognition. Although the exact relationship between perception and recognition is subject to debate, it is apparent that there can be no perception without some degree of recognition.

Interpretation

Perceptual illusions that give rise to false impressions are common experiences. The same sensory input may give rise to two different impressions depending upon the context in which it is seen. For instance, the vertical lines in *Figures 1A and 1B* are all parallel, but, depending on the context, are not seen that way. The visual transmission system is incapable of passing along all of the information presented to it from the retinal field of view. Information from the retina is "filtered" or "compressed," with transmission of only selected fragments. The incomplete representation of the retinal pattern is given meaning by its relation to our previous experiences or memories. Perception occurs when the transmitted pattern is matched to a previous memory. In effect, we attempt to reconstruct meaning from fragmentary patterns (*Figure 2*). If the transmitted pattern fails to match a previous memory, it may go unrecognized. If it is so incomplete or fragmentary that it matches more than one memory, then it can be perceived in various ways and is ambiguous.

We have all encountered patterns of lines or dots presented in such a manner that they it can be recognized in a variety of ways. Once the observer is aware of the artist's intent, it is easy to separate the various representations. For example, the closed line drawing in (*Figure 3*) is usually perceived as a vase, but when the observer is told to look for two faces the image changes. Thus, the ambiguity of visual stimuli can be resolved with additional information.

THE IMPACT OF CLINICAL HISTORY

EEG patterns and radiograph shadows, of course, are often ambiguous. The history allows one to match ambiguous perceptions to specific memory patterns and thus resolve the ambiguity—or fill in the gaps of a fragmentary image.

It is not surprising, then, that Williams and colleagues found that the clinical history influenced the analysis of EEG patterns. In fact, a number of studies assessing the impact of clinical history on the interpretation of a variety of radiographic tests have found improved performance with knowledge of the clinical history.[8–11] They show that observer improvement is based largely on an increased true-positive rate without an increased false-positive rate.

These findings reinforce the radiologist's plea for precise clinical information—a plea often disregarded by referring physicians.

Certain clinical specialties are reluctant to provide clinical histories, feeling that this is too cumbersome a task and that their own visual assessment of particular examinations is as good as the radiologist's. Berbaum and associates[10,11] compared the influence of clinical history on the accuracy of fracture detection by orthopedic surgeons and compared the results to an identical evaluation performed by radiologists. The orthopedists had the same degree of experience as the radiologists. Both groups of physicians showed improved diagnostic accuracy when provided clinical history, but the orthopedists were much more dependent upon the clinical history to detect the fracture. Even without the clinical history, the orthopedists' performance did not match the radiologists'.

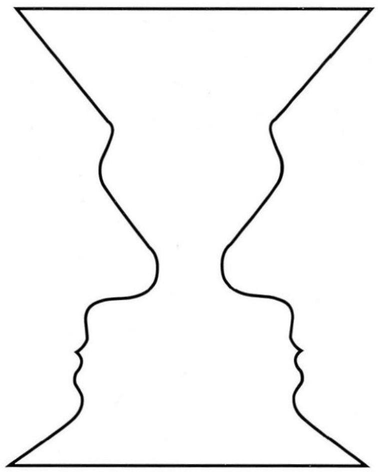

FIGURE 3. Ambiguous image. Many observers initially see a vase but, if provided with "specific history" two faces can be seen. However, both the vase and faces cannot be perceived at the same time.

These studies imply that any benefit of expert interpretation may be lost when the clinical history is not available. Clinicians usually have better access to clinical information relevant to interpretation of images than do radiologists. As a result, their interpretive performance may rival or better the radiologists' attempts without clinical history. But by not providing the radiologist with a specific clinical history, the referring physician risks losing the potential for further improvements in performance.

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