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Assessment of Simulated Spatial Disorientation Scenarios In Training U.S. Army Aviators (Reprint)

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The limitation of ground based training to raise the aviator's awareness of SD is widely acknowledged. A proposal was therefore raised to develop SD scenarios for presentation in a visual flight simulator.

The scenarios were developed using accident summaries from the U.S. Army Safety Center (USASC), Fort Rucker, Alabama, which were reviewed for suitable content. These were then presented as a series of scripts from which a trainer could reproduce the situation in a visual flight simulator.

The resulting scenarios were presented to 30 experienced aviators who completed questionnaire evaluations after each scenario and an overall evaluation.

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The scenarios have been developed as a U.S. Army aviation training tool and are being distributed to units worldwide. The scenarios were developed in a UH-60 (Blackhawk) simulator, but have been refined to make them relevant to other types of helicopter operations such as the AH-64 (Apache) attack helicopter.

Assessment of Simulated Spatial Disorientation Scenarios in Training U.S. Army Aviators

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SUMMARY

Spatial disorientation (SD) is considered to be present when a pilot fails to perceive the position, motion, or attitude of his/her aircraft with respect to the gravitational vertical or surrounding objects [1]. The results of SD in flight may be disastrous.

The limitation of ground based training to raise the aviator's awareness of SD is widely acknowledged. A proposal was therefore raised to develop SD scenarios for presentation in a visual flight simulator.

The scenarios were developed using accident summaries from the US Army Safety Center (USASC), Fort Rucker Alabama, which were reviewed for suitable content. These were then presented as a series of scripts from which a trainer could reproduce the situation in a visual flight simulator.

The resulting scenarios were presented to 30 experienced aviators who completed questionnaire evaluations after each scenario and an overall evaluation.

The results showed a high level of acceptance of this training tool by a group of experienced aviators with differing backgrounds.

The scenarios have since been developed as a U.S. Army aviation training tool and are being distributed to units worldwide. The scenarios were developed in a UH-60 (Blackhawk) simulator, but have been refined to make them relevant to other types of helicopter operation, such as the AH64 (Apache) attack helicopter.

INTRODUCTION

SD was considered to be a significant factor in 291 (30 percent) Class A-C helicopter accidents in the U.S. Army between 1987 and 1995 [2]. The total cost of these accidents was estimated at over $486M and 110 lives were lost. These figures are the visible result of SD in aviation; the invisible effects of reduced efficiency and performance or of curtailed and abandoned missions are more difficult to quantify.

Training is one of the available approaches to the problem of SD. The aim of training in this situation is to increase the awareness of aviators to the dangers of SD, the ease with which an individual or crew can become disorientated, and to increase the reliance of aircrew on the standard recoveries from disorientating situations, such as transition to instruments or a "go around" procedure.

Training has been restricted in many situations to classroom based demonstrations reinforcing formal teaching. These often take the form of rotating chair (Barany Chair) demonstrations that highlight the unreliability of the vestibular system in providing orientation information.

In some services this is supplemented with a demonstration in the aircraft. These vary from an extended "recovery from unusual attitudes" exercise to a formal disorientation sortie flown (ideally) by a qualified flight surgeon/pilot [3] or with a flight surgeon providing physiological explanation and commentary [4]

A major disadvantage of the classroom based training is that the demonstrations lack reality, both in the illusions which can be demonstrated and because the environment of the spinning chair is so far removed from that of the helicopter cockpit. It is suggested [5] that helicopter pilots are not regularly subjected to "classical" SD illusions, but are more usually exposed to high workload, bad weather and difficult flying conditions that lead to SD. In-flight demonstrations, while extremely effective, require considerable coordination and are affected by the variability of weather. The apparent cost for this type of training is also high, though when set against the background of the current cost of disorientation accidents even a small benefit from training may be cost effective [3].

The possibility of using a visual flight simulator to address some of the training issues was investigated. The aim was to produce a series of scenarios which would demonstrate to the pilot under training the risks of SD and some of the ways in which SD can be managed as a risk in aviation. This would be achieved in the risk free environment of the simulator, with the advantages of the hold and replay facilities that a simulator offers.

METHODS

Scenario Development

The USASC at Fort Rucker, Alabama maintains a database of all U.S. Army aviation accidents. This archive was searched to obtain outline details of accidents providing illustrations of how "real world" SD accidents occur. This search produced 81 accidents in summary form.

These summaries were reviewed to select those that would produce suitable scenarios for use in a visual flight simulator.

Paper presented at the RTO HFM Symposium on "Current Aeromedical Issues in Rotary Wing Operations", held in San Diego, USA, 19-21 October 1998, and published in RTO MP-19.

Accidents that were considered to be the result of careless or negligent behavior were rejected, as were those that called for information or flight characteristics which were outside the capabilities of the flight simulator. Examples of this category of scenario include those that would call for a clear view through the chin bubble of the aircraft, which is not possible in the UH60A/L simulator.

The elimination process resulted in 18 scenarios being developed for use in the simulator.

The scenarios were developed as scripts in such a way that they could be delivered in paper form with all of the information required to present the scenario in any U.S. Army visual flight simulator.

An example of a scenario is attached as Annex A to this paper. Each scenario is presented under the following headings:

Simulator Initial Conditions

The simulator operator is provided with the information required to set up the scenario, including the location, weather conditions, illumination conditions, and aircraft conditions (such as fuel states and equipment). Three of the scenarios call for the prior recording of a lead ship by the operator or instructor, details of which are included under this heading.

Scenario Development

The trainer is provided with a succinct briefing for the student that includes details of crew composition and duties, weather and task details and other details such as a tactical situation or background to the sortie. The scenario is not introduced to the student as a "spatial disorientation" exercise.

This section also contains information for the trainer and/or the simulator operator about the conduct of the sortie that is not conveyed to the student.

Debriefing

The debriefing starts with a statement that the situation just encountered was spatial disorientation and that the situation demonstrated has caused an aircraft accident. A summary of the source accident is given to the student, together with comments from the official inquiry.

A series of structured questions is included to assist the trainer to bring out the important learning points of the scenario. The debriefing may be followed, if necessary, by an opportunity to repeat the scenario to demonstrate ways of managing the individual situation using alternative flying techniques and better crew coordination, or as a demonstration flown by the trainer.

The SD Demonstration Scenario

The individual scenarios differ considerably, but each puts the trainer and student as a crew into a situation that resulted in an aircraft mishap caused by SD. In some situations the trainer is required to place the aircraft into a particular configuration, while in other scenarios the development relies upon the continuing crew coordination which allows a hazardous situation to develop. An example of this would be where the student allows the trainer to continue to fly into worsening weather until visual reference is lost completely.

The 18 scenarios are divided into the following groups:

- Day single aircraft
- Day multi-aircraft
- Night (unaided) single aircraft
- Night (aided) single aircraft
- Night (aided) multi-aircraft

Subjects

Each member of a subject group consisting of 30 experienced volunteer aviators was assigned to complete one group of six scenarios. The subject group was categorised by career group as shown in table 1. The mean age of the subjects was 35.5 years, with an age range of 25 – 61yrs.

Table 1 Subject group

Career group	Number	Mean flying hours
General Aviation	12	933
Staff Officer	6	1783
Instructor Pilot	9	5680
Medical/Research	3	667

Conduct of Trial

The 18 scenarios were divided into three groups of six for the purposes of the trial. Each group contained at least one each of day, multi-aircraft and night aided (with night vision goggles) situations. Each subject was allocated to complete one group of scenarios.

Each subject experienced the allocated six scenarios during one session. The subjects completed a questionnaire after each scenario together with overall evaluations after all six scenarios had been completed. The questionnaire is reproduced as Annex B to this paper.

The subjects also provided written comments of their overall impressions of the scenarios.

RESULTS

The results were in the form of a rating on a scale of 1-5 with 1 representing "extremely poor" and 5 representing "excellent" for the first two questions (rating the briefing and realism of the scenarios). The same rating scale was used for question 6 (rating the effectiveness of the scenario in training aviators). Questions 3-5 asked for a measure of agreement, again on a scale of 1 – 5, with the presentation of the factors that made SD worse (3), the preventive measures to avoid SD (4) and the measures to overcome SD (5). In these measures 1 represents "completely disagree" and 5 represents "completely agree."

The subjects found difficulty with question 3, so the meaning of the question was clarified for all participants. The intention of the question was to establish whether the subject agreed with the factors in the debriefing which were suggested as making SD more likely to occur.

Ratings are taken as the arithmetical mean of each group's responses to each of the questions asked. The scale of 1 to 5 is used as presented in the questionnaire. The overall ratings by career group are shown in Figure 1.

All four groups rated the scenarios above 4 (good). The lowest rating was from the group of general aviators, while the highest rating was from the Instructor Pilot group.

Figures 2–7 present the data from questions 1–6, respectively, of the questionnaire. The results are presented for each scenario, with the responses of all subject groups combined. Only one rating in the series of graphs falls below 4 (the briefing for sortie 1). All other measures are greater than 4 on the scale and the majority are above 4.5. The distribution of scores shows no scenarios scoring consistently lower scores than the group as a whole.

No individual scenario was consistently rated lower than the others, though the night scenarios, as a group, scored higher overall ratings than the day scenarios.

The answers to the open question (7) are interesting as the subjective view of individual aviators of varying experience. All comments were positive and recognized the training benefit of the scenarios. Comments included:

"This training should be added to all Army aviation training programs"

"Excellent training"

"Extremely realistic"

". . . should be implemented into initial entry rotary-wing training . . . ."

DISCUSSION

The aim of these demonstrations is to increase awareness of the risks of SD and the ways in which previous accidents have been caused. It is not the intention to train aviators to avoid specific situations or to teach avoidance or recovery maneuvers.

The obvious relevance of the scenarios by virtue of their relationship to recent accidents is thought to be a major factor in the popularity of the training. Aviators are able to relate the scenarios to everyday flying situations and they are not seen as an artificial or contrived set of situations.

The scenarios have been produced as a stand alone package [6] comprising the trainer notes for each of the 18 scenarios produced to date. It is intended that aviators will be able to experience these as part of routine flight simulator training.

It is not necessary for the pilot/student to be current on the simulated aircraft, as the actual flying and systems of the aircraft are secondary to the management of the situation.

The scenarios have also been modified to take account of the different roles of individual aircraft. Where the original scenario may call for a medical evacuation mission, this would be modified in an attack helicopter scenario to a refuel or re-arm transit flight.

It is intended that the scenarios will be refined and expanded through continued liaison between United States Army Aeromedical Research Laboratory and the U.S. Army Safety Center, thereby producing a continued flow of new scenarios highlighting the current trends in SD accidents.

A further observation of the study is that this type of scenario may be used to demonstrate the problems of poor aircrew coordination and further investigation is planned to develop these and other scenarios to assist with aircrew cockpit coordination training

CONCLUSIONS

This study has demonstrated the potential benefit of utilizing helicopter flight simulators in the process of increasing pilot awareness of the hazards of SD. The high level of acceptance and enthusiasm for the sorties by the subject group was encouraging. The scenarios are believed to be an effective training tool and were shown to be convincing and enjoyable.

From the results of this study, it was concluded that the Spatial Disorientation Awareness Training Scenarios were suitable for development and presentation as a training tool for the United States Army aviation community.

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ANNEX A
Example of a Spatial Disorientation Demonstration Scenario

SPATIAL DISORIENTATION SCENARIO #1

Simulator Initial Conditions:

The IO:
1. Selects IC#5 (TACTICAL - HARRIS FIELD).
2. Sets the visibility to 0.3 mile.
3. Requests snow conditions. (Some simulators are not capable of creating snow conditions. In such cases, dust conditions may be substituted.)

Scenario Development:

TRAINER READS TO STUDENT: Pre-mission Briefing- "You (the student) are assigned the role of PC[Pilot-in-Command] and I (the trainer) will play the role of the PI[Pilot]. Our mission is to perform hover training in snow (dust) conditions just south of the runway in South Sod. We are located at an airfield in Class D airspace. The weather is reported to be 2000 overcast with ½ sm visibility. The winds are calm. Due to the visibility and Class D airspace, a special VFR clearance will be required to operate in the South Sod. After receiving clearance, I will takeoff to a hover and hover taxi the aircraft, at 50 feet above ground level (AGL), down the length of Runway 20. At the end of the runway, I will turn to heading 190 and taxi approximately 400 meters to the field located at 21SWK1610063700." Perform before takeoff check and call for clearance.

TRAINER NOTE: The trainer establishes and maintains the aircraft in a 50 foot hover above the blowing snow. The trainer will mention seeing another aircraft in the distance and then direct the student to change the UHF radio frequency to Ground Control. While the student's attention is focused inside, the trainer begins an undetectable descent and drift to the rear. As the aircraft descends below 15 feet or when the student becomes aware of the dangerous situation, the trainer states, "I have vertigo, you have the controls!" The training flight concludes when the student recovers or crashes the simulator.

Debriefing:

1. Tell the student, "That was spatial disorientation. The situation we just experienced actually occurred and resulted in an aircraft mishap. The following is a summary of the actual spatial disorientation accident."

TRAINER READS TO STUDENT: The aircraft was at a 25 foot hover over snow-covered terrain when the PI, who was on the controls, inadvertently allowed it to descend rearward and contact the ground. The PI did not detect the drift and descent because his attention was focused on another aircraft moving to the front. The environmental conditions (fog/snow) resulted in a lack of visual cues. The PC, whose attention was focused inside, tried to take control of the aircraft, but over-controlled it by applying excessive collective. He did not have adequate time to acquire visual cues, reference points, or aircraft instrument indications. The result was that the aircraft ascended to approximately 50 feet, began a spinning descent, contacted the ground and was destroyed.

2. Ask the student:

a. "Why did this happen?" (Solicit feedback from student.)

b. "What factors made spatial disorientation more likely in this situation?" (The following list is not all inclusive.)

(1) Lack of visual cues. (Blowing snow)
(2) Perception of linear motion below threshold. (Drift too gradual to perceive)
(3) Aircrew coordination failure. (Improperly focused attention)
(4) Reaction was excessive. (Excessive control inputs)
(5) Poor awareness of the risk of spatial disorientation in those flight conditions.

c. "How could this accident be prevented?"

(1) Use proper aircrew coordination procedures.
(2) Perform tasks and maneuvers per the ATM [Aircrew Training Manual], applying appropriate environmental considerations.

d. "How could this situation be overcome once you're in it?"

By performing a go around.

3. If necessary, the trainer will demonstrate the preventive action by:

a. Performing proper aircrew coordination.
b. Performing proper snow hovering techniques.

4. If necessary, the trainer will demonstrate the corrective action by performing a go around per the ATM.

ANNEX B

SPATIAL DISORIENTATION POST SCENARIO QUESTIONNAIRE

Thank you for assessing the Spatial Disorientation Training Scenarios

Please answer the questions below. You may be assured that the information contained in this questionnaire will be treated with the utmost confidentiality.

********** SD is used as an abbreviation for Spatial Disorientation **********

Name .... Date ....

SCENARIO # ***(to be completed by simulator operator)***.. ☐

For questions 1 and 2, please rate this scenario on a scale from 1 to 5
1-Extremely poor, 2-poor, 3-adequate, 4-good, 5-excellent.

1. How would you rate the briefing on the scenario? .... ☐

2. How would you rate the realism of the scenario? .... ☐

For questions 3 through 5, please rate this scenario on a scale from 1 to 5
1-Completely disagree, 2-somewhat disagree, 3-no firm opinion, 4-somewhat agree, 5-completely agree.

3. Do you agree with the factors that made the likelihood of SD worse ? .... ☐

4. Do you agree that preventive measures would work? .... ☐

5. Do you agree that measures to overcome SD would work? .... ☐

For question 6, please rate this scenario on a scale from 1 to 5
1-Extremely poor, 2-poor, 3-adequate, 4-good, 5-excellent.

6. How do you rate the effectiveness of this scenario for training aviators? .... ☐

7. Please add any further comments on this scenario:

....

Please add any further comments to the feasibility of utilizing simulator scenarios for training aviators to avoid and overcome spatial disorientation (SD). **(To be completed once by each volunteer).**

....

Figure 4. Question 3: Do you agree with the factors that made the likelihood of SD worse?

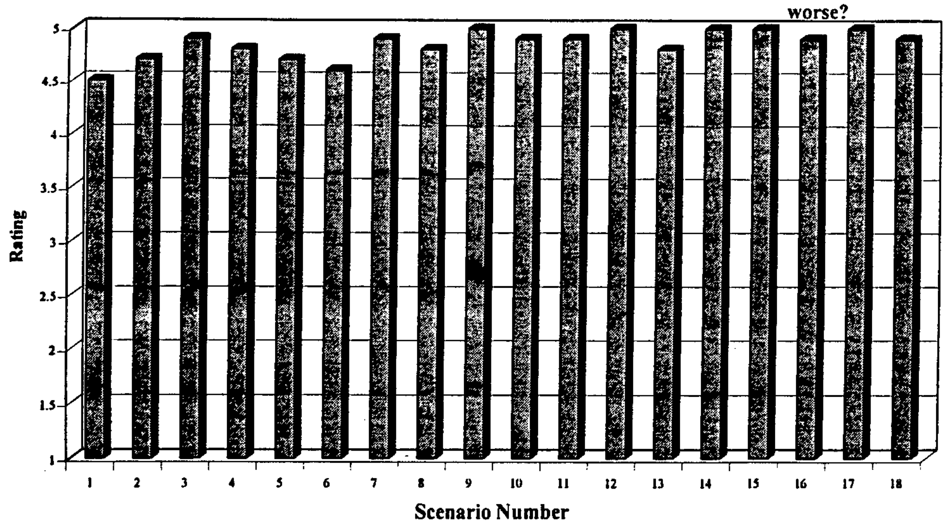

Figure 5. Question 4: Do you agree that the preventive measures would work?

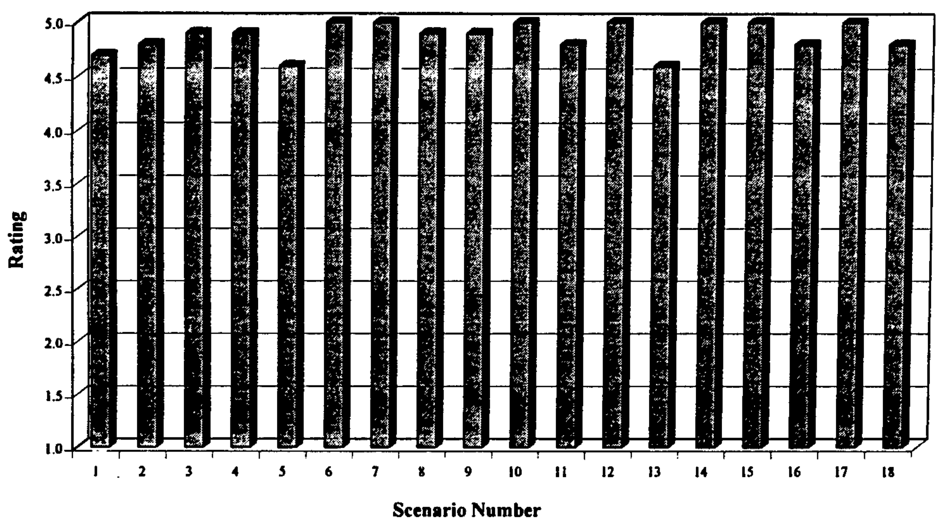

Figure 6. Question 5: Do you agree that the measures to overcome SD would work?

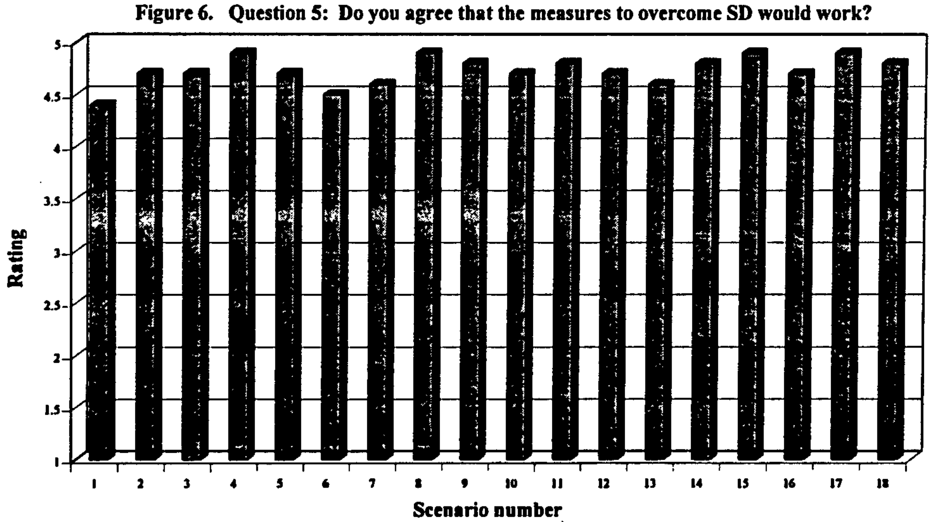

Figure 7. Question 6: How do you rate the effectiveness of this scenario for training aviators?

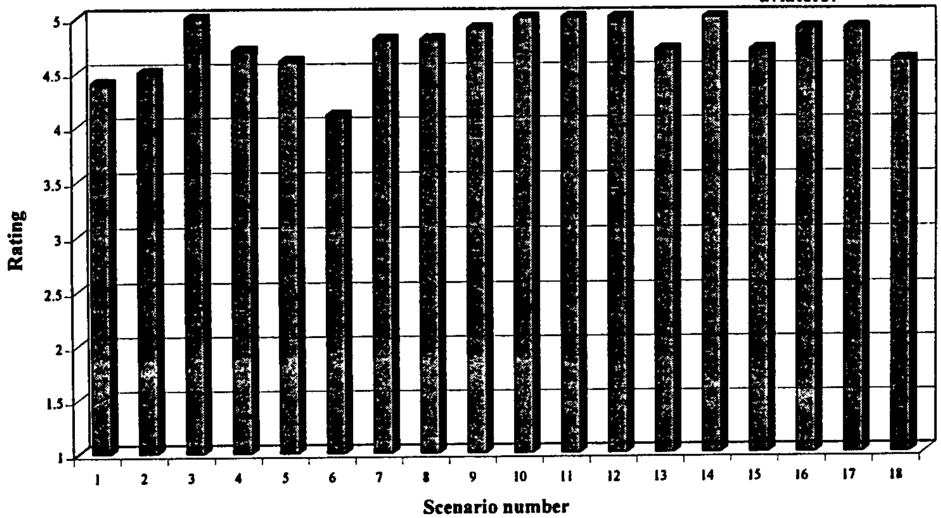

Figure 1. Overall rating by career group

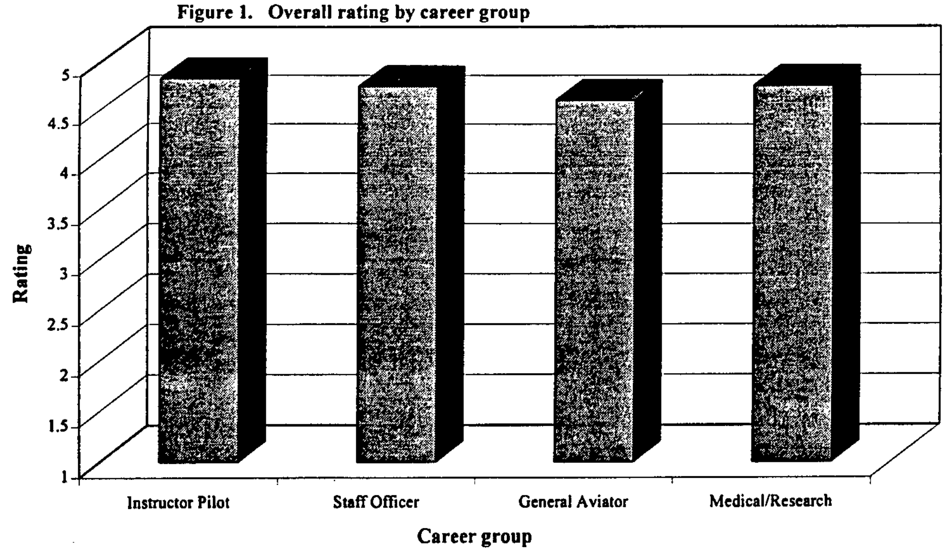

Figure 2. Question 1: How would you rate the briefing on the scenario?

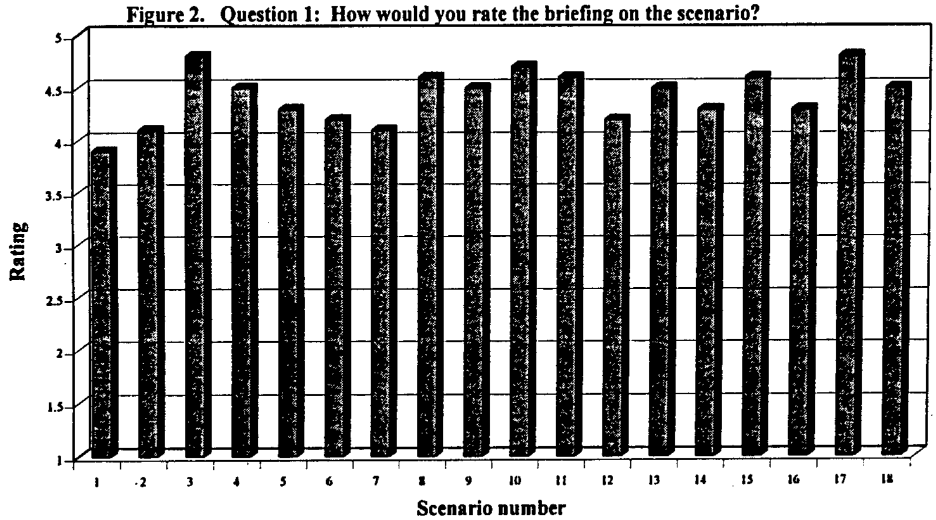

Figure 3. Question 2: How would you rate the realism of the scenario?