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*Human Factors in Image Interpretation**

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REPORT TO SUBCOMMITTEE III
PHOTO INTERPRETATION COMMITTEE 1962-63
AMERICAN SOCIETY OF PHOTOGRAMMETRY
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EVEN a cursory survey of human factors problems in image interpretation leads to the conclusion that the problems involved are manifold and extremely complex and that a broad, integrated program of research needs to be implemented. Today, interpreters are not only confronted with the problems of interpreting relatively large-scale, conventional black-and-white photographs, but they are also required to interpret small-scale and degraded photographs as well as radar, and infrared imagery. In addition, recent technological developments have increased the capacity of reconnaissance systems to obtain and process imagery at a rapid rate. The imagery obtained through this increased capacity and variety of image sources is ultimately placed before image interpreters who are asked to extract information to be used in important decisions.

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Yet existing knowledge about the basic psychological factors operating when interpreters examine reconnaissance imagery is severely limited. Relatively little is known concerning the perceptual and cognitive processes that occur when interpreters search imagery and make critical decisions concerning the presence or absence of significant objects. What clues or target signatures do interpreters use? What inferential processes do they employ? What are the effects of perceptual set, background information, stimulus quality, and personality variables on the speed, accuracy, and completeness of interpreters' final decisions? These are human factors questions; unfortunately, they are not easily answered.

Image interpretation is an extremely complex process. Impinging upon an interpreter's performance are factors related to his background, training, aptitudes, interests, and personality, as well as his momentary state of

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motivation and fatigue. Factors related to amount, quality, and content of the input imagery, time available for viewing the imagery, the kinds of instruction and target information the interpreter has received, and the techniques and equipment he uses in examining the imagery also play major roles in determining performance. Performance itself can be measured in a variety of ways—number of correct identifications, number of errors, per cent accuracy, per cent completeness, rate or speed of information extraction. And, of course, the task of the interpreter can vary. The task may consist of detection, identification, location, and mensuration, or a combination of these basic functions. The task may also include functional and traffic analyses, damage assessment, and depth determination to name a few.

The manifold problems can be summarized in two broad human factors questions: (1) What are the skills, abilities, and techniques necessary to extract information from conventional and newer types of imagery? (2) How can available human resources be utilized to cope with the ever increasing variety and amount of imagery while maintaining acceptable standards of speed, accuracy and completeness?

In order to answer these two broad questions, an integrated program embracing the following research areas is needed.

1. Identification of basic human factors in image interpretation
2. Interpreter viewing techniques for near real-time and multi-sensor imagery
3. Team approaches to image interpretation
4. Image interpreter functions in advanced equipment configurations
5. Techniques for selecting image interpreters
6. Training techniques for image interpreters

Before rapidly summarizing some of the latest research being conducted or planned in these areas, it should be emphasized that the research to date represents only a promising beginning. And, unfortunately, it is basically an uncoordinated beginning. There has not been sufficient communication or integration of research findings and plans to enable researchers to build upon the efforts of each other. This is not surprising. The problems are complex and researchers tend to bite off what little they can chew in a reasonable period of time. However, if substantial progress is to be made, not only must duplication of effort be avoided, but problem areas must be clearly delineated and the efforts of interested researchers must be pooled and coordinated. Some concrete suggestions along this line will later be made.

Research in the first area, identification of basic human factors in image interpretation, should have as its ultimate objective the improvement of interpreters' productivity through the optimal use of their talents, skills, and abilities. Unfortunately, most of the psychological research into perceptual and cognitive processes that has been conducted to date is only indirectly related to image interpretation per se. Generalization from these more theoretical studies to the problems of operational interpreters cannot be made easily. There are several notable exceptions, however. On the theoretical side, there is the extension of Tanner and Swet's auditory signal detection theory to the problems of visual detection (1954). Their basic ideas of optimizing performance, taking into consideration signal and noise distributional probabilities, along with the value of correct detections and correct rejections and the cost of false alarms and incomplete identifications, can be applied to the problem of image interpretation.

In an experiment recently conducted by the Army Personnel Research Office, the effect on performance of varying the value of correct and incorrect identifications was explored. Three matched groups of interpreters were given the same imagery, but each group was given different information about the relative importance of identifying all targets and of avoiding errors. Apparently emphasis on accuracy, in the situation where there was an ammunition shortage, significantly reduced the number of erroneous identifications without reducing the number of correct identifications made (see Table 1).

Considerable research in the basic factors area has been directed toward study of the relationship of such physical characteristics of imagery as image scale, contrast, granularity, and sharpness to the usefulness of imagery for the extraction of information. Research in this area has suffered from the limited range of physical variables studied, the artificiality of the imagery employed, the lack of experimental controls utilized, and inadequate performance criteria. Recently, however, the Cornell Aeronautical Laboratories and the Military Products Group of Minneapolis-Honeywell, both under contract to the Air Force's Rome Air Development Center, have initiated more comprehensive

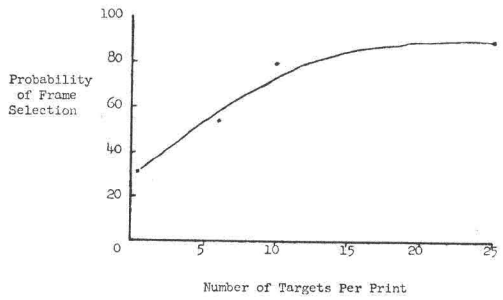

FIG. 1. Screening efficiency within 10 seconds by target density.

studies in this area. The principal objective of the Cornell study is to determine how physical image variables can best be combined into a summary measure which maximally predicts interpreter performance. The goal of the Minneapolis-Honeywell study is to determine the accuracy and speed with which selected objects of military significance can be identified at various levels of ground resolution and contrast. These studies are about half completed. Preliminary results from the Minneapolis-Honeywell study indicate that the physical variable, contrast, may be relatively unimportant in determining usefulness of imagery in the range of contrast normally found in aerial photos.

Time does not permit even a summary of all the other research that has been conducted in the basic factor area. However, the work of Baker, Morris and Steedman (1960) on target recognition in complex displays deserves to be mentioned, as do the studies of Enoch and Fry on visual search techniques, and the more applied studies of Kraft (1962) of Boeing on comparative cover viewing techniques and the Army studies on the validity of interpreters' feelings of certitude or confidence and the impact of suggestive information. (Sadacca, et al., 1961, 1962).

TABLE 1

EFFECT OF MILITARY SITUATION ON PERFORMANCE

Military Situation	*Mean Rights*	*Mean Wrongs**
Airborne Drop (Completeness)	20.1	22.4
Armored Attack (Intermediate)	16.7	13.7
Ammunition Shortage (Accuracy)	19.3	9.5

* Mean wrongs significantly different ($P < .01$)

Research in the second major human factors research area, interpreter viewing techniques for near real-time and multi-sensor imagery, should be closely tied in with research in the basic factors area. True, unique problems arise in the rapid scanning and detection of objects in near real-time and in the integrative viewing of imagery from several sensors. But many of the basic problems involved are identical to those present in the interpretation of photographic imagery under conventional conditions. Significant research in near real-time viewing has recently begun. The Applied Psychology Corporation, under contract to the Rome Air Development Center, is studying the effects on interpreter accuracy and completeness of viewing times, measured in seconds, and various work-rest cycles. The effects will be studied across imagery varying in scale, resolution, contrast, and target density and detail. Preliminary results indicate that the number of targets and features correctly identified increase as a function of logarithmic increases in the amount of viewing time.

The Army Personnel Research Office has also initiated a series of studies in real-time interpretation and screening efficiency. Figure 1 shows an example of the research findings obtained in screening efficiency. In a 10-second viewing period, the probability that a print will be selected for further study is seen to be asymptotic with regard to the number of targets actually on the print.

The most extensive research in the third human factors area, team approaches to image interpretation, has been conducted by the Army. Data were recently collected from approximately 175 interpreters working under 10 team methods involving variations in team size, procedures for examining prints, and amount of communication among team members. Team members worked together over a $2\frac{1}{2}$-day period. The data from this experiment are currently being analyzed. Data from previous experimentation have indicated that substantial improvement over individual interpretation can be achieved by pooling the efforts of a number of interpreters. The principal advantage appears to be in the reduction of erroneous identifications. If one interpreter makes an erroneous identification, the chances are that a second interpreter will not agree with him, whereas agreement is much more likely if an identified object is really there.

The fourth research area, image inter-

preter functions in advanced equipment configurations or facilities, calls for a continual reappraisal of the techniques used by interpreters and the role they play in information processing systems. Effective systems engineering and equipment design depend on data that define the capabilities of the human component. Evaluation of interpreter functions within entire configurations of displays, comparative viewers, computers, and rapid access files can be accomplished through experimentally varying the number and kinds of personnel utilized within the system, work flow procedures and techniques, imagery input loads, and required information output rates. Research in this vital area is currently being planned by both the Air Force Systems Command at Wright-Patterson Air Force Base and by the Army Personnel Research Office. The Systems Support Department of Nortronics (1962) is also considering problems in this area.

Two comprehensive studies have been concerned with the selection of image interpreters. The first, conducted by Meyer and Miller (1960) on Air Force image interpreter trainees, identified several promising aptitude tests and Airman Classification indexes. In a recently completed study, the Army Personnel Research Office administered an 8-hour experimental battery of spatial, perceptual, reasoning, memory, and vision tests to Army interpreter trainees. As a result of an extensive validity analysis, a four-test selection battery is being recommended for operational use. The battery, which takes two hours to administer, consists of two spatial and perceptual tests, a test of reasoning ability and a test of general knowledge of science, military tactics, and photographic techniques. In both the Army and Air Force studies, vision tests of acuity and depth perception failed to correlate significantly with the performance measure and school grade criteria used. Apparently, the ability to extract useful information from imagery involves higher order cognitive functions than the ability to see fine detail, although, of course, there must be some minimal acuity standards.

There is need for research in selection beyond the initial training phase. The possibility of achieving differential classification of interpreters into target area specialities—for example, strategic vs tactical—should be explored. Also, special aptitudes may be needed to extract information from multisensor displays or to detect targets in rapid screening or in near real-time interpretation. These possibilities will be explored as time permits by the Army and hopefully by other researchers.

The area of training research has, perhaps, received the least attention. The Rome Air Development Center, however, is currently considering additional research in this important area. The Data Systems Division of RCA, under contract to Rome, has just initiated a study into the feasibility of training interpreters in rapid screening and recognition techniques. Various presentation rates and reinforcement schedules will be studied using imagery varying in scale and target distribution. Various viewing distances will also be compared.

As indicated earlier, there is great need for more coordination and communication among researchers in these areas. This is especially true among researchers engaged in private or in-house research. The Photo Interpretation Committee may be able to serve in this regard. If the Committee, under the American Photogrammetric Society's auspices, could prevail upon the research groups engaged in human factors studies to send periodic summaries of their research plans, progress, and findings, to Society headquarters, a central file of ongoing research could be established. Investigators wishing to build upon the research of others could visit the file, or for a fee have the file reproduced and sent to them

The Committee could help solve another research problem by setting up an imagery exchange service. One main obstacle to research on image interpretation is the extremely difficult task of obtaining imagery of sufficient scope, variety, or representativeness. More than one-third of a researcher's effort can easily be expended in searching, often unsuccessfully, for suitable imagery. Researchers wishing to participate in the imagery exchange would send to the Society headquarters complete sets or representative samples of imagery used in their own studies along with descriptions of the kinds of objects located on the imagery and an indication of the samples of interpreters to whom the imagery has been administered. Researchers who are looking for imagery could study the material and write to the original supplier of the imagery in order to borrow the desired master negatives or positive transparencies or to obtain library print and film can numbers. There would, of course, have to be safeguards—and probably a fee—but I do think this could be done without too much expendi-

ture of effort on the part of the Committee or Society.

In summary, although much noteworthy research has already been accomplished and is now planned or already under way, the study of the complex human processes occurring when image interpreters examine aerial imagery is really only beginning. By acting in a coordinative capacity, the PI Committee may be able to greatly facilitate and expand future research efforts.

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*Technical Aspects of Air Photo Interpretation in the Soviet Union**

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ABSTRACT: *The present article reviews some technical aspects of air photography and air photo interpretation in the Soviet Union, taken from the Russian literature concerned with the subject and published after World War II. The most important technical means involved in the whole process of air photo interpretation are briefly outlined in the introductory section. In the two following sections the properties of the equipment used in air photography, such as cameras, lenses, films, and filters and their suitability for different surveying and interpretation purposes are dealt with in detail. The information presented in this paper may afford a contribution to a better knowledge of Soviet photo interpretation and to a basis for comparing its status with the one in western countries.*

SINCE the article by Troll "Fortschritte der wissenschaftlichen Luftbildforschung," which appeared in 1943 and contained a section on photo interpretation in the USSR, very little has become known about the further development of Russian air photography and interpretation methods and techniques. For example, in PHOTOGRAMMETRIC

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