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TITLE
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The Effects of Modafinil, Amphetamine and Placebo on Individual and Group Decision Making Processes in a Sustained Operations Environment

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To date little attention has been devoted toward understanding individual versus group decision making in sustained operations environments, or how these processes are enhanced or compromised by the use of drugs designed to reduce the effects of fatigue. Canadian Forces volunteers participated in an individual and group decision making task every 6 hours for approximately 84 hours, including 64 hours of sleep deprivation. In Phase A (individual portion) of each session, subjects provided numerical estimates and self-report measures for five intellectual knowledge questions. In Phase B, subjects met as a group and provided consensus judgments for each of the five estimate questions. Phase C involved individually providing self-reported perceptions concerning various aspects of the previous group session. We found robust effects of sleep deprivation (SD) on subjective measures of individual and group performance. Although subjects perceived that SD was having an increasing impact upon individual and group judgments and group decision times increased with SD, the actual accuracy of group judgments was not diminished. Group consensus judgments were more accurate than the average individual judgment but were often less accurate than the best individual group member judgment. Consistent with other tasks involving "higher level" cognitive processing, we found minimal effects of SD on these challenging individual and group decision making problems. In addition, accuracy was not affected by Modafinil or Amphetamine.

Introduction

When a collection of people makes a decision, there are typically two ways to achieve this goal. Individuals may form groups in which there is no subdivision of labour (Sniezek & Henry, 1989), or form teams which are a distinguishable set of two or more individuals who interact independently and adaptively to achieve specified, shared and valued objectives (Cannon-Bowers, Salas, & Converse, 1993). Group and team judgments are usually called for when a decision is extremely important, or where the workload or information load is simply too great for one person to handle.

Deficits in group or team performance often have profound effects in military operations. For instance, the aviation literature has consistently implicated a failure in crew coordination as a significant contributing factor in the majority of military and civilian aviation accidents (Foushee, 1982; Foushee & Manos, 1981). These issues are not limited to aviation theaters of operation, nor are they a function of the recent trends toward high technologies in military environments.

Commenting upon the already dangerous Atlantic escort duties of corvettes during the Second World War, one veteran noted that this tasking was made even more difficult by the crewing policies adhered to by the Royal Canadian Navy:

"Unfortunately as new corvettes and minesweepers were being commissioned, a ship's crew, that had the experience of working together as a team, were continually being drafted to other assignments that disturbed the working performance of most ships' routines. A crew must practice and perform together so that its response becomes sure and swift ... [Further

complicating matters, escort] ... groups were not left intact so the ships could get on the job training together to improve their efficiency ... In anti-submarine warfare, as with troops on the ground, you can't have good execution without teamwork and continuity. (Johnston, 1994, p.149).

Military groups or teams are often called upon to make important decisions and perform critical tasks that require teamwork. Moreover, often these judgments, and the actions based upon such judgments, occur under conditions of time pressure, complexity, uncertainty and fatigue. Thus, it is crucial to understand the dynamics that affect decision making.

Individual versus Group Decision Making

The research of Henry and others (Heath & Gonzalez, 1995; Henry 1993; 1995 Lim, 1994; Sniezek & Henry, 1989; 1990) have made direct comparisons of individual versus group decision making using numerical estimates of dates, car prices etc. Numerical estimations are useful decision stimuli in that they enable researchers to have a quantifiable correct answer, and provide an objective yardstick concerning the magnitude of accuracy (or error) of subjects' answers. This work has consistently demonstrated that group consensus judgments are typically more accurate than the average individual member decision. This superiority of group versus individual decision making is referred to as *process gains* or the *synergistic effects of groups*.

However, we also know that there are times when the demonstrated superiority of group decision making can go spectacularly awry. The most dramatic examples of these *process losses* (Steiner,

1972) are political or military in nature, for example the U.S. involvement in the Bay of Pigs debacle, and their escalating involvement in Vietnam.

Several factors have been identified as central to these group judgment deficits. Groups are vulnerable to "groupthink" (Janis, 1972; Kameda & Sugimori, 1993), where the desire for cohesiveness in a group becomes dominant, unconsciously overriding even the desire for judgment accuracy. Commitment to initial decisions, termed *sunk costs*, can act to bind groups to previous decisions, even after it becomes apparent that the initial judgment may not be optimal (Arkes & Blumer, 1985; Whyte, 1993). Other uniquely social phenomenon such as the specific norms of the group, social loafing, status differentials among group members, leadership style, expertise, and even individual levels of self-confidence and extroversion may be implicated in how groups combine individual judgments into a group decision (Klein, & Mulvey, 1995; Sniezek & Henry, 1989). It seems that it is simply often the case that "... in practice it will be difficult for groups to identify and use valid cues to accuracy ..." Sniezek & Henry, 1989, p. 9).

All of this suggests that the group decision process is extremely complex. To be sure, assessing the actual accuracy of judgments is crucial in decision research. However, the prior discussion also indicates that it may be just as important to begin to understand the underlying psychological and social forces that create these basic judgments. Thus, we directly assess selected personal and social perceptions to determine their role in the group judgment process and, ultimately, upon the answer the group provides.

Moreover, as important and illuminating as the prior research on individual and group decision making is, the previous designs have typically been limited to a single session. Thus, we know very little about "ongoing" or multiple session individual and group decision making, which is often the case in many important real-world contexts. Similarly, we have little understanding of the effects of real-world stressors such as sleep deprivation upon these sorts of decision processes. Such processes, and the judgments that may be influenced by these processes, may be of particular concern in military environments, where decision making is often made under less than optimal conditions, such as extreme time pressure and during sustained operations. Further speaking to this issue, we determine whether these decision processes are enhanced or compromised by the use of drugs designed to reduce the effects of fatigue: Amphetamine and Modafinil.

Summary of Research Questions

1. What are the effects of fatigue management aids such as Amphetamine and Modafinil upon decision making in sustained operations?
2. How does a stressor such as sleep deprivation affect subjects perceptions of their decision making processes at both the individual and group levels?
3. Does the documented effect of groups outperforming the average individual's answer on judgment tasks exist over an extended period of time, and under sleep deprivation?
4. Do groups outperform the best individual's answer on judgment tasks, demonstrating the synergistic effects of groups, and does this effect exist over an extended period of time, and under sleep deprivation?
5. Does group 'time to consensus' increase across a sleep deprivation period or does increased fatigue encourage short-cuts in judgmental processes?

Method

Subjects: Subjects included in these analyses were 34 Canadian Forces reservists and two regular forces personnel (33 males and 1 females). One subject did not complete all sessions due to illness, and her data was eliminated from data analyses.

Procedure:

Phase A - Individual Judgment Task: Every six hours, subjects' individually provided their best estimate of the correct answer to five numerical estimation questions (historical dates, population, amounts of precipitation, etc.). After making each judgment, subjects also made a series of ratings about each question, including the degree to which lack of sleep affected their answers (1 = not at all - 7 = a great deal).

Phase B - Group Judgment Task: Next subjects congregated in a communal room. While being videotaped, subjects discussed each question in turn and arrived at a consensus concerning the correct answer.

Phase C - Individual Assessment of Group Judgments: Once the group consensus judgments were made, subjects returned to their individual rooms and made a series of judgments concerning the group session just completed, including the degree of group conflict and cooperation (1 = low - 7 = high).

Results

Due to space restrictions, we present selected results of the individual and group decision making task. We divide the results into three broad categories. First, we address the effects of Amphetamine and Modafinil upon the decision making task. The second involves subjects' perceptions concerning the effects of specific factors upon decision making at both the individual and group levels: attributions of the effects of sleep deprivation as well as the amount of cooperation and conflict apparent in the group discussions. Third, we present results of objective measures of decision performance: judgmental accuracy and time to consensus for group decisions.

I) Drug Effects

In these analyses, repeated measures ANOVAS showed no effects of drug condition, thus the findings presented below were collapsed across the drug conditions.

II) Subjective Measures of Performance

Perceived Effects of Sleep Deprivation upon Decision Quality:

Recall, subjects were asked to provide their

perceptions of factors affecting their judgments at both the individual and group levels. One of these questions asked the extent to which they felt lack of sleep was affecting their answers. Results of the repeated measures ANOVA (judgment type x sessions) revealed only a significant sessions effect ($F(13, 429) = 21.59, p < .001$). As Figure 1 indicates, subjects felt that sleep deprivation was having an increasing effect both individual and group judgments.

Perceived Degree of Cooperation and Conflict in Group Decision Making:

Two additional questions assessed subjects' perceptions of the amount of conflict and cooperation apparent in each of the five discussions in each group session. Repeated measures ANOVAS yielded significant effects of sessions for both measures of cooperation ($F(13, 429) = 5.53, p < .001$) and for the amount of conflict ($F(13, 429) = 2.97, p < .001$) in the group consensus sessions. As depicted in Figure 2, there was a slight, although statistically reliable, tendency for subjects' to perceive less cooperation and greater conflict in the group sessions as sleep deprivation continued.

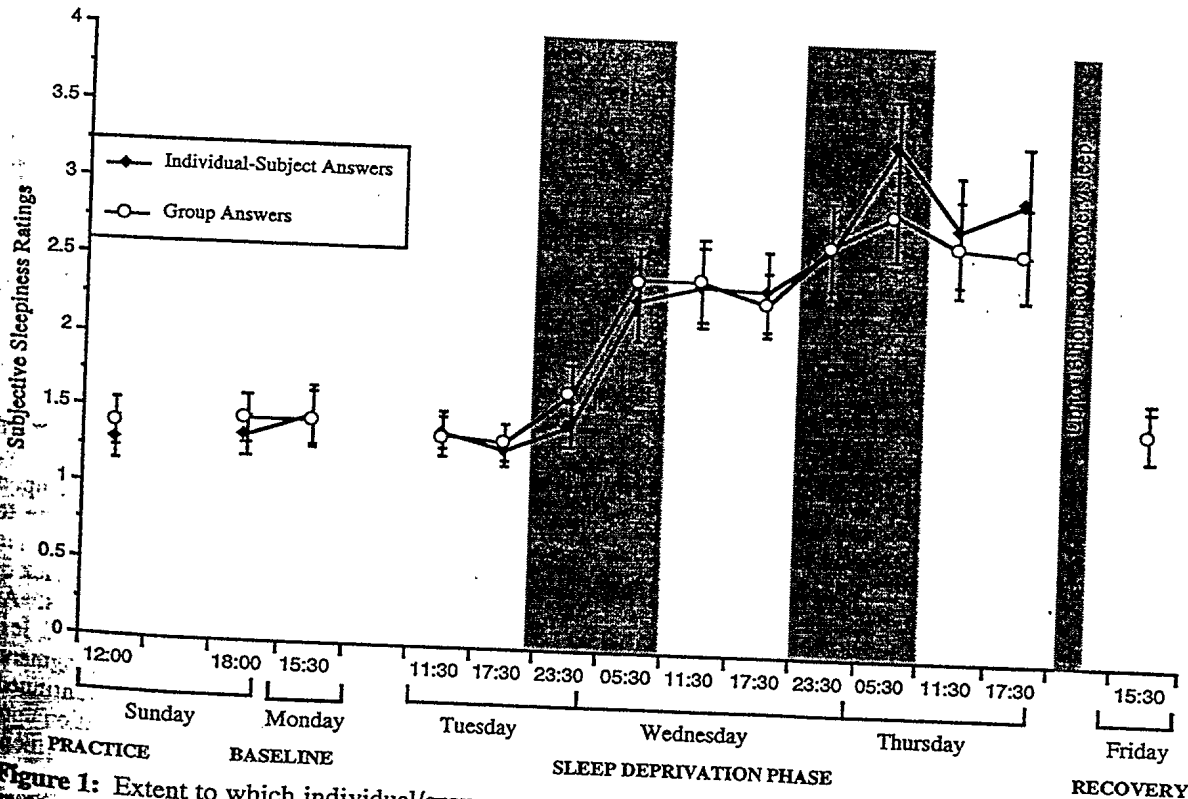


Figure 1: Extent to which individual/group answer was affected by lack of sleep

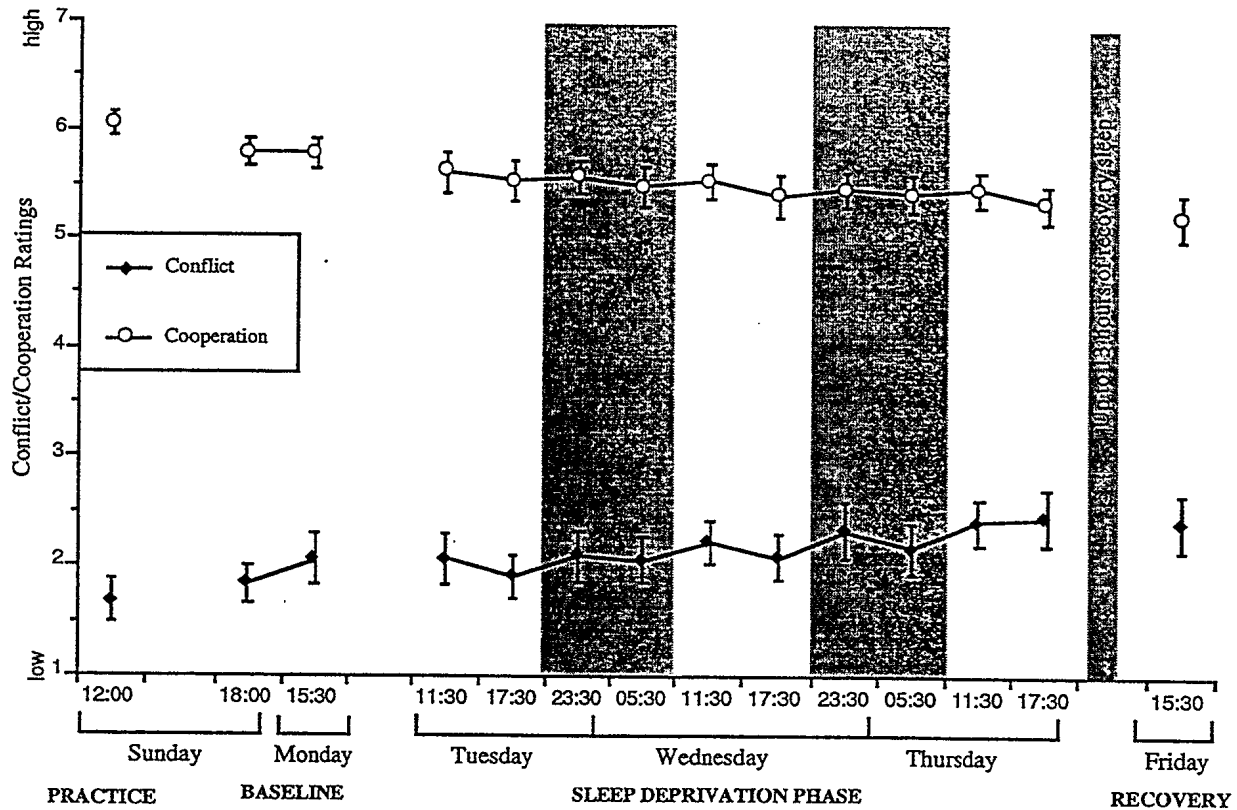


Figure 2: Degree of conflict and cooperation in group sessions

III) Objective Measures of Performance

Judgmental Accuracy: We use a formula from Sniezek and Henry (1989; 1990) to assess judgmental accuracy. Here accuracy is defined as the absolute value of the subject's answer (individual or group) minus the correct answer, divided by the correct answer. Lower scores indicate that the subject's (or the group's) answer more closely approximates the correct answer.

In this case, there were significant main effects of judgment type (median individual judgment, best individual judgment, group judgment) ($F(2, 10) = 103.69, p < .001$) and of sessions ($F(13, 65) = 18.13, p < .001$), which were qualified by a significant judgment type \times sessions interaction ($F(26, 130) = 3.43, p < .001$). As Figure 3 indicates, both median and group accuracy show initial increases in accuracy across sessions, while the best individual answers are consistently high in accuracy. Note that group answers more closely approximate the median individual answer, rather than the best individual answer. Importantly, there were no appreciable effects of sleep deprivation on group decision accuracy.

Time to Consensus:

Each group's average time to reach consensus across the five questions per session was obtained from the videotapes of the group interaction phase of the task. Figure 4 shows that after an initial decrease in group completion time per question, presumably as subjects became familiar with the task, subjects began to take longer to reach a consensus on these questions as sleep deprivation continued ($F(13, 65) = 6.00, p < .001$).

Discussion

First, as was the case with other higher order mental tasks in the larger Modafinil study, amphetamine and Modafinil had little effect upon individual and group decision accuracy or time to consensus. We did find effects of sleep deprivation in terms of people's perceptions of the impact of lack of sleep upon their individual and group answers. As well, subjects perceived greater conflict and less cooperation in developing their consensus judgments as the group decision making sessions continued. Despite the apparent effects of sleep deprivation upon subjects' perceptions of their powers of judgment, actual accuracy did not decline with increasing

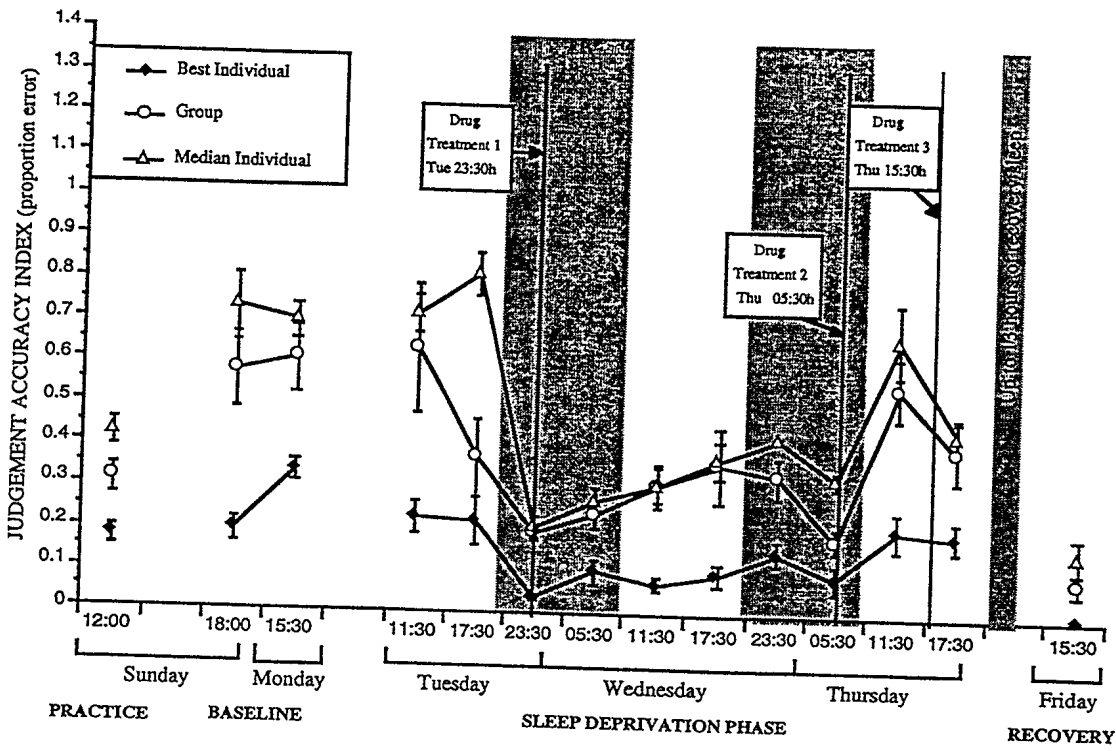


Figure 3: Individual and group judgment accuracy indices

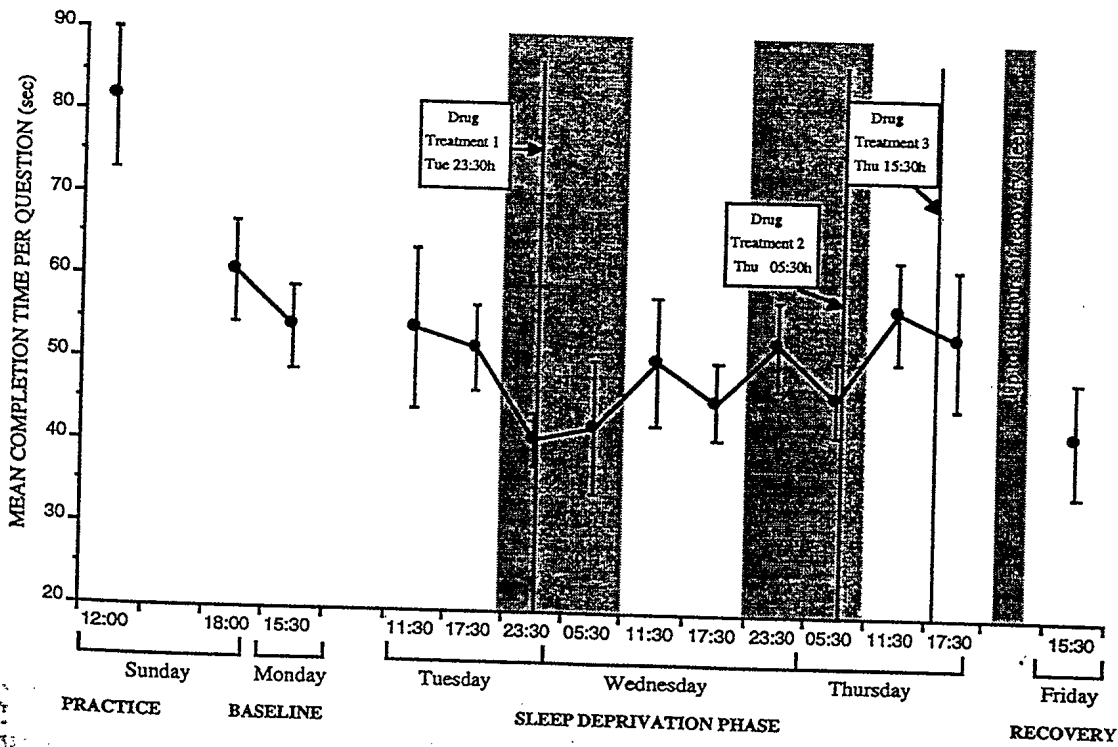


Figure 4: Group decision time

fatigue. While group judgments tended to be more accurate than the median individual judgments, groups did not outperform the best individual member. While judgmental accuracy did not decrease with sleep deprivation, time to reach consensus, and thus perhaps processing time, did show evidence of increasing across sessions.

A particular strength of this research lies in its ecological validity. Our participants were required to make judgments in multiple sessions under conditions of sleep deprivation. Thus, the conditions under which our groups performed their judgment task are particularly relevant to real-world decision making. Future research should be devoted to determining the impact of similar factors on decisions of a more military nature, for instance developing and updating ongoing mission strategies during sustained operations. Nonetheless, the present findings begin to address acknowledged weaknesses in the existing individual and group decision making literature and provide a compelling, although admittedly first step, toward a better understanding of these important decision processes.

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