application of interactive graphics technology
to the problem of standardizing diagnosis
and therapy of schizophrenic patients*

Walter Sidoruk

This paper is submitted to the readership of the
Schizophrenia Bulletin to stimulate interest in and
critique of a "new" interactive graphics system concept
designed to standardize diagnosis and treatment of
schizophrenic patients. A number of technologies from
various fields have been uniquely combined to create
a state-of-the-art device that provides the patient with
an unloaded, impersonal learning/social interaction
situation; i.e., an environment in which motivation and
behavior can be developed and performance assessed
without the threat of "human" judgment and disap-
proval. The interactive graphics system, properly pro-
grammed, is not only extremely well suited for the
difficult tasks of diagnosis and therapy, but it also
simultaneously provides a sound technical solution
to a continually pressing problem of patient needs
versus staff availability. A multistation interactive
system could increase staff capability by providing
an apparent 1:1 patient/therapist ratio (individualized
treatment) while actually processing a number of
patients simultaneously. A design objective might be
to process five patients at a time, 2 hours per patient for
an 8-hour period. This would allow a team of two
therapists to process up to 20 patients a day, resulting
in a therapist/patient ratio of 1:10.

The interactive treatment concept can be related to
both crisis and social judgment theories. Crisis theory
views the psychotic situation as a developmental (inter-
active) crisis with room for potential growth. The
objective of treatment is to guide the patient through
the episode, rather than repress his altered state of
consciousness. Since community environment factors
contribute to the crisis, treatment has been adapted
to include community-based therapy (Mosher, Goveia,
and Menn 1972). In a similar approach, social judgment
theory suggests that the only way to understand the
nature and depth of cognitive impairment of schizo-
phrenic patients is to assess their performance in
circumstances representative of the environment that
contributed to their illness. This information is then
used to formulate a strategy for behavior modification.

The interactive graphics concept shown in figure 1
borrows from both theories in that each patient terminal
creates a learning environment that can be precisely
controlled by the therapist.

Although interaction is primarily with a machine, the
machine represents a familiar social environment: the
classroom. This classroom is unique in that the authori-
tarian teacher/judge is replaced with a forgiving, imper-
sonal graphics display that will lead the patient through
a rather enjoyable learning sequence while covertly
assessing his performance. Relevant research in schizo-
phrenic social learning behavior was conducted by
Gillis (1969) and Gillis and Davis (1973) in which they
confronted patients with tasks characterized by a
multiplicity of cues and irreducible uncertainty in
cue-criterion relationships. The results of their studies
represent a beginning contribution toward understanding
the effects of specific psychoactive agents and inter-
active stimuli on social learning. Their initial study
(1973) using stimulus cards was modified to use an
interactive graphics terminal. Dr. Davis (personal com-
munication) has indicated that his research in this area
has produced favorable results. Schizophrenic patients,
who would ordinarily perform poorly in socially neutral
learning tasks, do as well as normals when interaction is
with a terminal rather than with hospital personnel.

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Patients wanted to interact with the terminal and were attracted by its responsiveness.

Gillis and Davis (1975) point out that their concepts can be extrapolated to other areas of learning:

...distressingly little is presently known of the action of common psychotropic drugs on learning. Psychoactive chemicals which facilitate learning have important implications for treatment beyond their direct contribution to symptom alleviation. The maximally useful chemical agents would be those which both facilitate interpersonal learning and result in marked symptom diminution.

Certain advantages will be gained by using an interactive graphics system for diagnosis, remotivation, and desensitization; but for every advantage a number of problems related to performance assessment must be solved. The following sections will attempt to provide a clear picture of what types of patient performance assessment are envisioned, but it is left to readers to identify and evaluate the more complex problems associated with the diagnosis and treatment of schizophrenia.

Simulation technologies either developed or used by Grumman Aerospace Corporation in the successful completion of NASA Lunar Missions and in many aircraft training programs have been applied to the interactive graphics concept shown in figure 1. The design takes advantage of demonstrated state-of-the-art capabilities in computer assisted instruction (CAI), interactive graphic terminal (IGT) design, data reduction/analysis, and large data-base information storage and retrieval system design.

The system concept proposed in figure 1 trains patients to use an IGT as an art medium. This is comparable to art learning situations where the teacher first instructs a student in the properties of water colors, oils, and acrylics, and then teaches the student to apply...
each medium, using various techniques. During CAI training sessions, the IGT functions as a diagnostic and therapeutic device. Figure 2 shows an Evans and Sutherland Computer Corporation picture system now in use. Such a device can provide a structured, computer-controlled learning situation and stimulus/response (SR) interface where each function available for patient activation (e.g., control input device) is correlated, via the computer output, to a patient's cognitive, psychomotor, and physiological processes. Patients' responses to the computer-controlled instruction scheduler (mediated by their available response strategies and learning level) are recorded and referenced to a computer-managed patient population data base and the statistical output takes the form of a patient profile.

CAI tasks must be designed to respond to subtle changes in behavior that might be induced by administration of chemotherapy, or by a new method of therapy. Software-controlled instruction sequences would be designed to inhibit schizophrenic thought processes and responses by appropriate negative or positive reinforcement under the therapist's control. Normal thought processes can be positively reinforced by careful selection of response contingencies that allow the patient to work through the instructional sequence to a “free art expression” period. This period is also extensively monitored by performance assessment software. Table 1 lists typical behavioral processes and measures amenable to statistical analysis. Applicable research studies and results are shown to establish a reference. Obviously, the clinical community must be intimately involved at every step of the data-base design effort and in the design of the IGT controls and computer-administered instructional programs. Each function available in the CAI and free art expression sessions must be empirically correlated to behavioral elements (i.e., measures in table 1). Hypotheses or assumptions regarding schizophrenic processes and associated observable behaviors (e.g., rate of progress, learning strategy, and use of art forms) must be tested and evaluated, either in the IGT or in other laboratory settings.

Assessment

IGT software assesses patient performance in two different situations. In one, the patient's behavior repertoire is developed and assessed by CAI while training to use the IGT. In the second situation, this same behavior repertoire is assessed via the output of the IGT.

Figure 2. Interactive graphics picture system

Courtesy of Evans & Sutherland Computer Corporation, Salt Lake City, Utah
Table 1. Performance assessment

<table>
<thead>
<tr>
<th>Processes</th>
<th>Measure</th>
<th>Applicable research</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cognitive</strong></td>
<td></td>
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<tr>
<td>• Subskill acquisition</td>
<td>Selection of correct functions</td>
<td></td>
</tr>
<tr>
<td>• Skill acquisition</td>
<td>Selection of correct functions</td>
<td></td>
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<tr>
<td><strong>Communication</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Data input (entry) technique selected or preferred; e.g., verbal vs. keyboard</td>
<td>Frequency, association with type of stimulus, etc.</td>
<td>Harrow, M.; Tucker, G.J.; and Adler, D. Concrete and idiosyncratic thinking in acute schizophrenic patients. &quot;Archives of General Psychiatry&quot;, 26(5):422-439, 1972.</td>
</tr>
<tr>
<td>• CAI output technique selected or preferred; e.g., visual vs. verbal</td>
<td>As above</td>
<td>Storms, L.H., and Broen, W.E., Jr. Intrusion of schizophrenics' idiosyncratic association into their conceptual performance. &quot;Journal of Abnormal Psychology&quot;, 79(3):280-284, 1972.</td>
</tr>
<tr>
<td>• Reading comprehension</td>
<td>Total time spent on instructions; randomized recall of data</td>
<td>Harrison, A.W.; Spelman, M.S.; and Mellsop, G.W. The proverb test for disorder of thinking in schizophrenia and mania. <em>Australian and New Zealand Journal of Psychiatry</em> (Carlton, Australia), 6(1):52-56, 1972.</td>
</tr>
<tr>
<td>• Listening comprehension</td>
<td>As above</td>
<td></td>
</tr>
<tr>
<td><strong>Psychomotor</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Response to visual/aural stimuli (simple)</td>
<td>Reaction time; e.g., function activation by depression of switch</td>
<td>Lhamon, W.T., and Goldstone, S. Temporal information processing in schizophrenia. &quot;Archives of General Psychiatry&quot;, 28(1):44-51, 1973.</td>
</tr>
</tbody>
</table>

References are keyed to processes categories.
<table>
<thead>
<tr>
<th>Processes</th>
<th>Measure</th>
<th>Applicable research</th>
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</thead>
<tbody>
<tr>
<td><strong>Psychomotor (Continued)</strong></td>
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<td></td>
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<tr>
<td>• Execution of procedures</td>
<td>Reaction time for initial response, total execution time for correct/incorrect responses</td>
<td>Scherer, M.W. Number and position of visual stimuli as determinants of reaction time in schizophrenia. <em>Canadian Journal of Behavioral Science</em> (Ottawa), 4(2):118-124, 1972.</td>
</tr>
<tr>
<td>• Text generation (e.g., use of data entry keyboard)</td>
<td>Volume, appropriateness (to be developed)</td>
<td>Schooler, N.R., and Goldberg, S.C. Performance tests in a study of phenothiazines in schizophrenia: Caveats and conclusions. <em>Psychopharmacologia</em> (Berlin), 24(1):81-98, 1972.</td>
</tr>
<tr>
<td>• Response to complex stimuli (multiple response required)</td>
<td>To be determined; e.g., ability to execute two parallel tasks</td>
<td>Payne, R.W. The effects of drugs on objective measures of thought disorder in schizophrenic patients. <em>Psychopharmacologia</em> (Berlin), 24(1):147-158, 1972.</td>
</tr>
<tr>
<td>• Tracking performance for computer-generated targets using different input devices</td>
<td>Total time on target, Root Mean Square (Error), tracking strategy, rate of skill acquisition, etc.</td>
<td></td>
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<tr>
<td>• Maze transition</td>
<td>Errors, cheating, time in transit, overall response to problem, etc.</td>
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<tr>
<td><strong>Art production</strong></td>
<td></td>
<td></td>
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<tr>
<td>• Color utilization</td>
<td>Types, combinations Level Level Frequency of association with other functions; e.g., geometric form, letters, characters, movement</td>
<td>Enaschescu, C. Dinamica expresiei plastice in schizophrenie. [The dynamics of art expressed by schizophrenics.] <em>Neurologia, Psihiatria, Neurochirurgia</em> (Bucuresti), 17(3):259-274, 1972.</td>
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<tr>
<td>—Luminosity</td>
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<td>—Saturation</td>
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<tr>
<td>—Function association</td>
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<tr>
<td>• Programmed form utilization</td>
<td>As above</td>
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<tr>
<td>• Graphic area utilization</td>
<td>Percent total area, central vs. peripheral, location of peripheral areas</td>
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</table>
which is the patient’s interactive-graphics art production. The following sections will attempt to give a clear picture of just what type of training assessment is implied and what type of art production can be generated and assessed. In this connection, the advantages and disadvantages of using an IGT will be discussed. Again, it must be restated, this paper is not proposing a specific computer-assisted system of diagnosis and therapy; it is proposing that such a system is feasible once a team of clinicians and engineers work together on its design. Application of the concept does not depend on which theory of schizophrenia is “correct” or which psychotherapeutic techniques are preferred.

**CAI Assessment**

Although many therapeutic benefits can be derived using a controlled training situation, this section will consider only the question of performance assessment; e.g., how the research team selects the behaviors to be assessed, how the instructional programs are generated, and how the “normative” data base for comparative diagnosis is utilized. The first task the design team must tackle is to research the literature to identify tasks that discriminate between various types of observable psychomotor, perceptual, and learning impairments. Next, using this information, a candidate list of functions must be identified for implementation in the IGT. These functions would represent those tasks that have maximum impairment-discriminating power. And, finally, the design team must generate the instructional material that will provide the basis for patient assessment.

Standard computer programming languages are not very suitable for preparing and administering instructional programs. The intricate formatting requirements are usually beyond the proficiency many clinicians have or are willing to acquire. However, PLANIT, a computer programming language designed especially for use by potential CAI authors, has been developed. PLANIT automatically translates the author’s inputs

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Table 1. Performance assessment (continued)

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<thead>
<tr>
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<tr>
<td>Art production (continued)</td>
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<tr>
<td>Psychophysiological</td>
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<tr>
<td>• Visual</td>
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<td>• Aural</td>
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<tr>
<td>– Stimulus levels under computer control</td>
<td>Response threshold</td>
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<tr>
<td>• Biomedical sensory modality stimulation</td>
<td>Range of physiological responses available (to be developed) via biomedical vest instrumentation.</td>
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</table>

1 References are keyed to processes categories.
into instructional programs. Like all CAI author languages, PLANIT has conditional branching capabilities for altering the sequence of instruction for individuals on the basis of their performance. This feature, shown in figure 3, is basic to IGT operation. At a minimum, the clinician (as an author) can designate specific instructional actions for each anticipated patient response. Actions include feedback messages, branching to various points in the instructional program or to other programs. PLANIT allows the clinician to provide for sequencing and feedback variations conditional on cumulative performance. Instructional decision points or "choice points" are provided where a patient is given the opportunity to respond.

These CAI response paths correspond to a given patient's ability to achieve a specified learning objective; e.g., slewing a computer-controlled cursor symbol from point A to point B. The simplest case would be a linear program (figure 3a) in which no variation in instructional content is allowed. The opposite complex case (figure 3d) represents a complete tree or net of conditional branching that provides a large number of routes to achieve a given learning objective. The program can base the next instructional action on data like those listed in table 1. For example, one of the first operations a patient must master is the theory of operation and use of the "cursor" function. At least four methods will be available for moving the cursor on the Cathode Ray Tube (CRT); each method requires use of a different set of psychomotor and perceptual behaviors. The proposed devices are:

- **Lite Pen.** This is a device held in the hand like a pencil. The operator touches the CRT face to initiate a cursor mode or some other computer action.
- **Slew-Stick.** This is a hand grip or stick device which can be displaceable. Movement of the device on its pivot point will control the proportionate displacement of a cursor symbol on the CRT. Again, the position of the cursor is known to the computer, so a number of functions can be commanded using the cursor position on the CRT as the origin of the action; e.g., make this point a line, or square, or circle, green, etc.
- **X/Y Switch (horizontal/vertical).** Actuation of this rocker switch moves the cursor at rates controlled by the computer.
- **Trackball.** This device accomplishes the same function as the slew-stick except that a rotating ball is manipulated with either hand. Rotation of the ball in
a specific direction moves the cursor symbol proportionately on the CRT.

If a CRT-tracking task is commanded, the patient may be given the choice of which control to use. Tracking information can be recorded and analyzed for each method/degree of tracking difficulty. Once tracking performance is established, a new set of learning and psychomotor tasks (instructions) can be administered to the patient. For example, a series of mazes of predetermined difficulty may be projected on the CRT and the patient asked to move the cursor symbol through the mazes, using each of the four control devices described above.

The size of each maze (and pathway) can be varied, and the gains and sensitivities of each device-controlling symbol movement can be changed. Initial maze tasks would be presented and perceived as a familiarization task, not a performance task. Variations of the maze problem, under clinician or patient control, can be an extremely useful method for assessing the effects of a variety of drugs or of different dosages of the same drug. In other situations, the emphasis could switch to performance assessment, where a time-to-execute constraint is introduced to measure the patient's psychomotor reactions to perceived stress. These types of assessments (within a training situation) will be able to discriminate between certain forms of learning and/or perceptual impairments that are correlated to psychic trauma or to brain lesions.

All control functions and associated CAI must meet the criteria of measurement validity. Like all other methods of diagnosis, the CAI method hinges on successful design of a “normative” (or patient) data base. Each patient's output in a variety of cognitive and perceptual tasks will not only be compared to his own previous performance, but it will be assessed in terms of data accumulated on thousands of patients. Obviously, all data bases located within participating hospitals must feed into a master information system, centrally located and large enough to provide continuity to the program. Coordination of related research and dissemination of information to the user community can be undertaken by agencies within the U.S. Department of Health, Education, and Welfare and periodicals like the Bulletin.

Art Assessment

A review of the literature on the use of art therapy in the treatment of schizophrenia shows unanimous agreement to provide this capability. Conversely, opinion regarding the diagnostic potential of art production analysis is for the most part inconclusive and negative. In my opinion, however, lack of progress in art assessment is due to the fact that both the media and environment are uncontrolled and the patient's art capability is unknown. The proposed IGT system overcomes these obstacles by controlling the learning environment and the use of the medium; e.g., limiting space, fixing the number of colors, and functions. When a patient's ability to use the media is known (performance), art assessment is possible. Identical methodology is employed by research teams when they develop and validate a projective test using a specific population.

Table 1 lists some pertinent research on the problem of standardizing art assessment. Enachescu's study (1972) of five paranoid schizophrenics identified eight categories or stages of mental deterioration by tracing the course of art production over extended periods. Zierer's study (1971) illustrates an approach to standardizing art production based on a series of 75 controlled stress situations that the patient must reproduce by painting. A numerical index was constructed to reflect personality strength based on the intensity level of color integration, flatness, and color disintegration. Another study by Lindo (1969) showed that his patients were prone to excessive use of blacks, blues, and to a lesser degree, reds. Black was considered to be a projection of psychic trauma. Wadeson and Carpenter (1974) showed how depictions of delusions and hallucinations elicited from psychiatric patients could be used to gain a fuller understanding of the psychotic experience. These and other studies indicate that the art assessment task can be managed if a controlled environment, in conjunction with a patient data base, is used.

A number of art assessment techniques, ranging from full computer assessment to full clinician assessment, with all combinations of computer and clinician evaluation, are feasible. Examples of professional level art that can be generated on a CRT (in color or gray/black/white, etc.) are shown reproduced in figures 4, 5, and 6. These productions illustrate full use of a free cursor mode, with no utilization of programmed geometric forms. Preference for linear modes of reproduction, as shown in figure 6, may serve to differentiate between types of psychic impairment, and may provide clues to how a patient “sees” his object world.
Figure 4. Warrior illustrating use of geometric line construction\(^1\)

\(^1\) This figure was produced by Bjoran Hansen, University of Utah Computer Science Department and supported, in part, by the Advanced Research Agency of the Department of Defense under Contract No. DAHC-15-73-C-0363 and Contract No. F30603-70-C-0300.
Figure 5. Head illustrating use of linear construction

1 This figure was produced by Duane Palyka, University of Utah Computer Science Department and supported, in part, by the Advanced Research Agency of the Department of Defense under Contract No. DAHC-15-73-C-0363 and Contract No. F30603-70-C-0300.
Different categories (levels) of art require different analytical assessment methods. For simple-to-moderate cases, a straightforward computer assessment would include a histogram analysis of the hues and saturation used, a count of line and conic segments, area used, changes made, and time taken to achieve the final design. If the CAI provides the capability of calling up and inserting programmed geometric forms into the art work, then this information could also be recorded. Obviously, each combination of functions represents a different level of complexity, or a hierarchy of information-processing capability. The clinical significance of this is the subject of the proposed research program. Hypotheses must be postulated and verified in much the same way any projective test or personality inventory is developed and validated. Functions designed into the IGT for patient use must be derived from an indepth analysis of the form of schizophrenic art and a comprehensive review of existing art assessment techniques.

It is entirely possible that the primary method for art assessment will still be the responsibility of the analyst. In this case, the computer merely functions to store the art productions of individual patients, with amplifying information similar to that itemized above. The analyst recalls art productions from off-line store for comparison. The assessment procedure gains in precision because the medium is controlled and other indices of patient performance are available. Again, the purpose of the research program is to evolve an optimum combination of computer-aided and clinical assessment procedures. The IGT system acts to constrain both the patient output and the assessment latitude available to the clinician. Both factors increase the probability that a meaningful patient data base can be created and used, a necessary first step if standardization of diagnostic and therapeutic procedures is to be achieved.

A typical systems effort would progress as shown in figure 7 (a, b, and c) from an amorphous phase to one where system boundaries would begin to crystallize. In

Figure 6. Portrait of an artist

1 This figure was produced by Dr. Frederic I. Parke, University of Utah Computer Science Department and supported, in part, by the Advanced Research Agency of the Department of Defense under Contract No. DAHC-15-73-C-0363 and Contract No. F30602-70-C-0300.
the preliminary design phase, a team of clinicians, engineers, and software specialists looks at requirements for diagnosis and therapy of schizophrenic patients and determines a first-level partitioning of subsystem functions (figure 7a). The exterior boundaries of the proposed system become more distinct (figure 7b) as attempts are made to partition the system into physical subsystems. At the next level (figure 7c), the design team gains an understanding of what the hardware and software would look like and how the systems would interconnect and communicate; i.e., subsystem interface drawings would be generated with input/output requirements. A detailed system design ready for a test and evaluation phase would be modeled (translated into algorithms) and simulated (debugged) in fast time using a clinical model of schizophrenic response characteristics. The real-time hardware dynamic system integration/test and operating phases represent an iterative, and in this case, an extensive research program to refine clinical concepts, diagnostic/therapeutic methods, and IGT/CAI hardware and software.

A review of the literature on schizophrenia indicates a pressing need for a breakthrough in the standardization of diagnosis and therapy. The IGT system described above examines these problems for patients who are functioning on levels where interactive behavior and motivation still exist. The proposed concept reflects a behavior-conditioning approach to diagnosis and therapy (an extension of crisis and social judgment theories). The objective is to reestablish basic links with the real world using software and display techniques proven in education, and technologies tried and tested in the aerospace industries. The approach is feasible and the technology is considered a low risk.

References


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**The Author**

Mr. Sidoruk is assigned to the Advanced Systems Department of Grumman Aerospace Corporation where he participates in all future system design projects. Depending upon job requirements, he is called on to perform as an experimental psychologist, a human factors engineer, a training specialist, or a system designer. He obtained his B.S. degree from New York University in 1961, majoring in biology. An M.A. in experimental psychology (major perception) was conferred in 1965 by the Graduate Faculty of the New School for Social Research (New York). Mr. Sidoruk has since completed all course requirements and initial doctoral examinations for the Ph.D. degree at the New School Graduate Faculty.

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**American Orthopsychiatric Association Annual Meeting**

"The State of the Family" is the theme of the 54th Annual Meeting of the American Orthopsychiatric Association to be held April 12-16, 1977 in New York City. The meeting is open to all mental health professionals interested in a multidisciplinary collaborative approach to the promotion of mental health and the study of human behavior.

Meeting highlights include: *The Family on Film*—an evening of films about the family with documentaries, television reruns, commercial films, and videotapes; *The Family in the Western World*—a roundtable discussion by leading experts from the United States and Europe; sessions, workshops, and panels ranging from a look at the *Family in the Novel and the Media* to *Schizophrenia in the Family*; consultation hours, institutes, and special courses.

Among experts on the program are: Murray Bowen, Salvador Minuchin, Elisabeth Kubler-Ross, Julius Richmond, Al Solnit, Peggy Papp, Stephen Chinlund, Charles King, Virginia Satir, James Framo, Rita Liljestrom (Sweden), and Magdalena Sokolowska (Poland).

Content includes: parenting, child development, treatment of children, adolescents, the aging, adults, delinquents; also learning problems, school and mental health programs, etc.

Programs are available by writing American Orthopsychiatric Association, 1775 Broadway, Room 2501, New York, N.Y. 10019.