DAYDREAMING IN HUMANS AND COMPUTERS

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Abstract

This paper examines *daydreaming:* spontaneously recalling or imagining personal or vicarious experiences in the past or future. The following functions of daydreaming, for both humans and computers, are discussed: support for processes of creativity, future planning and rehearsal, learning from successes and failures, emotion modification, and motivation. A computational theory of daydreaming is being implemented and tested in a computer program called DAYDREAMER. A prototype version of DAYDREAMER which produces several daydreams (in English) is currently running.

I. INTRODUCTION

An intriguing aspect of humans is that we spend much time engaged in thought not directly related to the current situation or environment. This type of thought, usually called *daydreaming,* involves recalling past personal or vicarious experiences and imagining what might have happened in the past or what might happen in the future. On the face of it, daydreaming may seem like a useless distraction from a task being performed. However, since daydreaming is so pervasive in human experience (Pope, 1978) (Singer, 1975), we must ask ourselves what purposes it might serve, both for humans and intelligent computer systems.

We hypothesize several important roles of daydreaming in human and computer cognition. These roles will be discussed in the context of the following episode and daydreams which might result from such an episode:*

NUART-EPISODE

Last night I went alone to the Nuart Theater to see a film. This actress whom I've always had a crush on also came alone and happened to sit down near me. I recognized her and started a conversation. At one point, she mentioned the obviously well-known director of the film we were about to see and I didn't know the name. I was embarrassed. I finally asked her if she'd like to go have a drink after the film. She said she had other plans.

DAYDREAM1

I feel embarrassed for not knowing who the director was. I should've pretended to know who the director was. In the future I'll read up on the film before I go.

DAYDREAM2

I'm disappointed that she didn't want to go out with me. She might change her mind if I were to ask her out again. I would call her up, but I don't have her telephone number. I should've asked for her telephone number when I had the chance. I imagine that I find out her telephone number, call her up, and she accepts my offer for a date. I regret not having asked for her telephone number. But she's a movie star and out of my league.

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* These daydreams are a composite of several daydreaming protocols we obtained from subjects via immediate retrospective reports (see Varendonck, 1921, pp. 215-216; Ericsson & Simon, 1984).

DAYDREAM3

I'm disappointed that she didn't want to go out with me. I imagine that she accepted my offer and we soon become a pair. When she has to do a film in France, I leave my job and travel there with her. As we continue to travel, my career suffers. I become unhappy and feel unfulfilled. She loses interest in me, because I have nothing to offer her. It's good that I didn't get involved with her, because it would've led to disaster. I feel less disappointed that she turned me down.

DAYDREAM4

I'm angry that she didn't want to go out with me. I imagine that I pursue an acting career and become a star even more famous than she is. She remembers meeting me a long time ago in a movie theater and calls me up. I'm glad she admits she was wrong about me. I go out with her, but now she has to compete with many other women for my attention. I eventually dump her.

II. SUPPORT FOR CREATIVITY

A relationship between daydreaming and creativity has often been suggested; e.g., see (Freud, 1908). We believe that the following attributes of daydreaming make this mode of thought useful as a form of *support for creativity:*

Relaxation of constraints: Daydreaming explores possibilities which would normally not have been pursued. Some of these possibilities, while perhaps unlikely at first glance, may lead to a new and useful solution to a problem. This is similar to the idea of "brainstorming" (Osborn, 1953).

Fortuitous analogy recognition: While daydreaming about one thing, it is possible to stumble into a solution to another problem. That is, daydreaming often includes the serendipitous recognition of analogies among problems. For example, suppose that the daydreamer is leafing through an alumni directory from the college he attended and notices that the telephone number and address of a famous astronaut is listed. He may then experience the following daydream:

DAYDREAM5

I thought famous people didn't list their telephone numbers. I am reminded of the actress I met. If I could find out where the actress went to college, and get an alumni directory from that college, I might be able to find out her telephone number. I'll have to find an article about her somewhere.

Revision: Daydreaming occurs in the context of a self-modifying episodic memory (called a "dynamic memory" by Schank, 1982). Each time a problem is examined, new information may be available that will enable a better, different, or more creative solution. For example, in DAYDREAM2 the daydreamer does not figure out how to find out the movie star's telephone number, while in DAYDREAM5 after receiving new information he is able to move one step closer to a solution to this problem. The daydreamer now has more ideas about how to contact the movie star, and thus future attempts have more possibilities from which to proceed.

Motivation: Daydreaming provides the motivation to create in the first place. For example, a daydream which anticipates aesthetic satisfaction or praise from others upon a successful creation provides a strong motivating factor to produce that creation.

Inspiration: Finding an initial solution to a problem through daydreaming may inspire one to flesh out that solution. DAYDREAM5 is an example of how daydreaming may spur new interest in a problem.

Daydreaming is often plot-oriented and thus is ideally suited to story invention. For example, the plots of DAYDREAM3 and DAYDREAM4 resemble those of several recent motion pictures. Daydreaming can provide initial ideas for a story and, once the story is begun, can suggest continuations and further possibilities.

III. FUTURE PLANNING AND REHEARSAL

Daydreaming is often concerned with *planning for the future* and *rehearsal* (Singer, 1975). Daydreaming may generate future plans which are incorporated into memory. For example, in DAYDREAM5 the daydreamer plans to find and then read a magazine article about the actress. The next time he is near a newsstand or library, he may remember this plan and look for an article about the actress.

Daydreaming often consists of the exploration of hypothetical future scenarios. This allows the consequences of possible future actions in possible future situations to be considered in advance. In this way, advantageous actions may be employed over less advantageous ones. For example, in DAYDREAM3 the daydreamer considers the results of going out with the actress, which in this case he deems to be negative. Simulating hypothetical future scenarios through daydreaming thus assists in decision-making and also provides an adaptive safety mechanism to avoid undesirable courses of action.

Daydreaming aids not only in making life choices, but also in choosing among detailed alternative methods for carrying out a plan in the face of various contingencies. For example, before a job interview one may anticipate questions of the interviewer in order to prepare a good response for each question. Rehearsing future actions through daydreaming may help increase the accessibility of planned actions and the skill with which they can be performed.

Instead of shutting a computer down, its free time can be spent daydreaming about future tasks. Although daydreaming cannot guarantee the best behavior in all situations, systems with daydreaming will always have an efficiency advantage over systems without daydreaming.

IV. LEARNING FROM EXPERIENCE

Daydreaming about a recalled failure or success is often concerned with the generation of alternatives which might have resulted in a different outcome. For example, DAYDREAM1 contains the alternative of having pretended to know the famous director. Each alternative that is generated highlights a reason for the failure or success. Heider (1958) has noted that one may learn by avoiding that to which failure is attributed or by strengthening that to which success is attributed. Through the abstraction of generated alternatives to planning strategies for use in future similar situations, daydreaming enables *learning from failures and successes.* For example, in DAYDREAM1 the daydreamer may learn to read up on films before going to see them or to pretend to know something he does not know in order to maintain a positive image. In DAYDREAM2, the daydreamer may learn to ask for a person P's telephone number while talking to P if he anticipates wishing to contact P in the future and there is no other way of contacting P in the future. The next time the daydreamer finds himself in a similar situation, he will probably remember to ask for the telephone number.

Learning from an experience is not necessarily complete after that experience. Nor does learning from an experience take place at one sitting afterwards. Rather, learning from past experiences is an ongoing process carried out through daydreaming. Often, this involves *reinterpretation* in light of experiences and knowledge that have been acquired in the meantime. This relates to the *revision* attribute of daydreaming previously discussed.

V. EMOTION MODIFICATION AND MOTIVATION

Daydreaming is often concerned with the reduction or elimination of negative emotions resulting from a recalled failure experience. For example, in DAYDREAM3 the failure is rationalized and the disappointment reduced through the generation of a daydream demonstrating that going out with movie stars is undesirable. In DAYDREAM4, the daydreamer gains a form of revenge against the actress, resulting in a positive emotion. Thus a function of daydreaming is to make the daydreamer *feel better.* In effect, failures result in a form of "cognitive dissonance" (Festinger, 1957) which must somehow be reduced. However, sometimes an increase, rather than decrease, of negative emotion results from daydreaming about a failure. An example occurs in DAYDREAM2 when the daydreamer regrets not having asked for the movie star's telephone number. In general, daydreaming results in modification of emotional state since emotions may result from imagined as well as real events.

From a purely computational point of view, it may seem pointless to incorporate emotions of any type into a system. As long as computers are driven by human-specified tasks this may well be the case. Independent agents, however, must find *motivations* to drive the creation and relative strength of their goals. We believe that emotions provide this motivational force. Suppose, for example, that one loses a wallet. In a planning system, the loss of possession of an object would create a goal on the part of the planner to repossess that object, which would in turn cause the planner to select a plan for achieving this goal. With people, however, the situation is more complex. What if one does not *feel* upset over the loss of the wallet? In this case it does not seem likely that effort will be expended in searching for it. That is, the activation and strength of the goal is based on the intensity of the emotional impact of an experience. Without the need to reduce the negative emotions of fear or anger, there would be no motivation to plan avoidance or retaliation. Without feelings of satisfaction arising from imagined goal accomplishment, there would be no motivation to achieve goals. Thus emotions both set and reflect the relative importance of goals and the amount of effort expended in planning for them.

VI. COMPUTATIONAL DAYDREAMING THEORY

The DAYDREAMER program is being constructed in order to implement and test a computational theory of daydreaming. DAYDREAMER takes as input simple situational descriptions, such as accidentally meeting a movie star, and produces as output 1) actions that it would perform in given situations, and 2) daydreams, all in English. DAYDREAMER learns as it daydreams by indexing daydreams, planning strategies, and future plans into memory for future use.

DAYDREAMER is composed of:

- an *emotion component,* in which daydreams initiate, and are initiated by, emotional states arising from goal outcomes (Dyer, 1983) and personality traits,
- a *relaxed planning mechanism,*
- a *personality model* which provides the goals and *control goals* which guide relaxed planning,
- a *dynamic episodic memory* of experiences used by relaxed planning, and
- *domain knowledge* of interpersonal relations and common everyday occurrences.

Control goals are postulated to help direct daydreaming. Four such goals are common in the transcripts we have examined:

Rationalization, activated by negative emotions resulting from a recalled failure, involves generating reasons for why an outcome is satisfactory to the daydreamer in order to reduce the negative emotions and maintain self esteem.

Revenge, activated by emotions of anger resulting from a recalled failure caused by another, involves imagining retaliations against that person in order to generate positive emotions.

Failure/Success Reversal, activated upon recall of a goal failure or success, involves altering reality by imagining scenarios in which failures were prevented or in which successes failed to come about in order to learn future planning strategies.

Preparation, activated upon recall of an event planned for the future, involves generating hypothetical future scenarios in order to learn planning strategies and/or specific actions to be used in possible future situations.

Once a control goal is activated, the relaxed planner selects and executes a plan to achieve that control goal. Plans for achieving control goals may often be captured by Plot Units (Lehnert, 1982). One plan for rationalization is expressed by the MIXED BLESSING Plot Unit, which represents the abstract situation of a goal success leading to the failure of another goal. This plan is employed in DAYDREAM3 in order to achieve the rationalization control goal activated by the emotion of disappointment resulting from being rejected by the actress. Here the MIXED BLESSING Plot Unit is realized as a fantasy in which dating the actress leads to eventual failure of the relationship and the daydreamer's career. Another plan for rationalization is captured by the SUCCESS BORN OF ADVERSITY Plot Unit, which represents the abstract situation of a goal failure leading inadvertently to the success of another goal. Here we could imagine a daydream in which, as a result of being turned down, the daydreamer imagines drowning his sorrows at a bar and by chance meeting a more beautiful actress.

Realization of plans for achieving control goals expressed as Plot Units may be simplified through reminding of appropriate episodes indexed by those Plot Units. For example, in DAYDREAM4 a revenge control goal is first activated by anger toward the actress. A plan for revenge is captured by the RETALIATION Plot Unit, which represents the abstract situation of a person A achieving a positive outcome by causing a negative outcome for B, where B had originally caused a negative outcome for A. Next, the RETALIATION Plot Unit along with other indices such as "rejection" might retrieve a vicarious episode such as the following:

Sarah applied to Yale for graduate school but was rejected so she went somewhere else. Years later she won the Nobel Prize. Then when Yale tried to recruit her as a professor, she spitefully turned them down.

This episode may now be adapted through analogy to the situation of DAYDREAM4 in order to achieve the active revenge control goal.

VII. CURRENT STATUS AND FUTURE WORK

A prototype of the DAYDREAMER program has been constructed using GATE (Mueller & Zernik, 1984), an integrated set of graphical artificial intelligence development tools for the T language (Rees, Adams, & Meehan, 1984), a dialect of Scheme running on Apollo Domain workstations. DAYDREAMER currently 1) participates in NUART-EPISODE by receiving and performing actions in response to input phrases such as 'You accidentally meet your favorite actress at the Nuart Theater' and 'She turns you down', 2) indexes the episode into memory under the DENIED REQUEST Plot Unit, 3) generates versions of DAYDREAM1, DAYDREAM2, DAYDREAM3, and DAYDREAM4 in simplified English, indexing the daydreams into memory via Plot Units and emotions, and indexing into memory the planning strategy formed during DAYDREAM2, i.e., not to forget to ask for someone's telephone number, and 4) participates in another episode in which it demonstrates that it has learned the above planning strategy. The computational theory of daydreaming which we are developing and the DAYDREAMER program are described in greater detail in (Mueller & Dyer, 1985).

Future plans call for the extension of DAYDREAMER to enable it to 1) participate in a larger variety of input episodes, 2) generate more daydreams in response to each episode, 3) incorporate many daydreams, planning strategies, and future plans into memory, and 4) demonstrate the use of recalled daydreams, planning strategies, and future plans in future internal (daydreaming) and external behavior. We intend for DAYDREAMER to be able to daydream continuously, stopping only to receive new experiences.

VIII. CONCLUSIONS

The functions of daydreaming and a computational theory of daydreaming are being implemented and tested in the DAYDREAMER computer program. We have argued that, far from being a useless epiphenomenon, daydreaming serves an important cognitive role in supporting creativity, future planning and rehearsal, learning from failures and successes, and emotion modification and motivation. Truly intelligent computers should not be idle when left unemployed by their users, but daydreaming like ourselves.

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