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TITLE OF PROPOSED PROJECT **Pilot: Modular computational models of creative problem solving**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 199,618	24 months	08/01/08	

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PI/PD FAX NUMBER 310-206-8525	

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME Alan H Bond	PhD	1966	310-828-8719	abond@mednet.ucla.edu
CO-PI/PD				
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CERTIFICATION PAGE

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The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

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Project summary

This project will develop a computer system which will solve problems creatively and will be based on the extension, abstraction and generalization of the cognitive processes that people use. The proposed research will lead to the development of new technologies to support human creativity. It will also improve our understanding of creative processes in web-based knowledge representations. By building and experimenting with such a system, original insights will be gained into the nature of creativity.

The model will be developed by extending an existing computational model which has been developed over the past several years by the principal investigator. This model already exists as a computer program for simple knowledge-based problem solving. It has a highly parallel architecture with components for processing goals, plans, memory and perception. In order to extend this model it will be necessary to extend its various components to incorporate new types of knowledge that are to be used creatively. It will be necessary to introduce new mechanisms for conceptual representations and their manipulation. This will need a method of representing knowledge allowing it to be flexibly abstracted or constrained as required to discover new problem solutions. The highly parallel nature of the existing model will allow many different kinds of knowledge to be activated together concurrently thereby allowing a large set of potential solutions to be considered, but it will also allow a large set of constraints to be applied together concurrently to find the best solutions.

The **intellectual merit** of the project will be in advancing our understanding of the important area of creativity by showing how different knowledge-based processes work together to creatively solve problems. Its **broader impact** will be in showing how to develop systems which support and enhance human creativity in the design of commercial products, in artistic and cultural activities, in understanding the development of creativity in our children, in educating our students to be more creative, and to have marketable creative skills.

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*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Project description

Objectives

The main objective of the project is to systematically investigate the creativity mechanisms of a computational model of creative problem-solving which has integrated planning, perception and memory aspects, and is highly parallel, and is inspired by human cognition and brain architecture.

This will result in the design and implementation of a creative problem solving system. We will also investigate the practical applicability of the system to the support of human creativity, and to the use of web-based knowledge.

The overall purpose of the project is to try to understand the properties of creativity in general as an abstraction, extension, and generalization of human creativity.

Aspects of human creativity. It seems that human creativity is not a special ability but is achieved using common cognitive abilities. At the cognitive level of analysis, there are many issues and phenomena that we need to understand. Here we list these known aspects of creativity:

1. Creativity is goal directed [18], and involves dynamic goal-setting and goal-changing.
2. Creativity involves the generation of alternatives, with variable degrees of constraint, and the efficient search of large sets of possibilities.
3. Generation is by construction, combination, merging and synthesis operations.
4. Creativity depends on the chosen representation of the problem.
5. Memory and knowledge are very important [25] [12], although their effects can be both positive and negative.
6. Visual imagery is important, including the construction of images, structured imagination and creative invention [1] [15].
7. Perception can be creative.

8. Analogy and metaphor are important mechanisms in generating and assessing creative results [16].

9. The abstraction, combination and merging of concepts is very useful and may be necessary.

10. Creativity involves the revision, re-representation, restructuring and reconstrual of the problem [28] [22] [23].

11. Evaluation of possibilities is important and involves multiple constraints in multiple perspective.

12. The role of routinization, overlearning and incubation has been emphasized by a number of researchers, however there is some contrary opinion, see for example Hayes [18].

13. There are many types of obstacles and traps in creative thought [26], in fact, some researchers have argued that recognising and extricating oneself from traps is the key to creativity.

14. Metacognition can be useful in the conscious control and management of the creative process [2].

15. There are neuroscience data [19] [3], and theories such as cortical arousal and focus of attention [20].

16. There are methods for improving creativity [29] [24], and there are methods for measuring creativity [27] [17].

The development of a general computational model of creativity will produce much-needed insights into many of these key issues and phenomena. Such insights will allow the better assessment of creativity and the development of methods for increasing and optimizing creativity.

Expected significance. The research will provide an understanding of creativity in general and a basis for improving creativity at work, and improving the development of creativity in children and students.

Relation to long-term goals of the principal investigator. The research develops the basic problem-solving/perception/memory mechanisms of the model to incorporate more extensive memory and to allow the representation of wider classes of cognition and behavior.

Relation to the present state of knowledge of the field. The proposed model will be more comprehensive than previous models of creativity, and based on parallel processing, human cognition and brain architecture, unlike most previous models.

Relation to the work in progress by the principal investigator under other support. We have just (September 2007) started a one year SGER grant from the CreativeIT program, and it will finish at the end of July 2008. The SGER will result in a feasibility demonstration of the computational architecture described here, and is expected to demonstrate some creative problem solving. The main problems to be solved are getting the basic problem solving cycle to work and getting the episodic memory to work as planned. More specifically it will involve the development and implementation of new functionalities: (a) for (re)perception of the problem at each step, (b) for greater constructional ability, in mental imagery and conceptual combination, (c) for memory-based plan elaboration: (i) several different plans at different abstraction levels, (ii) several arguments for each plan step from associated memories, and (iii) the action of plan steps associating with memories to form the new constructed state, and (d) for evaluation of the current constructed state.

The current proposal is intended to continue this effort from August 2008. It will systematically and more deeply develop the mechanisms of creativity that the architecture is capable of, and will explore the applicability of the approach to the support of human creative problem solving as well as to web-based systems.

The current other funding is mainly related to logical representations of knowledge in engineering and neuroscience. Thus the relation between the projects is at a theoretical and methodological level. He is however collaborating with the design process group at NIST, lead by Ram Sriram, whose main focus is on engineering design and manufacturing.

The principal investigator is also connected with the UCLA Center for the Biology of Creativity, headed by Robert Bilder and Peter Whybrow. This is currently concerned with discovering the genetic basis of creative abilities.

Relation to work in progress elsewhere. The proposed work will provide a more comprehensive model for comparison with work on the psychology and neuropsychology of creativity.

An overview of the proposed system

The architecture of the proposed system. The model will be developed by extending an existing cognitive model [7] [6]; an outline architectural diagram of the proposed computational system is given in Figure 1. The proposed system uses a modeling approach of a modular distributed computational architecture, with an abstract logical description of data and control, which has a correspondence to the cortex. In the last few years, we have conducted a series of studies and models concerning cognitive mechanisms, including problem solving [5], episodic memory [8], and spatial working memory [9].

In the current approach to brain-based cognitive modeling of problem solving, the action of the system, like the brain, involves the continuous parallel action of all processing modules, and each module is specialized for processing and storage of particular types of data. The set of rules in each module constructs data of types characteristic of that module. A module usually has more than one characteristic type. A module receives data of certain types from other modules and from these it derives and constructs data of its own types, which in turn it makes available to other modules.

The model has a set of interacting perceptual hierarchies, which process incoming information using constructive rules, to create abstraction hierarchies of representations of perceptions.

The continuous action of the system creates goals, selects a goal, retrieves a plan and executes

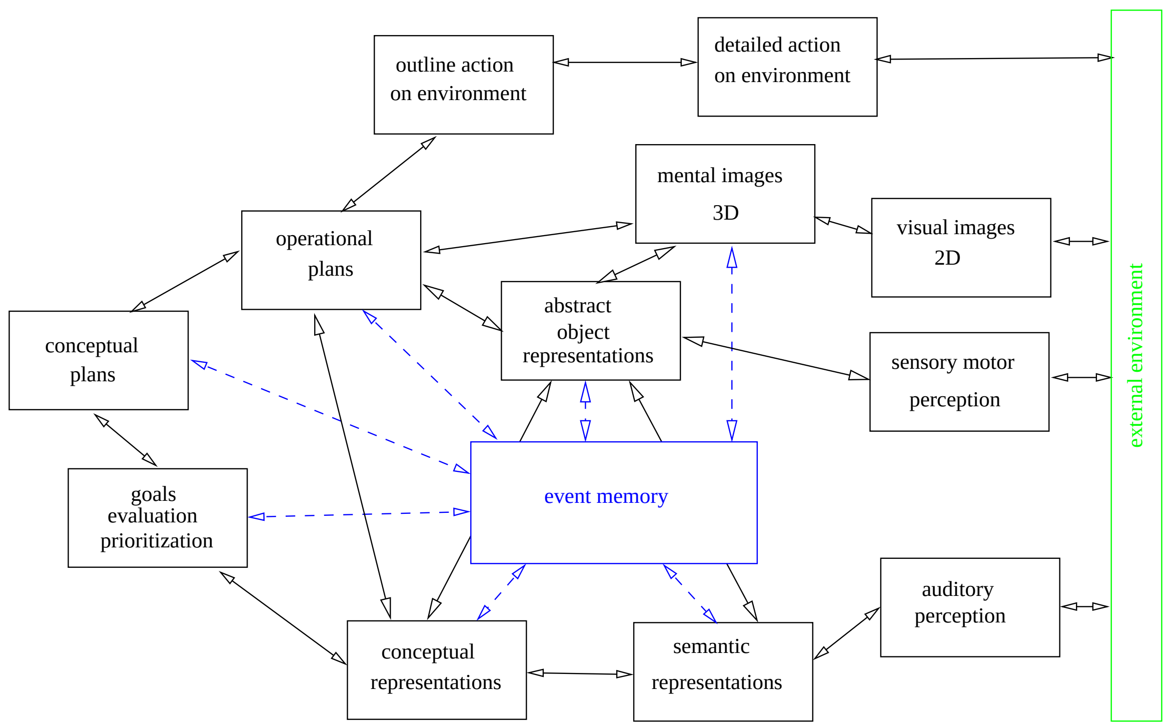

Figure 1: The architecture of proposed system

a plan step. Plan execution uses working goals in the plan execution module and also constructions and percepts that it receives from the perception hierarchies, in order to search different possible states and to construct new possible states. Goal selection, plan selection and plan step selection are reconsidered every processing cycle, and plan steps at different levels of abstraction run concurrently. Feedback, to these goal and planning modules from the constructed states, which are distributed over the modules of the perception hierarchies, can change their selections.

The proposed creative problem solving dynamics. In extending our model, our approach to creative problem-solving is informed by the work of DeGroot [11] and Newell and Simon [21] who give a clear description of the problem-solving cycle with a succession of narrow beam searches each ending in an evaluation. By a narrow beam, or “quasilinear”, search, we mean searching only one successor per node, and only occasional backtracking by one step before continuing forward. After each search, the subject reconsiders the position in the light of this evidence, possibly reformulates, reconceives and rerepresents the problem, generates a conceptual or logical goal, then an operational goal, and then makes another search. We give an outline diagram in Figure 2, indicating the sequence of searches and the operations in the problem solving cycle.

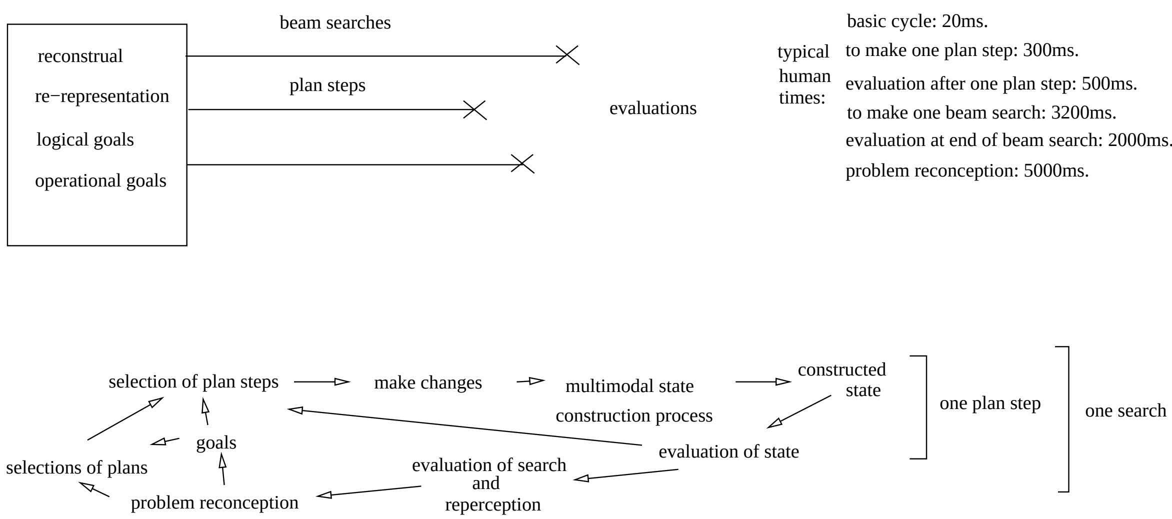

Figure 2: The proposed cycle of creative problem-solving dynamics

An approach to realizing creative problem solving

Let us first systematize the previously listed aspects of creativity, then we will outline our conceptual approach.

States, representations and problems

1. There are different types of representation, including 2D and 3D mental images or structures in 2D or 3D spaces, and topological and conceptual representations, together with various purely functional descriptions.

2. For each representational type, we can represent a whole set of different situations.

3. And for a given situation, there can often be more than one representation of a given

representational type, for example there could be more than one 2D representation of the same situation.

4. A situation in one type of representation can be perceived and represented also by another type of representation, for example a conceptual representation can be perceived and represented as a 3D image.

5. And vica-versa.

6. So a situation is usually represented by several different types of representation which mutually interact by mutual perception.

7. 2D or 3D images are probably the most important type of representation, so we will usually have a 2D or 3D representation as one of the set of interacting representations.

8. Each different type of representation corresponds to a different type of knowledge, and representations of situations are accompanied by knowledge, in the form of structures, assertions, construction rules, deduction rules and constraints, and a database of instances of represented situations.

9. A situation, or state, can be constructed by being given externally and perceived, or it can be constructed completely internally.

10. A problem can be defined as a state with a set of desired properties or a set of constraints to be satisfied, but where the state does not satisfy these properties or constraints. Thus there are at least three kinds of constraints, structural constraints defining the representations, integrity constraints on sets of representations, and problem constraints defining the problem or design solution criterion. In a logical formulation, a constraint is a logical statement which is asserted to hold, and it is checked by proving it, whenever it is required to be checked.

11. A problem is often given as more than one interacting representation with conditions on all the different representation types.

Processes involved in creative problem solving

1. A problem then is a problematic state with desired conditions or goals, and creative problem solving is goal-directed.

2. We need dynamic goal setting and dynamic goal changing during the creative problem solving process.

3. We need to be able to generate alternative representations, to synthesize them, and to construct them.

4. We need to be able to abstract a representation, combine representations and merge representations.

5. Relations between representations, within one type or between different types, can lead to analogy and metaphor.

6. We need to be able to evaluate, or assess, a representation using knowledge and complex requirements.

7. We need dynamic reconstrual of the problem state, rerepresentation and restructuring.

8. The management of the creative process may use a metalevel control process.

Our conceptual approach

We give a diagram as Figure 3. Part (a) shows the set of mutually interacting representations which form the current state of the item or situation being designed or solved. Part (b) shows the planning modules which initiate and control the changes made to the current state, and gather assessment information. Part (c) shows the episodic memory module which forms memories of events of the current state and the planning modules, creating associational links between corresponding events in different modules.

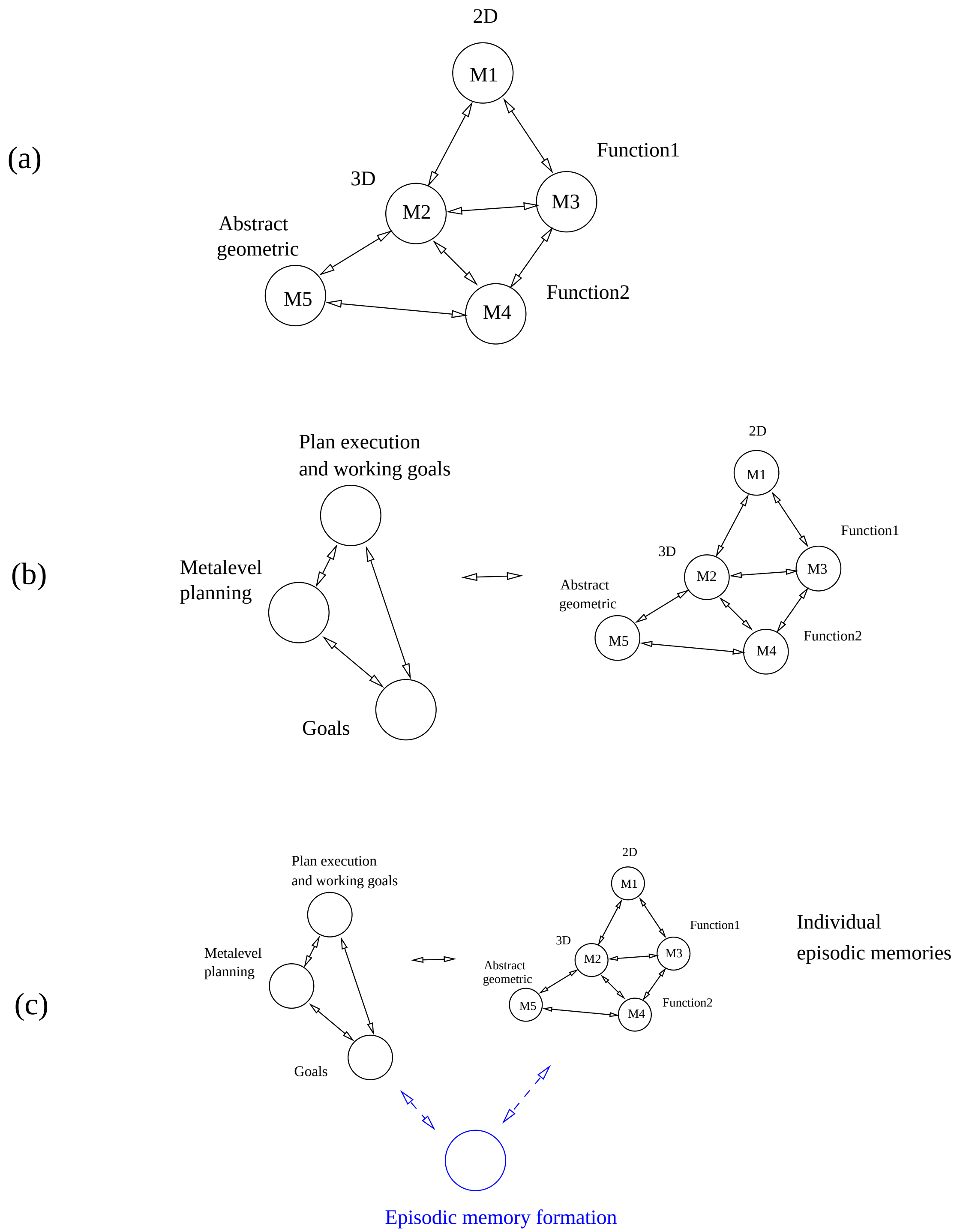

Figure 3: The proposed creative problem-solving system

1. Each representation type corresponds to a processing module which contains (i) the knowledge of this representation type, (ii) a database or long term memory of representations, (iii) a representation of the current state, and (iv) an episodic memory of other representations forming part of the current search space.

2. Modules are connected and can communicate. They receive information from each other which they perceive, and they send queries and commands/requests to each other.

3. The set of modules and representations will equilibrate to a distributed representation of the current state. That is, a change in one module may cause changes in other modules, and these changes will continue until a quiescent state is obtained.

4. There are goal, planning and metalevel planning modules which provide the high level control of the creative problem solving process.

5. The basic operation is an incremental change in one module, leading to a change in other modules and in the distributed representation of the state.

6. The set of representation types in a module has a logical theory, defined by a set of logical rules. The action of a module is the execution of this set of rules until quiescence, which leads to a fixed point and generates a minimal model of the logical theory. The minimal model is a set of elements and relation instances which is the most general model of the logical theory, that is the one which makes the fewest assumptions. Thus, from the logical part of the representation, the system dynamically constructs corresponding models. Data exchanged among modules correspond to atomic logical statements, and their presence in the module alters the constructed model.

7. The plan execution level of control involves a single narrow beam search, where a sequence of changes, usually within a single module, ends in an equilibrium state representation which can be evaluated or assessed.

8. There is an episodic memory module which associates together all the events in the set of modules to form a complete event, and also forms episodes consisting of sequences and sets of events, and stores these in an episodic memory. The event representations in this memory associate with representations of component module events which are stored in individual modules.

9. The plan level involves, after each new equilibrium state and its assessments, the choice of which next beam search to carry out. This choice is based on the current representation, the episodic history of the problem solving process, and the problem solving strategy being used.

With a stable representation, the system executes a sequence of beam searches and assessments. This leads to a solution state to the problem. The episodic memory contains the record of the search and the proof of the problem solution, see Figure 4.

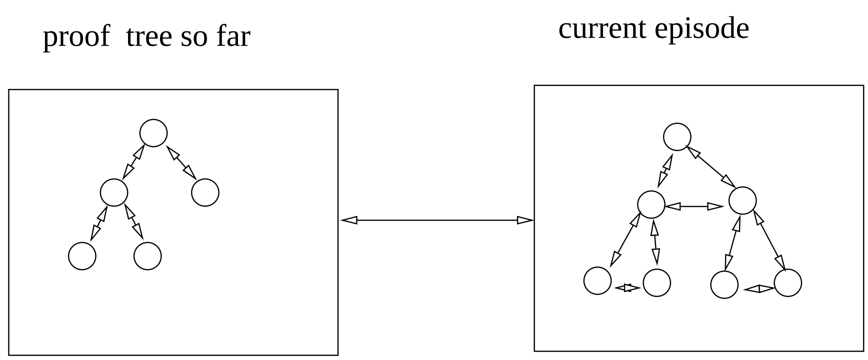

Figure 4: Episodic memory

10. However, the representation of the state and the problem is reconsidered, and may result in rerepresentation, restructuring and reconstrual. Restructuring arises by changing a component of the representation in one module and propagating this change to the other components of the state representation. Thus an initial representation in one module is perceived by a second module, producing a representation there, and a change in the rep-

resentation in the second module propagates back to the first module, producing a major change of representation. Figure 5 diagrams this idea.

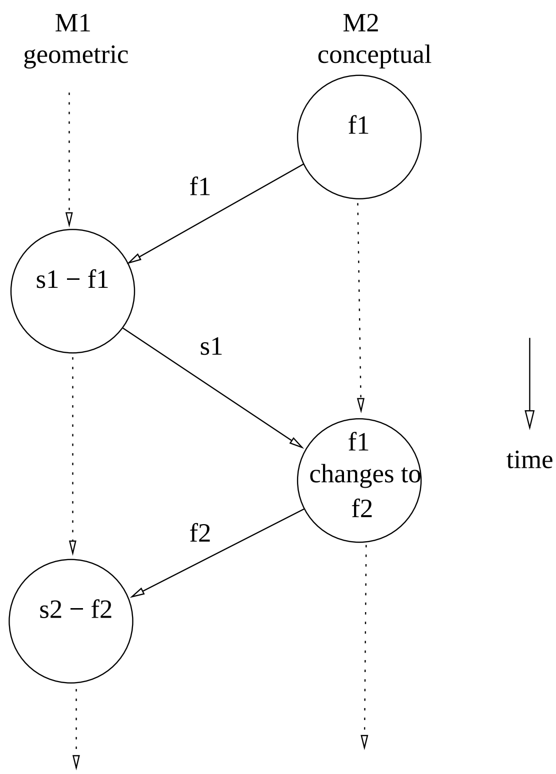

Figure 5: Restructuring in one module caused by an increment in another

The plan can also change its focus from searching changes in one module, to searching changes in a second module which has a different perspective and representation type.

11. A representation has constraint expressions, which reduce the number of structural possibilities. By temporarily ignoring some of these constraints the planner can search more abstractly and in different parts of the search space.

12. Evaluation of a state is achieved by evaluation functions in each module, which determine the extent to which its representation satisfies its goals and its constraints. We also evaluate the correspondence and "fit" between representations in interacting modules.

13. There can be an external environment, which can be useful for some applications. The problem solving state is however the internal state, that is, the distributed set of representations in the set of modules.

We are thus arguing that the proposed modular processing architecture lends itself naturally to creative problem solving by providing (i) different types of representations which mutually interact, allowing large ("lateral") changes of representation, (ii) a planning and metalevel planning regime which allows flexible exploration of alternatives, with changes of representation type, and (iii) an episodic memory facility which allows the history of the problem solving process to be used in planning further problem solving actions.

This creative problem solving architecture provides naturally for most of the known aspects of creative problem solving that we listed in an earlier section. They are consequences of the modular representation of the state, the parallelism of control, and the detailed dynamic memory of problem solving.

Research activities

The development and study of mechanisms of creativity

To develop this approach to creative problem solving, we propose to investigate the different aspects of creativity, including (i) dynamic goal setting and goal changing, (ii) restructuring by intermodule perception, (iii) merging of representations within a module, (iv) the use of problem solving episodic memory for planning, and (v) metalevel planning. We will also study the effects of knowledge and memory on the creative problem solving process.

Investigation of the applicability of the approach to practical problems

We will investigate practical uses of our research. As regards application areas, the author has some experience with collaboration in aircraft design [10], with logical modeling in CAD/CAM for the aerospace industry [4], and with data modeling in architectural design

[13][14]. He works part of the time in the design process group at the National Institute of Standards, headed by Ram Sriram.

Creative problem solving support. We will investigate allowing a user to cooperate with and to use the system for creative problem solving. The user can query the current state of a module and input different choices of construction and evaluation operations to it. We may need to provide graphical visualization of the state of the module. The user may be able to act as the metalevel planning module, or influence planning with direct input of commands.

Web creative knowledge modules. We will investigate the definition of a module as a webpage with XML representations for its components - knowledge, examples, constraints etc. If this can be achieved then we would like a user to be able to put together a creative problem solving system by linking a set of web modules together, and then linking them to web-based planning modules and episodic memory modules.

The research schedule

The first year will be mainly concerned with the systematic development and investigation of mechanisms for the different aspects of creativity listed above.

There will be a sequence of stages, each lasting about 3 months, in which we will investigate, and design and implement mechanisms for: (i) dynamic goal setting and goal changing, (ii) restructuring by intermodule perception, (iii) merging of representations within a module, (iv) the use of problem solving episodic memory for planning, and (v) metalevel planning.

In the second year, we will investigate practical uses of our research. We will develop demonstrations of creative problem solving support, and we will develop an approach to web creative knowledge modules.

Throughout, the research will involve the development of different cognitive model mechanisms and testing with creative problem-solving tasks. The choice of which problem-solving tasks to study is itself part of the research. There are some classic problems such as Duncker's radiation problem. Even the task of learning to solve the Tower of Hanoi problem involves discovering new strategies by making creative associations, for example, seeing the problem in terms of pyramids of disks, or realizing that parity can be used in constructing a strategy.

Results

Documentation and sharing. The documentable results of the project will be papers and programs which will be sharable with other researchers in the field.

Broader impacts. The project will integrate research and education by advancing our understanding of creative thought and how it can be improved and measured. Potential benefits to society at large will flow from the new insights and understanding of creativity which is a key issue in science, technology and the arts.

Cross-disciplinary benefits. The project will benefit research in brain-based cognitive modeling, showing the basic constructivity and creativity of brain architecture and function.

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[29] Charles S. Whiting. *Creative thinking*. Reinhold, New York, 1958.

Biographical Sketch: Alan Bond

a. Professional preparation

Magdalen College, Oxford University, Physics B.A. (First class honours), 1961
Magdalen College, Oxford University, Physics M.A., 1966
Imperial College of Science and Technology, London Univ., Theoretical Physics Ph.D. 1966

b. Appointments

(2005 - present) Research Psychologist, Semel Institute for Neuroscience and Human Behavior, Geffen School of Medicine, University of California at Los Angeles, Los Angeles, California
(2005 - present) Visiting professor, National Institute of Standards and Technology, Gaithersburg, Maryland
(Sept 1998 - 2004) Lecturer in Computer Science, California Institute of Technology, Pasadena, California.
(Sept 1996 - 2004) Senior Scientist, Departments of Electrical Engineering and Computer Science, California Institute of Technology, Pasadena, California.
(Sept 1995 - June 1996) Instructor, Department of Computer Science, University of California, Los Angeles.
(Feb 1994 - Dec 1994) Visiting Researcher, Division of Neurosurgery, School of Medicine, and Computer Science Department, University of California, Los Angeles
(Sept 1991-Jan 1994) Member of Technical Staff, Computer Systems Research Department, The Aerospace Corporation, Los Angeles
(Feb-Aug 1992) Sony Sabbatical Chair, Sony Computer Science Research Laboratory, Tokyo
(1985-1991) Principal Development Engineer, University of California, Los Angeles
(1969 - 1984) Lecturer (Corresponds to Assistant and Associate Professor) in Computer Science, Queen Mary College, London University (tenured from 1973)
(1968-9) Acting Assistant Professor, Engineering Department, UCLA, Los Angeles
(1967-8) Visiting Assistant Professor, Computer Science Department, Carnegie-Mellon University, Pittsburgh
(1966-7) Research Scientist, Computer Science Department, Carnegie Institute of Technology, Pittsburgh
(1966) Research Assistant in Computing Methods, Mathematics Department, Royal Holloway College, London University
Visiting Posts:
(1991) Esprit DAI project IMAGINE. Logic Programming Group, Imperial College, London
(1983-5) Senior Research Scientist, Electrical Engineering Systems Department, University of Southern California, Los Angeles
(1982) Visiting Research Professor, Image Processing Institute, University of Southern California, Los Angeles
(Summer 1981) Engineer, Naval Ocean Systems Center, San Diego
(Summer 1980) Visiting Researcher, Computer Science Department, Carnegie-Mellon

University, Pittsburgh
(Summer 1973) Visiting Lecturer, Mackerere University, Kampala, Uganda

c. Five publications relevant to the proposed project

Alan H. Bond. A Computational Model for the Primate Brain based on its Functional Architecture, Journal of Theoretical Biology, vol 227, pp. 81-102, 2004.

Alan H. Bond. Representing episodic memory in a system-level model of the brain, Neurocomputing, vol 65-66, pp. 261-273, 2005

Alan H. Bond. A System-level Brain Model of Spatial working Memory , Proceedings of the 28th Annual Conference of the Cognitive Science Society, pp. 1026-1031, 2006.

Alan H. Bond and Basuki Soetarman. Integrating Prolog and CADAM to produce an Intelligent CAD System. Software Practice and Experience, 20:1049-1076, 1990.

Alan H. Bond and Richard Ricci. Cooperation in aircraft design. Research in Engineering Design, 4, 115-130, 1992.

d. Synergistic activities

Innovations in teaching: Developed ten undergraduate courses in computer science and developed master's program in computer science, at Queen Mary College, University of London. Developed advanced level computer courses at California Institute of Technology. Tutor on university teaching methods for the University Teaching Methods Research Unit, London University.

Development of research tools: The CADLOG system at UCLA, and the BAD system.

Development of computation methodologies: Predicate logic approach to CAD/CAM. Logic programming approach to Brain Science.

e. Collaborators and other affiliations

Collaborators and co-editors: Professor Les Gasser, University of Illinois at Champaign.

Graduate advisor: Professor Raymond Streeter, University of London.

Thesis advisor: No graduate students within the last five years.

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION **University of California-Los Angeles**	**FOR NSF USE ONLY** PROPOSAL NO.	DURATION (months) Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR **Alan H Bond**	AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Alan H Bond - Research Psychologist	6.00	0.00	0.00	$ 43,775	$
2.					
3.					
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	0.00	43,775	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				43,775	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				11,382	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				55,157	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				4,000	
2. FOREIGN				2,000	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				300	
3. CONSULTANT SERVICES				300	
4. COMPUTER SERVICES				245	
5. SUBAWARDS				0	
6. OTHER				728	
TOTAL OTHER DIRECT COSTS				3,573	
H. TOTAL DIRECT COSTS (A THROUGH G)				64,730	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) Modified Total Direct Cost (Rate: 54.0000, Base: 64730)					
TOTAL INDIRECT COSTS (F&A)				34,954	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				99,684	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 99,684	$

M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $
PI/PD NAME **Alan H Bond**	**FOR NSF USE ONLY** INDIRECT COST RATE VERIFICATION
ORG. REP. NAME*	Date Checked / Date Of Rate Sheet / Initials - ORG

1 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

YEAR 2

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-Los Angeles

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Alan H Bond

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. **Alan H Bond - Research Psychologist**	6.00	0.00	0.00	$ **45,089**	$
2.					
3.					
4.					
5.					
6. (**0**) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	**0**	
7. (**1**) TOTAL SENIOR PERSONNEL (1 - 6)	6.00	0.00	0.00	**45,089**	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (**0**) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	**0**	
2. (**0**) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	**0**	
3. (**0**) GRADUATE STUDENTS				**0**	
4. (**0**) UNDERGRADUATE STUDENTS				**0**	
5. (**0**) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				**0**	
6. (**0**) OTHER				**0**	
TOTAL SALARIES AND WAGES (A + B)				**45,089**	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				**11,723**	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				**56,812**	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				**0**	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				**4,000**	
2. FOREIGN				**2,000**	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ **0** 2. TRAVEL **0** 3. SUBSISTENCE **0** 4. OTHER **0**					
TOTAL NUMBER OF PARTICIPANTS (**0**) TOTAL PARTICIPANT COSTS				**0**	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				**500**	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				**300**	
3. CONSULTANT SERVICES				**300**	
4. COMPUTER SERVICES				**252**	
5. SUBAWARDS				**0**	
6. OTHER				**728**	
TOTAL OTHER DIRECT COSTS				**2,080**	
H. TOTAL DIRECT COSTS (A THROUGH G)				**64,892**	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) **Modified Total Direct Cost (Rate: 54.0000, Base: 64892)**					
TOTAL INDIRECT COSTS (F&A)				**35,042**	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				**99,934**	
K. RESIDUAL FUNDS				**0**	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ **99,934**	$

M. COST SHARING PROPOSED LEVEL $ **0** AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Alan H Bond

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

 ***ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET**

SUMMARY PROPOSAL BUDGET

Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months)	
	Proposed	Granted
AWARD NO.		

ORGANIZATION
University of California-Los Angeles

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR
Alan H Bond

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Alan H Bond - Research Psychologist	12.00	0.00	0.00	$ 88,864	$
2.					
3.					
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (1) TOTAL SENIOR PERSONNEL (1 - 6)	12.00	0.00	0.00	88,864	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL SCHOLARS	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				88,864	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				23,105	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				111,969	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				8,000	
2. FOREIGN				4,000	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				2,500	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				600	
3. CONSULTANT SERVICES				600	
4. COMPUTER SERVICES				497	
5. SUBAWARDS				0	
6. OTHER				1,456	
TOTAL OTHER DIRECT COSTS				5,653	
H. TOTAL DIRECT COSTS (A THROUGH G)				129,622	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				69,996	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				199,618	
K. RESIDUAL FUNDS				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 199,618	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME
Alan H Bond

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

Budget Justification

Senior Personnel Salaries(A): 50% salary for Dr. Alan Bond who will work on all aspects of the project, including theory, design and implementation of the model.

Fringe benefits(C): The fringe benefit rate of 26.0% is assessed on salaries.

Travel

(E1): Domestic travel is requested to present results at conferences and for collaboration. It also includes travel to an annual CreativeIT Principal Investigator's meeting.

(E2): Foreign travel is for international conferences and for discussions with informal international collaborators.

Other direct costs(G):

1. Materials and supplies include a workstation for the principal investigator.

3. Consultant services will be required for assistance with installation of linux software.

4. The charge for computer services is a campus wide charge per year for technical infrastructure support, which is mainly for the computer networks at the campus and departmental levels.

6. We will require a continuing annual software license for a Sicstus Prolog System, which costs 520 euros per year, which we have converted at the rate of 1.4 to give $728.

Indirect costs(I): F and A charges are 54.0% of all direct costs.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Alan Bond

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: NIST IPA

Source of Support: National Institute of Standards and Technology

Total Award Amount: $ 60,000 Total Award Period Covered: 06/01/07 - 05/31/08

Location of Project: UCLA and National Institute of Standards

Person-Months Per Year Committed to the Project. Cal: 6.00 Acad: 0.00 Sumr: 0.00

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: A computational model of creative problem solving

Source of Support: National Science Foundation, CISE, IIS, CreativeIT

Total Award Amount: $ 91,491 Total Award Period Covered: 08/01/07 - 07/31/08

Location of Project: UCLA

Person-Months Per Year Committed to the Project. Cal: 6.00 Acad: 0.00 Sumr: 0.00

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Facilities, equipment and other resources

Computer networks for research: UCLA medical school has an impressive network of computers for research.

Brain mapping center UCLA has a very large brain imaging center with an international reputation.

Library: UCLA's comprehensive library system, with six million books, and a specialized biomedical library, is second in the nation (after Johns Hopkins).