

THEORY DIRECTED READING DIAGNOSIS RESEARCH USING COMPUTER SIMULATION

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Abstract

A five year project studying the diagnosis and remediation of children with reading problems is described. The discussion includes observational studies of reading diagnosticians at work, observations of diagnostician training programs and computer simulation of theories about decision making in reading diagnosis. The results of the observational studies are mentioned and the theories and systems for computer simulated diagnosis are described.

I Introduction

The Institute for Research on Teaching is a federally funded project whose purpose is to investigate teaching, where teaching is conceptualized as an information processing task. The Clinical Studies project of the Institute is just finishing its first five year plan studying teachers who diagnose and remediate children with reading problems. This paper should serve as a short introduction of this work to the AI community.

The Clinical Studies project has been primarily concerned with understanding reading diagnosis and remediation - whether performed by classroom teacher, reading specialist, learning disability specialist or school psychologist. Theories or models have been developed to account for the significant behaviors that occur when one of the teaching professionals works with a child. These theories have been tested against 1)direct observational studies of the specialists working with cases, 2)training studies observing the instruction of new specialists, and 3)computer simulation studies observing the behaviors implied by the theory through simulation. Results of these studies have shown that an individual's decision making may be very unreliable - suggesting that individual behavior may not warrant simulation. Before turning to the computer simulation studies, consider briefly the theory and results of the other studies.

II Theories and Models

The content-independent theory that attempts to account for the problem solving behavior of the clinicians is termed the Inquiry Theory [1]. The reading clinician-child interaction is viewed by this theory as follows:

1)The case is considered to be an information

processing system that must perform a certain set of tasks. Some information processing abilities are critical to the adequate performance of these tasks. An adequate diagnosis of a problematic case must contain a statement relevant to each such critical ability. There may exist prerequisites for these critical abilities. An adequate diagnosis will include a statement relevant to all prerequisites for each deficient critical ability. Finally, a good diagnosis will include a statement of the history of the case that has led to current deficiencies.

2)The clinician must diagnose a case as described above. This is accomplished by the application of elementary information processing tasks to an understanding of how a case performs its function. The elementary tasks include ones such as hypothesis generation, hypothesis testing, cue collection, cue interpretation, etcetera [2].

The theory that describes the reading process is the Model of Reading and Learning to Read (MORAL) [3]. It describes six critical abilities: 1)recognizing some written words instantly, 2)decoding other written words using language regularities, 3)associating the recognized words with meaning structures, 4)phrasing and segmenting sets of words into simple propositions, 5)building higher order propositions from existing ones, and 6)associating propositions in the text with higher level meaning structures. The MORAL goes further to detail the most important prerequisite skills for each critical ability and the most important aspects of probable learning histories for all prerequisite skills. For example, the prerequisite skills for decoding written words include: 1)visual discrimination of letter and word forms, 2)auditory discrimination of letter and word forms in connected speech, 3)knowledge of language regularities in the association of sounds with symbols, 4)blending ability to combine sounds, 5)the ability to adjust blended sounds to conventionally spoken English, 6)language experience adequate to know the meaning of a decoded word, and others. Similarly, the MORAL describes many of the factors that could effect the learning history for this decoding ability. These include: 1)the amount of relevant engaged academic time spent in practice, 2)the adequacy of affective and corrective feedback, 3)motivation due to influences from self, parent, and peers, 4)visual acuity, 5)auditory acuity, and so on. Of course, with reading conceived as an information

processing task, the MORAL describes other significant aspects of behavior required such as the allocation of information processing capacity and conditions of information overload.

At the current time the MORAL describes the critical abilities for human reading. It further details what other factors might effect these abilities and cause deficiencies and how correction of any deficiency might be attempted. To date it appears to be quite effective in determining the reading problems in a case. The MORAL does not at the current time make any attempt to describe how reading comprehension takes place. Instead the various types of reading or listening comprehension tasks which people must perform to be good readers are listed. Of course the MORAL is at best incomplete and possibly incorrect. But it does serve to direct research and diagnose cases of reading difficulty.

One final note with respect to theory - it is the intersection of these two relatively independent models (a content independent model of clinical problem solving and a content dependent model of the reading process) that is our area of concern. The questions that arise include: how do the specialists diagnose and treat children, how should they do it, how can they be trained to do what they should, what impact does the model of reading have on the decision making process, etc.

III Observational and Application Studies

The observational studies of teaching professionals and clinicians in reading have basically indicated one thing - the specialists are not reliable. Careful observation in seven interconnected studies of these professionals diagnosing a simulated case of reading difficulty has shown correlations generally not significantly different from zero, whether from the same clinician diagnosing the same case twice or different clinicians each diagnosing the same case once. This finding holds for professionals selected by their peers as the best; for classroom teachers, reading specialists, and learning disability specialists. After eliminating most counter explanations of low reliability through carefully designed replication studies, the reliabilities are still of borderline significance from zero (e.g., 0.10 - 0.15). [4]

Training studies have indicated more optimistic possibilities - in thirty hours of instruction, the correlations may be raised from 0.1 to 0.4 - a value close to physician reliability. Close observation of the training process and its transfer to work settings will hopefully uncover means by which reliability may be raised further.

IV Computer Simulation Studies

With this backdrop, consider the contribution of computer simulation to this program of research. For this discussion we will ignore the use of case simulation which has been so vital for stimulus control in our experimental design and

turn instead to clinician simulation based on the theories described earlier.

All of our simulations of reading specialists have been simulations based on the Inquiry Theory and the Model of Reading and Learning to read described earlier. In this way, the results of each simulation can be used to expand and refine a model that directs our research efforts in simulation, training and observation. All studies described here were run on an interpretive procedural language whose primitives were based on the Inquiry Theory. This system is entitled BMIS - the Basic Management Information System. Effectively, a system subroutine was created for each elementary information processing task described by the Inquiry Theory (e.g., hypothesis generation, cue collection, diagnostic determination, etcetera). Each subroutine could be called up by a command in an interpretive language. An initial hypothesis directed program was set up in which the hypotheses generated about a case direct the collection of information about a case and information interpretation, which generated more hypotheses, and so on. On the basis of any decision that was made (accept hypothesis X as part of the diagnosis, reject hypothesis Y, etc.) sub procedures might be activated to handle the peculiarities of the particular decision.

This system was designed for theory investigation and was not intended to be easy to use or flashy. Furthermore, there were many restrictions on its input to bypass the natural language communication problems. As time permitted, a new system was created to rectify these and other identified shortcomings of BMIS. The new production oriented system with similar types of primitives is entitled MOSES, the Multiple Object Simulated Encounter System. Both systems are available through TELENET on the Wayne State University Amdahl 470v6.

*The SIMCLIN Modeling Study: The first simulation study was basically a modeling study. Given the framework provided by the Inquiry Theory, memory structures were created by systematic interview with a senior reading clinician. Such things as hypotheses, cues, observations, diagnoses, strategies, etc. were defined. The goal was the creation of a simulation that would closely emulate this specialist's problem solving behavior.

Comparisons were drawn between the human specialist and the computer analog as they diagnosed the simulated cases of reading difficulties mentioned earlier. The results indicated that the simulation was a very effective model in terms of all measures used - the number and order of cues collected, the diagnosis and suggested remedial plan, etc.

*The Pilot SIMCLIN Reliability Study: With the very low human clinician reliability, it became clear that modeling of individual people was a pointless procedure. Instead we directed our efforts to the simulation of behavior of

groups of clinicians; i.e., to the simulation of models of diagnosis agreed upon by clinicians. At this point, then, the emphasis turned to the creation of intelligence that would be reliable and valid with respect to group reading diagnosis and still be teachable to unaided human specialists. It was at this point that the development of the Model of Reading and Learning was begun - it would serve to define the content of clinician memory.

This study examined the reliability of a computer diagnostic system that was based on the Inquiry Theory and the newly developed MORAL. The simulated clinician (SIMCLIN) was set up and asked to diagnose four simulated cases twice (no SIMCLIN memory of previous runs was allowed but different initial contact settings were used). These diagnoses were compared with respect to reliability with the diagnoses of human clinicians.

The results were that the SIMCLIN had a reliability of 0.65 compared to human reliability of 0.10. Further, commonality scores - which indicate how an individual agrees with a criterion group diagnosis - indicated that the SIMCLIN included 80% of the categories agreed upon by the group of human clinicians while the mean for individual human clinicians was 50%.

*The Pilot SIMCLIN Validity Study: Finally, a simulation study has been run to get a first measure of the validity of the SIMCLIN's diagnostic decisions when those decisions are directed by the Inquiry Theory and MORAL. Reading case records were taken from Michigan State University's reading clinic for SIMCLIN workup. Records were selected which indicated correct diagnosis and others that indicated poor diagnosis (as measured by the child's response to treatment). The areas of concern were the adequacy of the SIMCLIN as an embodiment of the theories, the reliability of the SIMCLIN diagnosis and the validity of the SIMCLIN diagnosis. It was hoped that the SIMCLIN would agree closely with the clinic's diagnosis for the correctly diagnosed case and not as closely for the poorly diagnosed one.

The SIMCLIN did, in fact, behave as dictated by the MORAL - the simulation checked out the critical abilities of reading and the prerequisite factors and past history of those that were problematic. The reliability of the diagnostic decisions was essentially 1. Adherence to the MORAL almost guarantees this. With respect to the SIMCLIN diagnosis on the well and poorly diagnosed cases, the results were equivocal. The reason for this is that data required by the SIMCLIN was not present in the clinic files. Such things as classroom observation of engaged academic time, listening comprehension scores, and change scores over time were not available. In fact, indications are that these types of data are not routinely collected by reading clinicians, although the SIMCLIN considers them significant. The model and its simulation might well demonstrate inadequacies in the state of the art

in reading diagnosis.

V Conclusion

In conclusion, the research paradigm described here has been quite effective. Models and theories direct and focus research designs. These designs - whether observational, training or simulation - reflect back to expand and refine the theories. Substantial data has shown that an individual's decisions may be very unreliable. Training in decision making models and content area theories can improve the reliability. But the key to effective problem solving seems to be the validity of the theories that are used to direct decision making. One effective means for examining the validity of such theories is through computer simulation. The next step will be the completion of a production oriented SIMCLIN that will be used as a preceptor during instruction of student clinicians and a decision aid by reading specialists in schools. The validity of the MORAL SIMCLIN will be checked by following its recommendations and watching the results for real children. The research will continue to be theory oriented. Further information on many aspects of this research program may be obtained by contacting the Institute for Research on Teaching at Michigan State University.

References

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