16:02:25 OCA PAD INITIATION - PROJECT HEADER INFORMATION 10/20/88

Terminated

Project #: G-42-619 Cost share #: Rev #: 0
Center # : R6610-0A0 Center shr #: OCA file #:
Work type : RES
Contract#: 7 R23 HD20522-04 Mod #: Document : GRANT
Prime #: Contract entity: GTRC

Subprojects ? : N
Main project #:

Project unit: PSYCH Unit code: 02.010.154
Project director(s):
BILLMAN D PSYCH

Sponsor/division names: DHHS/PHS/NIH / NATL INSTITUTES OF HEALTH
Sponsor/division codes: 108 / 001

Award period: 880801 to 890331 (performance) 890630 (reports)

Sponsor amount	New this change	Total to date
Contract value	38,800.00	38,800.00
Funded	38,800.00	38,800.00
Cost sharing amount		0.00

Does subcontracting plan apply ?: N

Title: LEARNING STRUCTURED CATEGORIES FROM INTERRLATED FEATURES

PROJECT ADMINISTRATION DATA

OCA contact: E. Faith Gleason 894-4820

Sponsor technical contact

NORMAN A. KRASNEGOR, PH.D, CHIEF,
(301)496-1303
HUMAN LEARNING & BEHAVIORAL BR, CTR
FOR RESEARCH FOR MOTHERS & CHILDREN
NICHHD/NIH BETHESDA, MD 20892

Sponsor issuing office

SYLVIA JONES
(301)496-1303
OFFICE OF GRANTS AND CONTRACTS
NATL INST OF CHILD HLTH & HUMAN DEVL
BETHESDA, MD 20892

Security class (U,C,S,TS) :
Defense priority rating : N/A
Equipment title vests with: Sponsor
HOWEVER, NONE PROPOSED NOR AUTHORIZED

ONR resident rep. is ACO (Y/N): N
NIH supplemental sheet
GIT X

Administrative comments -
INITIATION. GRANT HAS BEEN TRANSFERRED FROM THE UNIVERSITY OF PENNSYLVANIA.
AWARD IS SUBJECT TO REVISION PENDING NIH RECEIPT OF FINAL FSR (FROM U OF PA)

GEORGIA INSTITUTE OF TECHNOLOGY
OFFICE OF CONTRACT ADMINISTRATION

NOTICE OF PROJECT CLOSEOUT

Closeout Notice Date 05/31/91

Project No. G-42-619 Center No. R6610-0A0

Project Director BILLMAN D School/Lab PSYCHOLOGY

Sponsor DHHS/PHS/NIH/NATL INSTITUTES OF HEALTH

Contract/Grant No. 7 R23 HD20522-04 Contract Entity GTRC

Prime Contract No.

Title LEARNING STRUCTURED CATEGORIES FROM INTERRLATED FEATURES

Effective Completion Date 900331 (Performance) 900630 (Reports)

Closeout Actions Required:	Y/N	Date Submitted
Final Invoice or Copy of Final Invoice	Y	900711
Final Report of Inventions and/or Subcontracts	Y	
Government Property Inventory & Related Certificate	Y	
Classified Material Certificate	N	
Release and Assignment	N	
Other	N	

Comments

Subproject Under Main Project No.

Continues Project No.

Distribution Required:

Project Director	Y
Administrative Network Representative	Y
GTRI Accounting/Grants and Contracts	Y
Procurement/Supply Services	Y
Research Property Managment	Y
Research Security Services	N
Reports Coordinator (OCA)	Y
GTRC	Y
Project File	Y
Other	N
	N

NOTE: Final Patent Questionnaire sent to PDPI.

December 21, 1990

Donald E. Clark, chief
Office of Grants and Contracts
National Institute of Child Health & Human Development
National Institutes of Health
Building EPN Room 505
Bethesda, MD 20892

RE: R 23 HD20522

Dear Dr. Clark:

Enclosed please find my final reportfor my NICHHD Grant R23HD20522. My vita and reprints accompany this report. The report summarizes several lines of research supported under the grant. A book chapter, Billman (in press) provides an overview of much of the empirical work. A chapter with Barsalou (1988) treats many of the theoretical issues, while a recent chapter with Martin discusses recent computer modeling. More detailed reports are included in journal articles and conference publications.

Please let me know if there is any other information which would be useful. Thank you for the support of from this grant. It has allowed subjects to be run, programs to get written, and provided substantial support for graduate students.

Sincerely yours,

Dorrit Billman
Assistant Professor

encl: report
reprint

Dorrit Billman
Final Report for 5 R23 HD20522
December 21, 1990

National Institute of Child Health and Human Development
National Institutes of Health
Public Health Service
Department of Health and Human Services

I. Overview

Research conducted under this grant investigated several aspects of learning, primarily learning correlations in unsupervised concept learning tasks. Concept learning experiments investigated what facilitates discovery of correlational structure in input, possible mechanisms, and whether simple instance similarity models are sufficient to explain learning. We also developed computational models of unsupervised concept learning. Other experimental work investigated learning strategy in the game Othello, the role of categories in guiding induction, effect of prior knowledge on assessing covariation in new data, and beliefs about stereotypes others hold. All of the research concerns the nature or accuracy of self-guided learning. Each line of research is summarized here with reference to the papers where the work is reported more fully. A current vita and reprints are attached.

II. Research on Unsupervised Concept Learning.

In unsupervised concept learning people are exposed to some material or given the opportunity to notice regularities without the experimenter classifying examples into categories or even suggesting that there are any categories to learn. Following this incidental, observational learning opportunity, subjects' knowledge is assessed. Language acquisition, specifically of syntax, is a striking example of successful "unsupervised" learning of very complex knowledge. No one classifies utterances for the child as grammatical or ungrammatical, nor labels words as verbs versus adjectives. Further, knowledge of syntactic categories (Noun, Verb Phrase, etc) is a cornerstone of syntactic competence.

IIA. Studies of learning syntactic category.

Early in the grant we ran several studies following up my dissertation work on acquiring syntactic categories. These studies continued to examine whether and how multiple interrelated attributes facilitate learning. In these

experiments animated scenes "described" in sentences of an invented language are presented to a language learner. The languages were very unlike the familiar, Indo-European languages, but preserved key syntactic properties of natural language. I compared subjects' ease in learning a set of systematically varied natural-language analogs to test predictions about learning mechanisms.

I outline the core idea tested, because the same idea of interpredictivity among attributes pervades my work. (Elaboration of this and related theory can be found in Barsalou & Billman, 1988.) Psychologically "good", coherent categories are good because they mark multiple interpredictive properties. Among animals, type of locomotion, type of body covering, type of limb, and habitat are related (though imperfectly); birds fly, have feathers, have wings, and live in trees. Knowing an item is a member of such a category provides a lot of information. Syntactic categories have analogous structure; for example, in English nouns these properties correlate: following Determiners, reference to concrete objects, marking for plural, and position in sentence phrase structure.

Further, I hypothesized and tested for a learning procedure that "hones in" on such structure, facilitating discovery of the relations among interpredictive properties (the basis of category formation). My research on syntactic categories took extensive work to design the variety of languages which were complex enough to assess the hypothesis, yet simple enough to be learned in a week in the lab. Learning in these experiments, as hypothesized, showed the predicted pattern of facilitation (Billman,Heit,&Dorfman,1987; Billman, 1989).

IIB. Studies of other natural categories.
I have run several studies on the same principle of mutual facilitation from concordant correlations. Several experiments with text descriptions of people did not work out. We tried to make the task more interesting by framing it as a script writer learning about soap opera characters, but the task of learning a dozen text descriptions of individual with 10 attributes or so each was simply very difficult. These experiments did not succeed in addressing the hypothesized differences among conditions, because the task was too hard. They did suggest some hypotheses about where learning complex correlations may be relatively easy and where hard.

I switched tactics and used pictures of animals where body parts covaried. A couple of these studies were developmental. Here

learning seemed to be much easier, and I found a valuable, nonlanguage test domain, at last. Some of these studies tested the same learning principle (attribute interpredictivity) as in the artificial grammar work. We again found evidence for this learning principle (Billman&Jeong, 1989; Billman&Knudsen,1990). Subjects were more likely to learn about the relation between type of head and type of habitat when other attributes such as body covering and type of leg also covaried. Early studies compared learning a correlational rule when it is the only correlational rule to learning the same rule when it occurs in isolation. Thus one condition differs both in the number and in the organization of the correlation in input. The most recent studies, reported at Psychonomics 1990, equated the number of pairwise correlations but varied their organization. We found that organization into related sets facilitated learning pairwise correlations, even when the number of correlations was matched and number of possible instances controlled

One central, intuitive contrast in theories of concept learning is that between generalization by similarity comparisons to old instances and generalization by reference to a rule or pattern abstracted across instances. In other studies, I precisely specified classes of models--"similarity" versus "abstraction"-- so they could be distinguished. Models of learning based on simply storing instances and generalizing by similarity comparisons have proved very powerful and difficult to disconfirm. This series of studies tested when subjects go beyond simple similarity to discover rules or patterns across multiple instances (Billman, in press; Billman & Richards, in review).

III. Simulation of Unsupervised Learning

Much of the empirical work described above was motivated by a theory of efficient unsupervised learning. The core claims were that people generate feedback internally by projecting attribute values and comparing the projected and observed value. This information is used to revise beliefs about predictive rules. This process can be focused in a search through a large space by an attentional bias to pay additional attention to those attributes proving predictive. This type of learning bias will preferentially direct discovery to sets of interpredictive attributes. Implementing a simulation of this learning process provided a complementary method of theory development. Systematic evaluation traced out the model's performance and revealed unexpected implications for certain types of learning problems (Billman&Heit, 1988; Chalnick& Billman,1989). Since coming to Tech my computational work has focused on

algorithm development, with the collaboration of my student Joel Martin, in the College of Computing (Martin & Billman, 1990, in press). Here the task is defined by some human ability --e.g. the ability to learn overlapping categories--but the primary goal is algorithm efficiency not psychological veracity. We also expect hypotheses about human performance in parallel tasks to derive from this work. Completed research and work in progress have demonstrated that the combination of psychological and AI methods to address the problem of unsupervised learning is very fruitful.

IV. New research on language

I have been a critic of structuralist approaches to language processing which completely derive a theory of processing from a theory of representation (1986;Billman&Peterson,1989). Work begun at the end of the grant, in collaboration with computer science colleagues will develop a language "comprehender" that will address some classic problems of ambiguity--cases where the form-to-meaning correspondences are not direct or simple. To do this we rely heavily on linguistic analysis to identify the rich information specified in the syntactic form of the utterance, but also on flexible processors capable of combining information from multiple sources. Since this problem is very large, we are focusing on how information in the syntax of verbs constrains event representations. This computational work complements a new line of experimental work on event categories; both focus on the relation between verb structure and event representation.

V. Concept learning and representation

Several studies have focused on how concepts are supported by background knowledge or on how one set of categories can provide background knowledge to another. After all, categories do not exist in isolation, but are part of a broad system of skills and facts. This section summarizes studies which investigate the relations between categories and complex sets of background beliefs.

A student who was then the American champion of the game Othello gave me the opportunity to look at broad conceptual reorganization. As with much of my work on object categories, this investigated the role of abstract conceptual change versus memory for particular cases. The research focused on a culturally transmitted strategic concept, "mobility". This concept was evidently discovered once in Japan and then spread through the Othello community. Much prior work on skill acquisition (eg chess) has stressed the importance of building up memory for particular examples from prior games.

However, little attention has been directed to the possibility of conceptual change where a new strategic concept reorganizes the skill. Analysis of change in Othello playing identified and analyzed just such a strategic, conceptual change (Billman&Shaman,1990).

In unsupervised learning, subjects typically have many new examples but little background knowledge. However, when background knowledge is available, adults and children can use just a single example to draw a sensible analogy (Holyoak,Junn,&Billman), or identify sensible inductions (Macario,Shipley&Billman,in press; Billman,1988). Working with our graduate student, Macario, children were given information about the basis for including items in one category; subjects were then shown a single instance of a new category. In fact, children picked which property of the one instance should be generalized across the whole new category by using information from the contrasting category. These studies identified one way that children as well as adults use background knowledge about contrasting categories to guide generalization about a new property or a new category.

Category learning is often based on discovering which properties correlate with one another. However, people can also assess how strongly two variables are related by giving a direct estimate. Many researchers have deplored how poorly people judge correlations in data and how much they are overwhelmed by prior expectations of how variables will be related. Using more detailed comparisons, we assessed how the type of prior belief affected assessment and distinguished lack of sensitivity from bias (Billman, Bornstein, & Richards, in press).

Social stereotypes show interesting effects both of background expectation and ability to detect real correlations between group membership and a target property. This research assessed "stereotypes of stereotypes", one group's beliefs about what another group's stereotypes are. Initially, we looked at what one target group (business students or women) believed another group (arts &science students or men) thought about them. Eventually, we looked at regional stereotypes so we could assess what A thinks B thinks about C as well as about A. We found that members of one group exaggerate how much another group stereotypes. Further, this is true whether estimating what another group thinks of one's own group or what that group thinks of a third group. We believe not only that we are stereotyped more than we are, but also that others generally stereotype more than they do (Rettew,Davis,&Billman).