A TEAM PERSPECTIVE ON SITUATIONAL AWARENESS (SA): CUEING TRAINING

Renée J. Stout, Janis A. Cannon-Bowers, and Eduardo Salas
Naval Air Warfare Center Training Systems Division,
Orlando, FL

ABSTRACT

With the importance of situational awareness (SA) well established, there is a dire need for training to improve this crucial skill. This is also apparent in the team environment, because the skill of team SA is required to enable teams of operators to develop a compatible understanding of the situation at hand so that they can take appropriate actions in concert. This paper identifies and discusses one potential strategy for improving team SA - cueing training - in which relevant information in the task situation is made salient to the trainee. We describe a theoretical perspective of how this strategy was derived, discuss how this strategy might be implemented to heighten team SA, and provide an example of what this strategy might look like.

ABOUT THE AUTHORS

Rene e J. Stout is a Research Psychologist who works in the Aviation Team Training Lab, Training Technology Development Branch, of the Naval Air Warfare Center Training Systems Division, Orlando, FL. She received her Ph.D. from the University of Central Florida in Human Factors Psychology in August, 1994. She has worked in the area of team training, and human performance measurement for more than eight years. In addition to other projects in the area of aviation team training, she is currently the Principal Investigator of Office of Naval Research (ONR) funded team situational awareness research and is working on an ONR research project on conditioned-based maintenance and on-board diagnostics. Her other research interests include determining the role of mental models and shared mental models in team and aviation team training, as well as determining other cognitive, attitudinal, and behavioral factors that influence team proficiency.

Janis A. Cannon-Bowers is a Senior Research Psychologist in the Science and Technology Division of the Naval Air Warfare Center Training Systems Division (NAWCTSD), Orlando, FL. She holds M.A. and Ph.D. degrees in Industrial/ Organizational Psychology from the University of South Florida, Tampa, FL. As the team leader for Advanced Surface Training Research at NAWCTSD, she has been involved in a number of research projects directed toward improving training for complex environments. These have included investigation of training needs and design for multi-operator training systems, training effectiveness and transfer of training issues, tactical decision-making under stress, the impact of multi-media training formats on learning and performance, and training for knowledge-rich environments. She works closely with the Aegis community and has contributed to the development of several training systems such as the Battle Force Tactical Trainer, Joint Tactical Combat Training System, and Aegis Combat Training System.

Eduardo Salas is a senior research psychologist and the head of the Training Technology Development Branch, Science and Technology Division, of the Naval Air Warfare Center Training Systems Division. He received his Ph.D. degree (1984) in Industrial/Organizational Psychology from Old Dominion University. His research interests include team training and performance, training effectiveness, tactical decision making under stress, team decision making, human performance measurement and modeling, and learning strategies for teams. He has co-authored over fifty journal articles and book chapters and has co-edited four books.

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Many modern warfighting environments require the use of multiple operators working as teams to complete complex, dynamic missions which impose conditions of rapidly changing goals and task characteristics (Cannon-Bowers, Salas, & Grossman, 1991). In these settings, team members must assemble information from divergent sources and must quickly assess the situation at hand to enable appropriate, timely, and efficient operations among the team. A skill that has been identified as paramount to effective performance and safety under the task circumstances described is situational awareness (SA) (Endsley, 1988; Hartel, Smith, & Prince, 1991; Stout, Cannon-Bowers, & Salas, 1996).

Given its recognized importance, the necessity of training SA in team environments is crucial (Salas, Prince, Baker, & Shrestha, 1995; Stout et al., 1996). Unfortunately, little guidance is available from the literature on what instructional strategies are most beneficial for enhancing SA. This is especially the case when considering team SA, because very few efforts have even addressed the team element in SA (Salas et al., 1995).

Recent work by Salas et al. (1995) and Stout et al. (1996) has attempted to provide a conceptual understanding of team SA as a beginning step for identifying potentially effective instructional strategies for improving team SA. Stout et al. presented a theoretical framework of team SA which suggested that team SA is a dynamically changing state, affected by several contextual factors, and is developed by individual cue and pattern assessments, team processes, and the shared understanding of the team. Based upon their framework, they recommended several specific potential strategies for heightening team SA.

Through a review of the team SA training strategies suggested by Stout et al. (1996) and further conceptualizing about how to improve team SA, one particularly potentially beneficial training strategy has emerged, which is referred to here as *cueing training*. In essence, with this instructional strategy, relevant cues in the task environment are made more salient, increasing the probability for which they will be attended. A review of the literature, in addition to the Stout et al. article, reveals that while this training strategy holds potential promise for directly enhancing team SA, it appears that it is the most deficiently studied of all of the strategies recommended by Stout et al. In fact, no studies were found which used this approach within the complex team environment. There is a need to further understand this training strategy and how it can impact team SA.

Therefore, the purpose of this paper is to expand upon the work of Stout et al. by exploring more explicitly the strategy of cueing training. Specifically, we will explain why we believe that this training strategy is crucial to improving team SA and how this strategy can be implemented to improve team SA. We begin by summarizing the Stout et al. article, giving special attention to their theoretical framework of team SA, from which cueing training was derived.

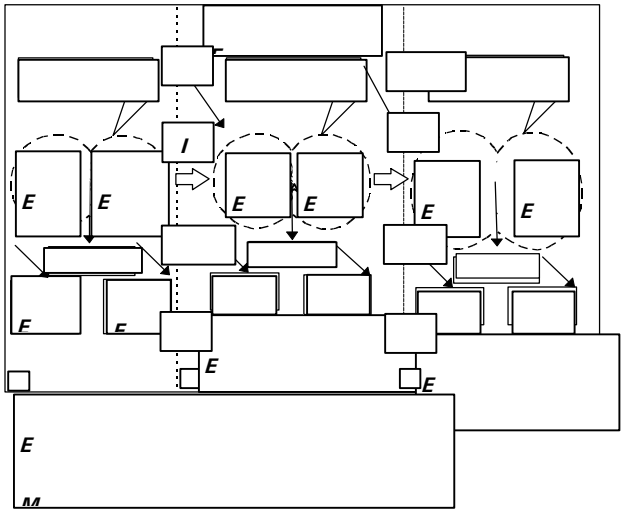
Summary of Stout et al. (1996) Model of Team SA

In attempting to delineate the major components that comprise team SA, Stout et al. (1996) reviewed and integrated the literature in several areas, including research and theory on SA, team training and team performance, and shared mental models, as well as the general literature in cognitive psychology and instructional design. Based upon this review and synthesis, they proposed that shared mental models are a prerequisite for enabling high levels of team SA in complex, dynamic, and rapidly changing task conditions. They further explained that shared mental models are built through shared declarative knowledge bases (e.g., knowledge about the team task, standard operating procedures, and team member role responsibilities) and procedural knowledge bases (e.g., knowledge about the steps that are necessary to complete the task and the sequence in which task activities should occur). They reasoned, however, that when the task or mission is high in time pressure, requires a rapid response, and requires team members to adapt to changing task conditions, shared strategic

knowledge enables high levels of team SA through utilizing pre-existing declarative and procedural knowledge bases. Strategic mental models contain knowledge of how procedures should be implemented in context, knowledge of what team members should do when events are unexpected or information is absent or ambiguous, and knowledge of actions that should be taken when proposed task solutions fail.

To illustrate their theoretical argument for the importance of shared mental models to the accomplishment and maintenance of team SA, these authors presented a model which explained how shared declarative and procedural knowledge bases are transformed into shared strategic mental models. They then described how shared strategic models are next transformed into team SA, which in turn lead to the taking of appropriate task action. This framework was used to explain task performance across three divergent task conditions varying in the extent of time pressure and immediacy of required actions when: 1) communications are unrestricted; 2) communications are permissible but must be highly efficient and timely; and 3) communications are virtually precluded.

Also from their review, Stout et al. (1996) proposed an initial model, which delineated the major components of team SA, which is shown in Figure 1.



Stout et al. suggested that team SA is composed of the culmination of: 1) the SA of each individual team member (based upon the knowledge bases that each team member brings to bear to the task situation, and the cue and pattern assessments made by each team member due to pre-existing mental models and bottom-up processing); and 2) the shared understanding of the team (developed through shared mental models and team processes, such as planning, communication, leadership, adaptability/flexibility, and team self correction behaviors). Thus, the three major components of team SA are cue/pattern assessments (via mental models), shared understanding, and team processes. Each of these differentially affect the team SA that is achieved based upon the influence of a host of variables, such as the task characteristics and requirements, the context in which performance occurs, environmental constraints, and temporal factors. Moreover, each component of team SA is differentially required due to the above listed variables.

In summary, Stout et al. reviewed, integrated the literature, and proposed a model depicting how cognitive mechanisms (i.e., shared mental models) facilitate the development of team SA in dynamic task environments. They also developed a model describing the three major components of team SA, and then delineated several potential training strategies for enhancing team SA. We focus on one of these -- Cueing Training -- that is, the prompting of the trainee's attention to relevant information in the task environment.

The two crucial questions that arise regarding cueing training are: 1) what information should be prompted in cueing training to improve team SA; and 2) how should the prompting or cueing take place. Each of these questions will be addressed in the following sections.

What Should be Cued?

According to the Stout et al. model of team SA, information relevant to the three major components of team SA (i.e., individual cue and pattern assessments, team processes, and shared understanding) should be emphasized during cueing training. While it is important to point out information necessary to share an understanding of (Klimoski & Mohammed, 1994), cue/pattern assessments and the *relationship* between team process behaviors and cue and pattern assessments are really what helps to develop the shared understanding. For these reasons, it is perhaps most important to gain a better understanding of cue and pattern assessments. Thus, we next briefly discuss literature that has addressed the importance of understanding relevant cues and patterns to effective task performance.

The Importance of Assessing Cues and Patterns to Learning and Performance.

One of the described characteristics of developing expertise in a domain is to more quickly and completely recognize and assess relevant features, cues, and patterns that are often quite subtle (Druckman & Bjork, 1994; Means, Salas, Crandall, & Jacobs, 1993). As a result, there has been a great deal of concentrated research aimed at understanding how individuals come to learn cues that discriminate one case or situation from another. Much of this research has been conducted within the areas of cognitive and educational psychology and is beyond the scope of this paper. As an example of this more basic research, however, we will describe a series of work on cue learning that was summarized by Bransford, Franks, Vye, & Sherwood (1989). From this set of studies, Bransford et al. concluded that simply informing individuals of relevant cues, such as "notice the small chimney on the house" or "notice aircraft 'A' is an enemy" is insufficient for helping the student to learn the cues. These authors explained that this type of information is not terribly helpful because information of this type is really the output of an expert's cue and pattern assessments, and does not permit the novice to ascertain for him/herself what the relevant cues are and how they compare with other cues under differing task conditions. It would be much more helpful to specify the cues and features that allow one to determine that an aircraft is an enemy, for example. These authors also explained that it is crucial to provide contrasts in order for cues to take on meaning, such as indicating that an aircraft is an enemy because of features "x, y, and z" when it is surrounded by other aircraft with varying degrees of features "x, y, and z".

The importance of understanding relevant cues in the task environment has also been discussed in more applied settings (Adams, Tenney, & Pew, 1995; Cannon-Bowers & Bell, 1997; Endsley, 1995a, 1995b; Gaba, Howard, & Small, 1995; Kaempf & Klein, 1994; Kaempf, Wolf, Thordsen, & Klein, 1992; Orasanu, 1990; Salas et al., 1995; Sarter & Woods, 1991; Stout et al., 1996). For example, Klein (1989) postulated a theory of recognition primed decision making in which, perhaps, the most important factor in effective decision making among experts is to correctly assess the situation. He indicated that experts can rapidly assess a complex set of cues and patterns based upon their experiences in which they use the situational context to draw accurate inferences from the available cues and take appropriate actions.

Perhaps the greatest insight of the importance of assessing cues and patterns in task accomplishment comes from studies that have directly examined cues used by experts or have compared cues used by experts to those used by novices. Several of these studies exist and, in general, lead to the same conclusion regarding how experts make their cue assessments. That is, surprisingly experts often use unexpected strategies in assessing cues and patterns and they are often unable to articulate the specific cues that they attended to and/or how they used these cues to make their assessments. In order to use a cueing training strategy to improve team SA, it is important to determine which cues to point out to the trainee. This information should be gathered by identifying the cues that an expert would attend to in making his assessments, given the same task parameters. Here there is a paradox, because it is difficult to gather this information from experts, given conscious unawareness. Fortunately, there are techniques that have recently emerged in the areas of cognitive engineering and knowledge elicitation, and assessment that can be used to identify training content (see Cooke, 1994, for a review of these techniques). A treatment of these techniques is beyond the scope of this paper. The point here is that these techniques should be employed to delineate the content of cueing training. Given a better understanding of what to cue, we now turn to how cueing should take place.

How to Cue

As noted, several authors have indicated that one of the most crucial aspects of attaining and maintaining a high level of SA is to accurately assess the relevant cues in the situation (Adams et al., 1995; Endsley, 1995a; Salas et al., 1995; Stout et al., 1996). In the team environment, while other factors such as shared knowledge structures and team process behaviors affect the attainment and maintenance of team SA, individual SA developed through these cue and pattern assessments remains crucial (Stout et al., 1996). Therefore, one potential training strategy for enhancing team SA is to prompt the individual and/or team to attend to relevant cues when accomplishing their tasks, thereby increasing mental models and resultant team SA. This process of bringing the trainee's attention to relevant task parameters is termed here as *cueing*. Cueing is distinguished from on-line feedback in that some form of pre-performance *guidance* is provided instead (as an attempt to prevent the development of inaccurate mental models, which have been shown to be so difficult to change). When considering the research which suggested the importance of understanding relevant cues to task accomplishment, it is recommended that a cueing training approach would be beneficial in each of these

cases.

For example, consider the work previously described by Bransford et al. (1989). These authors indicated that one of the most important ways to train individuals to use information that they learn is to help make them aware, or help them to notice, crucial features, in the first place. They stated their assumption that experts have a variety of experiences, which provide them with internal contexts and alternatives or contrasts upon which to draw when presented with a set of stimuli. This notion was supported by Mann and Decker (1984) who argued that effective learning depends on the contrastive value of the stimulus to be learned (i.e., its distinctiveness) and the meaningfulness of the item. The implication for helping novices to recognize important features or cues in their task and performance environments is to make these cues more salient by providing relevant contrasts.

For example, scenario segments could be provided to include various system malfunctions, where sometimes cues are relevant and sometimes they are not relevant, and they would be pointed out only when relevant. This could help the trainee to develop an accurate mental model of which set of specific cues or which pattern of cues predicts the system malfunction, and which cues do not. Referring to the arguments of Bransford et al. (1989) and Mann and Decker (1984) that making relevant cues distinctive is a key, distinctiveness can be created in several ways, including: 1) displaying the behavior out of context; 2) exaggerating the behavior; 3) repeating the behavior frequently; and 4) using learning points or instructional cueing to identify the key behavior. Bransford et al. specifically suggested the use of videotape with random access to show specific contrasting segments to the trainee, although other methods may accomplish the intended goal as well.

Results from the studies on situation assessment and those that have specifically investigated the cues attended to by experts suggest that it is crucial that trainees be made aware of the cues relevant to their task performance. That is, given that novices may learn accurate or inaccurate cues when not specifically guided about to which to attend; there is a high probability of developing inaccurate mental models when novices are not specifically cued. Because mental models and shared mental models are so important to team SA (Stout et al., 1996), this suggests that cueing training can help to facilitate the development of team SA. We next, more specifically, describe a cueing training strategy and how it can be implemented to increase team SA and performance.

Implementing Cueing Training

Cueing, or guiding the trainee's attention to relevant information in their environment can be accomplished in several ways. For example, cueing can be delivered via system input (e.g., relevant gauges are highlight or faded) or through instructor input (e.g., the instructor describes or points out the relevant information). This can also occur through passive demonstrations or as the team/individual is actively practicing. Finally, this can be accomplished via direct information presentation or via questioning. In each case, the relevant cues come from several sources, including, for example, the cockpit indicators, the environment, the mission, *and* fellow team members. The actual cueing or prompting to the relevant information can include having the individual/team attend to specific relevant cues, as well as pointing out effective team processes and task steps to be taken. For team SA, only certain task steps and team processes may be necessary to identify.

Based upon a review of the literature on strategies that provide some sort of prompting or guidance, the following operational terms have been provided to subsets of cueing training from the above discussion (and are summarized in Figure 2):

Passive System Prompting: cueing which occurs through a passive demonstration, such as a videotape or a static system demonstration, which shows the system prompting the relevant information as in active system prompting

Active System Prompting: cueing which occurs on-line, or as the individual/team is practicing their tasks and which is provided by the system (e.g., via highlighting or fading)

Behavioral Coaching: cueing which occurs through a passive demonstration, such as a videotape or a real time demonstration by an instructor in which the instructor verbalizes the cues he/she *is* attending to in accomplishing the tasks, the relevant processes, and the necessary steps being taken

Instructor-Guided Practice: cueing which occurs on-line, or as the individual/team is practicing their tasks and which is provided via instructor comments, where the instructor points out the cues to attend to, the processes to attend to, and the necessary steps to take to

accomplish the tasks.

In each of these cases, the information can be either directly presented as statements of fact, can be presented by questioning the trainee, or can use a combination of the methods.

CUEING TRAINING

	Passive	**Active**
System	Passive System Prompting	Active System Prompting
Instructor	Behavioral Coaching	Instructor-Guided Practice

Figure 2. Categorization of cueing training methods.

Note. From "Team SA (SA): Cueing Training" by Stout, R. J., Cannon-Bowers, J.A., & Salas, E., (in preparation). Reprinted by permission.

Each of these methods can be used to enhance team SA by pointing out the cues and patterns necessary to make individual situation assessments, and by emphasizing appropriate team processes to utilize within the team setting, given situation assessments. Because each method directs the individual to relevant information in his/her task environment and thus helps to build team SA, the choice of one method over another is probably best made on practical grounds considering resources available. However, developmentally, it is argued here, that the strategies of active system prompting and instructor-guided practice are best suited for enhancing strategic knowledge and thereby directly impacting team SA, although the other two strategies provide some aspects of strategic knowledge, yet not as complete due to their passive nature. Each of the strategies can help to develop compatible mental models of the situation at hand. These strategies can also point out relevant information in changing task conditions, to provide contrasts, so that trainees will know what information to share and will be able to interpret cues in a manner that is both consistent and expected by fellow team members.

With active system prompting and instructor-guided practice, it is hypothesized that team members will form: 1) common explanations of the meaning of task cues; 2) compatible assessments of the situation at hand; 3) common expectations of additional task and information requirements; 4) accurate predictions of team member behavior; and 5) appropriate and expected task strategies. Research is needed to test each of these training strategies to determine their impact on team SA. In addition, research is needed to determine how these strategies should be sequenced in the educational process. That is, behavioral coaching may need to precede instructor-guided practice for optimal impact on team SA. Perhaps most importantly, research is needed to determine what the relevant cues are that should be emphasized during cueing training. As noted, this can only be accomplished using a systematic framework to guide the research and using innovative techniques, such as knowledge elicitation approaches. It is suggested here that the Stout et al. model can be used as such a guiding framework. We next describe, through examples, what a cueing approach may look like and how it might help enhance team SA.

What Might a Cueing Training Approach Look Like?

To describe what a cueing training approach might look like, consider an aviation example with a helicopter crew consisting of the pilot, copilot, and crew chiefs in the back of the aircraft. Assume that this crew is performing a Search and Rescue (SAR) mission over water, and that their helicopter is in a hover over the downed aircraft with a swimmer on the hoist half way down, when symptoms of an engine problem occur. Assume also that we use knowledge elicitation techniques for this scenario and learned that crucial cues for diagnosing the engine problem are from engine gauges (torque, rpm, NF relative to NR, temperature, and whether or not an engine chip light is illuminated), cues for safety of flight are from engine gauges and the environment (altitude, airspeed, and visual cues of the water), and cues for correctly taking action are from the environment (where the swimmer is), and at times are only obtained by the cockpit crew from the crew chief's communications. We would want the trainee to know to look for each of these cues in this situation, to understand the significance of each of these cues, to know what should be communicated to build/reinforce team SA, and, based upon team SA obtained, to take appropriate actions. Now, consider each of the specific methods of cueing training discussed earlier, starting with the more passive instructional strategies. An example of how behavioral coaching can be used to help enhance a trainee's SA in this situation is to create a videotape of a crew performing this scenario. An instructor could then sit down with the student and talk through what cues he/she would be looking for and thinking as a pilot, as a copilot, and as a crew chief. The instructor could also explain how to specifically state the problem such that all crew members understand it, and what else needs to be communicated so that team SA is optimized (with all of this being based upon the

knowledge elicitation results).
For example, the instructor may state,

> "As a pilot or copilot, given that we are in a high hover over water, I might expect salt from the ocean to cause some type of problem with the engine, so I would be scanning my engine gauges. As a pilot, I would also continue to scan altitude and airspeed to maintain a safe hover, and I would keep an eye on the water to see if the waves look larger or smaller, and to see if I am level. As a copilot, I would back the flying pilot up by looking at the same cues. The first indication of an engine problem would probably be a change in torque or rpm. Either the pilot or copilot might notice it, and then each of us would look for secondaries, expecting either NF to go below NR (or for NF to split off from NR) or a change in engine temperature. If either or both of these occur we might ask the crew chief to look for any other secondaries in the back, but I would assume that we have an engine problem and would ask my copilot to execute engine shut down procedures while I watch for safety of flight items (altitude, airspeed, and visual water cues). Given that we are over water with an engine problem and are not single-engine capable, we may need to land it in the water as soon as possible, so I would have stated the symptoms that I had seen originally to all crew and stated that there was a possible engine problem, and once confirmed by the secondaries, I would tell the crew that we need to land it in the water as soon as possible. The crew chief would then look for the swimmer if he/she was still on the hoist and make a determination of whether or not to cut the swimmer or bring him/her on board based upon his/her distance from the water, which would be communicated to me. Once safe, I would tell the crew that we are putting it in the water. The crew chief would let me know that the passengers are strapped in and I would land it in the water."

This could all be demonstrated and communicated by the instructor to the student while in the simulator as well. This may appear similar to any form of behavioral coaching, but the key difference here is that the instructor would not simply be saying what he/she would be doing, but would be emphasizing critical cues, and what he/she would be thinking to develop and maintain team SA. Keeping in line with what was suggested by Bransford et al. (1989), the output of the expert's judgment is not what is presented – rather, the processes used to make that judgement are presented.

Through passive system prompting, the video could be edited to draw visual attention to the gauges in the proper sequence at the appropriate time, text lines could be added which emphasize important communications, and graphics could be provided of external visual cues, such as the water and swimmer. With instructor-guided practice, the trainee could be performing in the simulator while the instructor is walking him/her through what to look at, how to interpret the cues, and what to say to enhance team SA. Via active system prompting, a simulation could be developed that allows the trainee to practice the scenario while the crucial gauges are highlighted or faded where appropriate, communication to and from fellow teammates are recorded into the system, and external visual cues are presented graphically or through external views out of the cockpit. When using any of these techniques, the relevant cues could also be emphasized through questioning the trainee about what he/she is attending to and thinking and providing correct answers or information regarding what the expert would be attending to and thinking (based upon knowledge elicitation results).

Also, keeping in line with the suggestions of Bransford et al. (1989) and Mann and Decker (1984), regardless of which specific method is chosen to deliver the cueing training, relative contrasts can be provided by using varied scenarios with varied critical cues and parameters. For example, if we learned from the knowledge elicitation process that a less serious problem of a sprague clutch slippage is often misdiagnosed with an engine problem, we could highlight the specific cue(s) that differentiate one from the other and explain their significance. Also, if a transmission chip light is often interpreted as unrelated to the sprague clutch failure when it actually is related, we could emphasize that metal particles can get into the transmission when the sprague clutch begins to slip, so a chip light is actually a cue to a sprague clutch problem (because a chip light is an indication that there are metal "chips" detected). This section has simply served as an example of the myriad of specific instruction that could be provided via cueing training. Again, research is greatly needed to empirically determine how best to implement this instruction.

CONCLUSIONS

The purpose of this paper was to extend our understanding of how team SA can be improved through training. It did so by expanding upon work done by Stout et al. (1996) by elaborating upon one potential training strategy suggested by Stout et al. - cueing training. It first summarized the work of Stout et al. and provided illustrations of two models proposed by Stout et al. from which potentially effective training strategies were derived. It then emphasized what should be cued in a cueing training approach, including discussing the importance of the perceiving and correctly interpreting cues, the importance of using knowledge elicitation techniques to determine crucial task cues, and the role played by human information processing mechanisms. It also discussed how cueing training should proceed by revisiting literature emphasizing the importance of cues to learning and performance and proposing how cueing training could help individuals learn relevant cues. In addition, it proposed four categories of cueing training that vary in terms of whether an instructor or a system provides the training, and whether or not the training occurs through passive observation or during active task performance. Implications of these cueing training strategies for enhancing team SA were discussed through examples of how these four categories or methods of cueing training could be implemented. We hope that this stimulates interest and research in this important area.

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AUTHOR NOTES

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