CHAPTER TWO

Situation Models in Comprehension, Memory, and Augmented Cognition

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This chapter is about how people understand situations and events, and how this understanding affects how they think about the world and their interaction with other people. The larger aim is to provide some insights into how augmented cognition can be better achieved by a more thorough understanding of how people conceive of and communicate about events. We do this by taking a perspective on event comprehension and memory known as situation model theory (Johnson-Laird, 1983; van Dijk & Kintsch, 1983; Zwaan & Radvansky, 1998). We first provide a brief overview of the critical components of situation model theory and the aim of efforts in augmented cognition. Then we discuss some research on how people are able to identify situations in which they interact with strangers. After this we describe how a person's understanding of a dynamic, ongoing event affects their ability to perform in that situation, in this case, an aerial combat simulation. Finally, we address issues of how the structure of the ongoing situation is aided or hindered by various types of augmented cognition assistance.

SITUATION MODEL THEORY

Situation models are mental simulations of real or possible worlds (Johnson-Laird, 1983) that isomorphically capture the elements and their interrelations of an event. First, a situation is embedded in a spatial-temporal framework. This is the location in space (or some virtual space, such as a chatroom) in which the situation unfolds and the span of time that the situation operates as a coherent whole. The spatial-temporal framework provides the context that defines a static situation (e.g., Bower & Morrow, 1990; Radvansky & Zacks, 1991; Radvansky, Zwaan, Federico, & Franklin, 1998).

Within the spatial-temporal framework of a situation model are a number of tokens that stand for the entities involved in that situation, such as people, animals, objects, abstract concepts, and so on. Associated with these tokens can be various properties that are relevant for the current situation, including external (e.g., physical) and internal (e.g., mental or emotional) properties. Finally, there are *structural relations* among the tokens, including spatial, social, and ownership relations. The probability that these components are included in the situation model is a function of the degree to which they involve an actual or likely interaction among those elements. The entities and their functional relations provide the content for the static situation (Radvansky & Copeland, 2000; Radvansky, Spieler, & Zacks, 1993). Entity properties are of less importance unless they provide information about the functional relations among the entities in the situation.

In addition to individual moments in time, a situation model can capture more dynamic aspects of an event. This can be done by joining a series of spatial-temporal frameworks by a collection of linking relations. These linking relations include temporal and causal relations and are presumably grounded in the tokens of the situation model that stand for the entities undergoing transition in the situation. During the first reading of a text, reading times increase when there are breaks in causal coherence (Magliano, Trabasso, & Graesser, 1999; Magliano, Zwaan, & Graesser, 1999; Zwaan, Magliano, & Graesser, 1995) and temporal contiguity (Magliano et al., 1999; Therriault & Rinck, in press; Zwaan, 1996; Zwaan et al., 1995). Causal and temporal connectivity are strong predictors of coherence judgments (Magliano et al., 1999). Furthermore, the degree of causal connectivity of story constituents is a primary predictor of recall and summarization (see van Den Broek, 1994).

Isomorphism

Most of the work on situation models has focused on text comprehension and memory. However, situation models should capture events of all sorts, including those that are experienced directly. This is consistent with recent discussions of embodied cognition and perceptual symbols (Barsalou, 1999; Glenberg, 1997; Wilson, 2002; Zwaan, 2004). We adopt the view that human cognition evolved operating in and adapting to complex environments. This requires an organism to mentally represent various aspects of the world, mentally manipulate that information, and store it for future use. This is an ability that humans have developed to a high degree.

The standard way to think about situation models is that they are built up from propositions that are used as a scaffolding to create them. Although this may occur in some cases, such as in reading, it seems implausible for nonhuman organisms. Instead it is more reasonable to assume that these beasts are using mental representations derived from the perceptual qualities immediately available. The abstraction of propositions is a more highly developed skill that may have emerged out of our use of language.

As such, the situation model is the more fundamental mental representation, whereas abstract propositions are more complex and fragile. This is reflected in their more rapid rate of forgetting (Kintsch, Welsch, Schmalhofer, & Zimny, 1990) and proneness to distortion. In line with this thinking, we view the characteristics of situation models observed in text comprehension research as reflective of a more general event comprehension and memory process.

Augmented Cognition

The work being reported here is being done in the context of the idea of developing an augmented cognition system. Essentially, this is a computer-based system that would augment a person's current cognitive processes of comprehension and memory by monitoring important information that is likely to be out of a person's current awareness, detecting discrepancies between a person's current mental state and the actual state of the world, and monitoring changes in the current situation to help the person avoid pitfalls that could arise.

For any augmented cognition system to operate effectively in the real world, it needs to efficiently capture critical aspects of the evolving and dynamic situation in which the person is embedded. This includes general aspects of situation structure, such as spatial-temporal location, entities that are actually or potentially being interacted with, the relations among those entities, and the flow of the situation over time. More important, such a system must take into account the mental state of the person, such as their goals and understanding of the state of affairs and course of events. In addition, the system should keep track of past behaviors for the purpose of learning from the past or at least reminding of past actions.

The work reported here is aimed at achieving these goals. The work on inferring a stranger's goals takes into account the broader aspects of the situation, characteristics of the person, as well as how the person is involved in the situation. The work on situation structure looks at how a person's interaction with an ongoing situation in the world is affected by aspects of the environment that are identified and defined by situation model theory. Finally, the work on augmenting cognition looks at how various types of assistance can influence performance in an ongoing situation. Specifically, it considers when the assistance is provided in terms of the structure of the situation, the nature of the assistance given, and the mental state of the person receiving the assistance.

Inferring Others' Goals

An augmented cognitive system capable of assisting a person must be able to recognize the goals of the person and situations faced. Although goals may vary widely, we assume that there is a relatively closed set of possible ones within a particular context. Furthermore, computer applications, Internet sites, document and e-mail content, locations at work, and times of day provide further constraints on goals. The degree to which these cues inform an augmented cognitive system of a person's goals can vary. For example, a computer application and the file content may be more indicative of a person's goal than the time of day when that document was created.

Situation model theory provides a framework for an augmented cognitive system to categorize and evaluate the informativeness of cues associated with people's goals. Just as readers must understand and represent evolving narrative situations to understand why characters do what they do, augmented cognitive systems must understand and represent the unfolding experienced events. As such, we assess the situations faced by a person that correspond to the spatial-temporal framework, entities, and linking relationships.

In the coarsest sense, assuming that a user has a laptop computer, personal digital assistant (PDA), or similar device, the spatial-temporal framework could provide cues to the user goals. For example, perhaps a user only works on certain goals in certain locations at particular times of day, such as downloading sports scores only when on the train to/from work. From a more sophisticated perspective, Internet sites may also serve as (virtual) spatial-temporal frameworks, which are further intimately tied to the goals of a user. Namely, we go to specific sites to gather information to meet our goals. Thus, it is important for an augmented cognitive system to understand the classes of goals associated with specific Web sites.

Computer Applications and Documents as Elements of Computer Situations

Applications are an interesting aspect of a computer use episode because they could be considered either a location or an entity. They may be locations in that users view programs as places in the local computer environment (e.g., "get out of the word processor and go into the spreadsheet"). However, applications could be considered a tool and, as such, an entity that a user interacts with. Applications could be informative of goals to the extent that applications can be used for specific purposes (e.g., Word processors are used to create documents, spreadsheets are used to store data for analyses). Ultimately it is an empirical issue to address how and when applications are perceived as tools or locations. As becomes clear later, different types of cues have different levels of informativeness with respect to identifying the unfolding situation.

We consider user documents (e.g., word processing files, spread sheets, e-mail messages) as entities. The contents of the documents produced by a user are extremely informative of a user's goals. For example, if one is writing a specific report, that document file should have a considerable amount of topic-relevant language (e.g., words and phrases). Furthermore, documents that are being created to achieve a larger goal should share semantic content to the extent that they contain the same content words and ideas. As such, it is important for an augmented cognitive system to be able to assess the contents of documents and determine the relations between them.

This analysis is not a trivial task. New advances in computational linguistics and semantic processing, such as latent semantic analysis (LSA), may make the analysis of document content feasible. LSA is both a method for extracting and representing word meanings from a large corpus of text as well as a theory of knowledge representation (Landauer & Dumais, 1997). LSA uses a statistical method of extracting, representing, and inferring the semantic similarity among words. It is beyond the scope of this chapter to provide a detailed discussion of LSA, but it is important to understand that it can be used to assess similarity between any two units of language (e.g., words, sentences). If an augmented cognitive system had a corpus of documents that reflected different goals that the user faces, LSA could be used to identify the goal addressed in a document by comparing it with its LSA corpus. Specifically, the likely goal could be determined by identifying other documents most related to the current one. One caveat is that this approach is contingent on there being a relatively closed set of goals that a computer user would address in the work environment, as well as the extent that the user draws on different words, concepts, and phrases when creating documents to address those goals.

Computer User Emotions. An important aspect of this process are the computer users—specifically, their emotional states. It is important for an augmented system to understand when a user needs assistance. However, such indicators vary in their ease of extraction. For example, it is relatively easy to record how hard a user punches the keys on a keyboard or mouse. Significantly greater force may be a sign of frustration. Other indicators of emotion are facial expressions (Ekman, 2003) and sitting position. However, recording and interpreting these signs requires sophisticated hardware and software.

Dynamic Relations Between Actions

The dynamics involved in monitoring the relations between actions of a user are complex. For example, suppose a user receives an e-mail, goes directly to a spreadsheet file, transfers numbers (e.g., copy and paste) from that file into a new e-mail message, and transmits it to the sender of the original message. It can be inferred that these events are causally related and are all related to a common goal initiated by the first e-mail. An augmented cognitive system should be able to infer these kinds of relations. This is particularly important when creating a record of the goal episodes of a user. However, developing the procedures for inducing these relations is not trivial.

INFERRING AN AGENT'S GOALS

Researchers at Northern Illinois University (Joe Magliano, Anne Britt, John Skowronsky, Dominik Guess, and Aaron Larson) and Sandia National Laboratories (Chris Forsythe) have conducted studies for the development of the situation recognition algorithms for an augmented cognitive system. The underlying assumption is that a system should recognize circumstances faced by a user in a psychologically plausible way and that situation model theory provides a framework for achieving this. Our strategy was to develop an experimental paradigm that would be similar to the problem faced by a situation recognition system. We were particularly interested in determining the procedures for evaluating the relative importance of the different situational components. Of specific interest was the idea that this situation recognition system would combine cues in a linear fashion, and we needed to assess the psychological viability of this assumption.

We chose an experimental situation that involved assessing the goals of strangers during unsolicited social interactions (i.e., the stranger initiates the interaction without an invitation to do so). We sampled a broad range of goals, such as the solicitation of goods or services (e.g., wanting money, help jump-starting a car, or to borrow an object), establishing social relationships (e.g., wants to become a friend or a romantic partner), and harming another (e.g., rob or kill). It is expected that the static elements of the situations associated with these stranger goals would be very different. For example, the time, location, characteristics of the stranger, actions of the stranger, and characteristics of oneself (e.g., dress or emotional response) would differ in situations in which strangers want to become a friend or romantic partner relative to situations in which the stranger wants to rob you. Presumably, people have schemas associated with various social goals that index the co-occurrence of these situational elements.

Experiment 1

The first experiment was done to elicit the features of the situations associated with stranger goals within the categories defined earlier. One-hundred sixty people were asked to imagine a scenario in which they are interacting with a stranger who has a particular goal (e.g., wants to become our friend, wants money, wants to rob us) and then answered a questionnaire that elicited information about the time and location of the interaction, the characteristics and actions of the stranger, and the characteristics of oneself (see the appendix for the general structure of the questionnaire). We then identified nonidiosyncratic cues associated with each goal (i.e., cues produced by more than one participant). This approach yielded a cue × goal matrix containing the frequency with which each cue was related to each goal. We used this matrix to calculate the strength and uniqueness of association between the cues and the goals (see equations), which provided a basis for further studies:

Equation 1: Strength of association (SA) = (Freq of cue_i for $goal_n$)/(total number of participants who considered $goal_n$)

Equation 2: Uniqueness of associations (UA) = (Freq of cue_i for $goal_n$)/(Sum of the frequencies for cue_i for $goals_{1-9}$)

Presumably, some cues should be more informative than others. Furthermore, the relative informativeness of SA and UA may vary across cue categories. We conducted two additional studies to assess this.

Experiment 2

In Experiment 2, 133 people considered whether a stranger in various situations would have a particular goal (i.e., any given participant was asked to consider only one goal throughout the experiment). People were given one cue at a time and asked to judge how likely a stranger would have that goal given the presence of the cues. Participants made judgments for the cues elicited in Experiment 1. In this context, some cues should be more informative of a given goal than others. For each goal, a distinction was made between the cues elicited in Experiment 1 (i.e., informative of the goal) and those cues that were not. For each participant, the average predictability judgments were calculated for the diagnostic and nondiagnostic cues within each category (i.e., location, time, stranger characteristics, actions of the stranger, and characteristics of oneself).

A series of regression analyses were done to assess the informativeness of the SA and UA scores. The dependent measure was the average predictability judgment of the cue-goal pairs (i.e., there were 1,410 items of analysis because there were 141 cues in the matrix multiplied by 10 goals). The independent variables were the SA and UA scores for a given cue-goal paring. Regression analyses were done separately on each cue category, and the results are provided in Table 2.1. These results suggest that SA and UA have different degrees of importance across the cue categories. For the spatial-temporal framework cues (i.e., location and time of day), SA appears to be more important than UA. Specifically, locations and times associated with stranger goals were more predictive of them. As such, it is plausible because we interact with individuals with a wide variety of goals across a relatively limited set of locations and times. As such there are relatively few instances in which a location and time are uniquely associated with a goal. For example, various campus locations, such as the dorm, classroom, and cafeteria, tend to be highly associated with multiple goals (e.g., friendship, filling out a survey, religious conversion). The same is true for time. Certain times of the day tend to be highly associated, but not uniquely associated with specific goals (e.g., noontime is moderately to highly associated with friendship, romance, needing money, survey, and religious conversion).

For the entities, SA and UA function differently for characteristics of oneself and the stranger. These characteristics include emotional states (e.g., happy, sad, scared), facial expressions, dress (e.g., casual, formal), and objects that one is carrying (e.g., bookbag, clipboard, gun). The SA scores associated with oneself were predictive of a stranger's goals, whereas UA scores were not. In contrast, both SA and UA scores were predictive of a stranger's goal, but the regression coefficients indicate that UA

TABLE 2.1
Standardized Beta Coefficients and Variance Explained for Regression Analyses Conducted on Each Cue Category for Experiment 1

	Cue Category				
Predictor Variable	*Location*	*Time*	*Self*	*Stranger*	*Actions*
Strength of association	0.34*	0.39*	0.21*	0.24*	0.27*
Uniqueness	0.15*	−0.06	0.11	0.43*	0.40*
Variance explained	20%	12%	7%	34%	39%

Note. $^*p < .05$.

was more informative than SA. In these cases, many of the characteristics of an entity tended to be uniquely associated with a relatively small set of goals. For example, the cue of a stranger having a bible was only present for the religious conversion goals, and the cue of having a weapon was only present for the goal to rob or kill.

The most direct evidence for the role of linking relations involved the cues associated with a stranger's actions. Given that actions are understood by inferring causal links between those actions and a goal (e.g., Suh & Trabasso, 1993; Trabasso et al., 1989), it is reasonable to assume that these findings imply that people were inferring causal relations between the stated action and the goal they were considering. The regression analyses on the cues associated with the stranger action indicated that both SA and UA were predictive of a stranger's goal, but the coefficients suggest that UA was more informative. As with entity cues, many actions tend to be uniquely associated with specific goals. For example, asking whether someone has jumper cables was only present in the goal to get a jumpstart, and asking for a phone number was only present in the goal to establish a romantic relationship.

Experiment 3

Differences in the estimated variance explained in the regression analyses suggest that there are differences in the extent that the cues are informative of a stranger's goal. Both characteristics and actions of the stranger accounted for the most variance. Next was location, which accounted for more than time of day, which accounted for more than characteristics of oneself. Experiment 3 was done to further explore this informativeness hierarchy. The method used for Experiment 3 was similar to that used for Experiment 2, except that, here, 150 people were shown combinations of all cue categories. The informativeness of the cue categories varied from high to low. An informativeness score for a cue of a goal was calculated by summing its weighted SA and UA scores. The weights were determined by the regression coefficients for SA and UA that were derived from the regression analyses performed on the data from Experiment 2.

A series of regression analyses were done on the mean predictability judgments for each cue category combination for each goal. The predictor variables were the informativeness scores for each cue category. To estimate the variance explained by each global category specified by situation model theory (e.g., spatial-temporal framework, entities and properties, and linking relations), a series of two-step hierarchical analyses were done. In the first step, all variables were force entered into the equation except those that corresponded to the global category under consideration, and these variables were force entered in the second step. To esti-

TABLE 2.2
Standardized Beta Coefficients and Variance Explained for Regression Analyses Conducted on Each Cue Category for Experiment 2

Predictor Variables	*Beta Weight*	*Variance Explained*
Spatial-temporal		1%*
Location	0.06	
Time	0.11*	
Entities		7%*
Stranger	0.29*	
Self	0.10*	
Linking relations		11%*
Stranger's actions	0.40*	
All variables		54%

Note. $*p < .05$.

mate the variance accounted for by a global category, R^2 changes were calculated for the second step in the equations. Table 2.2 lists the estimated variance explained for each global category and beta weights for each predictor variable. These results indicate that there are differences in the extent to which cue categories are informative of strangers' goals. Specifically, linking relations (as specified by a stranger's actions) accounted for the most variance. The entities and properties accounted for the next highest amount of variance. Both characteristics of the stranger and oneself were predictive of a strangers goal, but the beta weights suggest that characteristics of the stranger are more informative that those of oneself. Finally, the spatial-temporal framework accounted for the least amount of variance. Time of day was a significant predictor, but location was not.

CONCLUSIONS

The results of these experiments contribute to the development of a context recognition component of augmented cognitive systems, with respect to situation-goal elements of contexts. First, these results indicate that the situation model theory can serve as a framework for identifying the cues that should be monitored by an augmented system. Moreover, an augmented cognition system needs to be sensitive and able to compute the relative informativeness of different cues that are monitored. Furthermore, the informativeness of a cue can be computed by determining measures of SA and UA.

The data from Experiment 3 allow us to address the issue of whether a system assumes that cues combine in a linear fashion. However, the question remains as to whether this is a psychologically valid assumption. The regression equation for Experiment 3 assumes a linear relationship between cues and accounted for 55% of the variance. We plotted the average human judgments per item against the predicted scores derived by the regression equation. We assessed the extent to which quadratic and logarithmic functions describe this relationship. The quadratic equations accounted for 51% and the logarithmic function accounted for 43% of the variance. Thus, these results indicate that an assumption of a linear relationship between cues is reasonable.

SITUATION STRUCTURE AND PERFORMANCE

What we have discussed so far is the ability to identify the type of ongoing situation. Now we look at how a person's performance within that situation is affected by the dynamic structure of the ongoing events. We have a detailed analysis of an ongoing event—namely, a person's ability to successfully perform while playing a computer aerial combat game, and how this ability is influenced by a number of situational characteristics. This is important to the development of augmented cognition because any system that interacts with a person, and has the aim of accentuating their mental abilities, must understand the mental state of the individual and how that mental state is affected by the structure of the current environment and how dynamic aspects of that situation alter a person's understanding.

Experiment 4: Situation Structure and Performance

This section and the next are part of a larger study conducted by Seth Allen, David Copeland, Greer Kuras, Tiffany Milligan, G. A. Radvansky, Jenny Rinehart, Maureen Ritchie, and Brian Stouffer at the University of Notre Dame, as well as Chris Forsythe at Sandia National Laboratories. In this section, we focus primarily on the structure of the evolving situation and how this influences performance within that situation.

The Situation

For the purposes of this study, we had people play a video game. This was done to give people a dynamic situation in which to interact. The game chosen for this study was "Master of the Skies: The Red Ace." This is a World War I flight combat simulation in which the player is given various missions that involve destroying ground targets and shooting down enemy planes.

We coded performance for changes in the dynamic situation according to the principles outlined by situation model theory and assessed performance as a function of achieving predefined goals. We assessed the occurrence and changes of situational elements during game play. In terms of the spatial-temporal framework, because time was continuous, we did not code for this component. Space was also continuous. However, unlike time, there were various elements of the regions in which the space was defined by clear landmarks, such as mountains, road intersections, bridges, collections of buildings, airfields, rivers, and so forth. We divided each combat zone into predefined regions based on these landmarks and noted which region a player was in at any given moment in time.

As for the entity information, we coded the situations for four types of entities: (a) allied planes, (b) enemy planes, (c) enemy targets, and (d) enemy anti-aircraft guns. Some of the relational information is implied by the nature of the entities. For example, a friendly relation exists between the pilot and the allied planes, and an adversarial relation exists between the pilot and the enemy planes, targets, and anti-aircraft guns. We also explicitly coded spatial relations. Of primary interest was whether the entities were within a zone of interaction with the pilot or were distant and there was no possibility of interaction.

This sort of situation is interesting because it allows us to also code situational characteristics of the person's actions within the situation—something that has not been possible with narrative text or film. For the pilot we coded how (s)he interacted with the other entities. This included firing machine guns, dropping bombs, or firing rockets. In this simulation, a pilot had the option of using the machine guns in every mission. However, for any given mission, the plane was equipped with either bombs or rockets depending on the needs and goals of the mission.

Performance

The relationship between changes in situational dimensions and pilot performance was assessed. Pilot success was determined by the number of completed missions, enemy planes that were destroyed, enemy targets that were destroyed, enemy anti-aircraft guns that were destroyed, and hits taken by the pilot (i.e., from enemy fire). More generally, we looked at performance in terms of (a) individual missions as a whole, and (b) ongoing performance by dividing actions into 5-second bins and assessing performance as a function of situational characteristics within those bins. As such, mission success was only used in the mission analyses, and the other dependent measures were used in both types of analyses.

Before looking at the influence of each situational component on performance, it should be noted that many of the data analyses were done using conditionalized subsets of data. For example, when looking at the ability of a pilot to destroy enemy targets, we only consider that subset of data in which targets were actually present. Another component of this type of analysis was the idea of a *zone of interaction*. The regions in which pilots were flying were rather large. As such, not all entities in the space were relevant to the situation because some entities were far away. We assume that performance was more likely to be affected by entities that were relatively close to the person because these entities were in the foreground of the unfolding situation. This zone included an area around the player in which entities could affect the pilot (e.g., shoot him or her) or the pilot could affect them (e.g., shoot a target). For this task, in the upper right-hand corner of the screen was a display that essentially served as a radar screen with the pilot in the center and entities of interest (i.e., targets, enemy planes, allied planes, and anti-aircraft guns) indicated by various symbols. Entities that were far away were on the edge of this circle. Closer entities were within the circle. For our purposes, we defined the zone of interaction as being a circle whose circumference was halfway from the pilot's current position and the edge of the circle. Unless otherwise stated, or where it is implausible, all bin analyses are based on data selected for entities within the zone of interaction.

Spatial Framework. *Shifts in space* were defined as a player moving from one predefined region to another. Because this involved looking at transitions, we only looked at spatial shifts in the bin analyses. The results of these analyses are reported in Table 2.3. In terms of enemy entities, people were less successful at destroying enemy targets and anti-aircraft during a time that they had made a spatial shift than otherwise, although these differences did not reach significance, $t(14) = 1.69, p = .11$, and $t(14) = 1.39, p = .19$, respectively. There was no difference for destroying enemy planes, $t < 1$. This is consistent with the idea that spatial shifts can be disruptive to processing, much as what is observed in text processing, but this is more likely to be true when a person is interacting with entities rooted in the defined regions. In this case, the enemy targets and anti-aircraft guns were located in specific spatial regions, whereas the enemy planes were not. Thus, whether a person was moving across spatial re-

TABLE 2.3
Mean Performance for the Different Combat Dependent Measures as a Function of Spatial Shifts in the Aerial Combat Study. This Is Probability of Occurrence During a 5-Second Bin

Variable	*Shift*	*No Shift*
Enemy planes killed	.180	.176
Enemy targets destroyed	.196	.236
Enemy A.A. guns destroyed	.050	.079
Hits on pilot	.392	.370

gions when interacting with an enemy plane was of less importance. Finally, people were more likely to be hit by enemy gunfire when making a spatial shift than when not, although this difference also did not reach significance, $t(14) = 1.75, p = .10$.

Entity Variables. There were a number of entities in this situation with which the pilot could interact. These were: (a) allied fighters, (b) enemy fighters, (c) anti-aircraft guns, and (d) ground targets. We consider the influence of each of these entity types on performance.

For the allied fighters, because these were additional entities that were largely working to help satisfy the person's goals, it might be expected that their presence would facilitate performance. However, because people must be constantly monitoring the situation, it could also be that their presence could impede performance because this is an additional, dynamic element of the ongoing situation that the person must keep track of. The data are presented in Table 2.4. As can be seen in the attempt analysis, destroying enemy plane performance was significantly worse when allied planes were present than when they were not. Although this pattern was nominally present in the bin analysis, it did not reach significance. Conversely, although there was a nominal deficit in the attempt analysis for destroying enemy targets when allied planes were present, this pattern was significant in the bin analysis. Both of these types of analyses suggest that pilots were less likely to destroy enemy entities if there were allied planes present (in the zone for the bin analysis) than if there were not. This suggests that these additional entities can disrupt performance.

TABLE 2.4
Mean Performance for the Different Combat Dependent Measures as a Function of Allied Plane Presence in the Aerial Combat Study. This Is Rate of Occurrence for a Given Mission for the Attempt Analysis and the Probability of Occurrence for the Bin Analysis

Variables	*Present*	*Absent*
Attempt analysis		
Mission success	.19	.20
Enemy planes killed	1.82	2.82*
Enemy targets destroyed	1.89	3.02
Enemy A.A. guns destroyed	.22	.02*
Hits on pilot	4.80	4.73
Bin analysis		
Enemy planes killed	.156	.169
Enemy targets destroyed	.237	.178*
Enemy A.A. guns destroyed	.130	.070*
Hits on pilot	.404	.354

Note. $^*p < .05$.

It is unclear what to make of the anti-aircraft data given that in the attempt and bin analyses are somewhat conflicting. Part of this may be due to the relatively rare rate of anti-aircraft guns being destroyed for a mission, making the attempt analysis more suspect. The bin analysis is consistent with what is observed with the success of destroying ground targets.

Finally, it should be noted that the presence of allies did not influence the success of completing a mission or the ability to avoid being hit by enemy gunfire. This may have to do with the fact that enemy planes are the same type of entity as the allied planes, making it easier to coordinate that type of information, and that most of the hits pilots took were from enemy planes. Alternatively, it may also be that enemy planes were engaged with the allied planes as well as the pilot's.

What about entities working in opposition to the pilot? In this situation, these were enemy planes, targets, and anti-aircraft guns. To look at the influence of these entities on situation processing, we looked at the correlations between the number of entities of each type on the different performance measures (enemy planes killed, targets destroyed, anti-aircraft destroyed, and hits taken), again selecting only those data in which the entity of interest is in the zone of interaction during a 5-second bin. The results of these correlations are shown in Table 2.5.

A number of things can be clearly seen. First, for any given performance measure, there was a significant positive correlation with the number of entities involved for that task. For example, people were more likely to destroy an anti-aircraft gun when there were more of them in the zone of interaction ($r = .138$). This likely reflects that it is easier to hit a target when more are available.

Second, and more important, with regard to the entities that are not the focus of a given task, the more of these irrelevant entities there are, the less likely that a given task will be successfully completed. For example, the more enemy planes that were present in the zone of interaction, the

TABLE 2.5
Correlations of Performance for the Different Combat Dependent Measures With the Number of Entities of Different Types in the Aerial Combat Study

	Enemy Entities in the Zone of Interaction		
Variable	*Planes*	*Targets*	*Anti-Aircraft*
Enemy planes killed	*.135**	*−.087**	*−.059**
Enemy targets destroyed	−.023	.135*	−.084*
Enemy A.A. guns destroyed	−.120*	−.029	.138*
Hits on pilot	.088*	.144*	.154*

Note. $^*p < .05$.

less likely a pilot would successfully destroy an anti-aircraft gun that was also in that zone. Of the six correlations of this type, four of them were significant, and the other two were in the same direction. Finally, the number of entities of any type present in the zone of interaction also made it more likely that a person would be hit by enemy gunfire. Thus, the more entities that a person needed to track in the situation, the more difficult the task was.

Relational Information. In this aerial combat simulation, there are a wide variety of interrelations among the entities, as well as between the pilot and the entities, that are going to influence a person's understanding of and performance in that situation. To provide an illustration of these influences, we look at relational information in the situation in two ways. The first is in terms of whether the person is actively interacting with entities in the situation, and the second is whether entities are in the zone of interaction.

With regard to the pilot's actions, there are two types of actions pilots can take in which they are clearly interacting with other entities in the situation. These are firing their machine guns and dropping a bomb or launching a rocket at a target. Because there will almost certainly be a positive correlation between taking these actions and destroying the enemy, we focus on the cost to the pilots—namely, the number of hits taken. For firing their machine guns, there was no correlation between whether the guns were being fired and hits being taken when there were enemy entities in the zone of interaction ($r = .004, p = .88$). This is likely because gunfire is usually directed at enemy planes. These planes can either be attacking the pilot or flying away. Thus, there is little relation between the pilots' actions and the consequence of those actions for this case. In contrast, for dropping bombs and firing rockets, there was a significant mean correlation between this activity and taking a hit ($r = .200, p < .001$). Thus, when a pilot was making a run on some target, he or she was more likely to be hit by gunfire, which usually came from some entity not currently the focus of the ongoing situation. As such, a person was more susceptible to damage when the situational structure in his or her mind opened him or her up to this possibility.

The other way to look at relational information is in terms of entities in the zone of interaction. Perhaps the comparison of most interest in this context is whether enemy planes are in the zone of interaction when the person is attacking enemy ground targets. In this case, the enemy planes are irrelevant entities that could disrupt the attack on the ground targets. What we did was look at those cases in which there were ground targets in the zone of interaction and there were enemy planes present somewhere in the situation. We looked at the success of destroying a target when the enemy planes were all out of the zone of interaction or when there were some present in the zone. What we found is that people were nominally more successful when there were no planes in the zone (M = .218 success), compared with when there were some (M = .207), but this difference was not significant, $t < 1$. Thus, although there was some support for the idea that the presence of other entities that can interact with a person in the situation can disrupt processing, the effect was minimal at best. What these findings may indicate is that when people are focused on one element of the situation (such as a target), people do not actively attend to and process other entities in the situation that are outside of the foreground of the situation model.

Combined Analyses. At this point, it is clear that there are a number of aspects of a situation that can influence how a person is actively processing and operating in the course of events. However, for more thorough understanding of the impact of situational structure on performance, it would be best to consider the combined influence of various factors, rather than individual pieces one at a time. This can be done in the current context by entering the data into a series of regression analyses that incorporate the variables described earlier.

We did four regression analyses, the results of which are reported in Table 2.6. By taking into account all of the factors we have discussed, although many of the previously reported results reemerged, there were some interesting differences. First, when spatial shifts were considered alone they did not have a significant impact on performance, but when more of the situation is considered there were two marginally significant influences. Specifically, spatial shifts were associated with a lower likelihood of destroying an enemy target and a lower likelihood of being hit by enemy gunfire. Essentially, it appears as if, during a spatial shift, people are less likely to engage with the enemy perhaps as a side effect of having to mentally manage the spatial shift.

TABLE 2.6
Regression Analyses Results, in Terms of Beta Weights, for the Various Performance Measures in the Aerial Combat Study

Variable	*Spatial Shifts*	*Allied Planes*	*Enemy Planes*	*Enemy Targets*	*A.A. Guns*	*Firing Guns*	*Bombs/ Rockets*
Enemy plane killed	*.007*	*–.021*	*.142**	*–.074**	*–.068**	—	—
Targets destroyed	–.042**	–.070*	–.005	.138*	–.063*	—	—
A.A. guns destroyed	–.030	.079	–.194**	–.183*	.198*	—	—
Hits on pilot	–.019**	–.061*	.141*	.127*	.124*	.004	.158*

*p < .05.
**.05 < p < .10.

In terms of the presence of entities in the situation, as was observed earlier, people were more likely to accomplish a given task (e.g., shoot down enemy planes) when there was more of that entity type present in the zone of interaction, as evidenced by the large positive beta weights (.142, .138, and .198, respectively). Again, the more things there were to destroy in the zone, the more likely this would happen. However, in terms of irrelevant entities, in every case where there is a significant or marginally significant effect, these additional entities had a disruptive influence on performance. This was also true for many of the nonsignificant effects as well.

Finally, in terms of the relational information captured by whether a person was actively interacting with entities in the situation, taking into account a broader view of the structure of the situation, it is seen that whether people are firing their machine guns did not influence their being hit by enemy gunfire, but they were much more vulnerable when they were focusing on a fixed target with their bombs or rockets.

Conclusions

This study illustrates that it is possible to take the principles and methods developed in research on situation models in language comprehension and memory and adapt them to ongoing situations in which the person is an active participant. Aspects of a situation that involve updating information about the ongoing event, or tracking multiple, similar aspects of the event, have the potential to disrupt processing. By providing this demonstration, we can identify cases in which the structure of the situation will both improve and, more important, diminish the performance of the person in achieving his or her goals. Taking this as the basis, we can now look at ways that we can augment a person's cognitive processes, using knowledge of the structure of the situation, by providing assistance to a person in an ongoing, developing, dynamic situation.

AUGMENTING COGNITION

In this section, we move from describing how the structure of a situation influences performance to a consideration of how providing assistance can help or harm people when they are interacting in these environments. This research looked at the impact of providing assistance to people while they were actively involved in a dynamic situation.

Overall, the results of three experiments are discussed. Experiment 4 looked at a situation in which, during an unfolding situation, people chose to provide assistance and the effectiveness of this assistance. This is a further analysis of the same study reported in the previous section. Experiment 5 was a more controlled study that looked at the impact of different types of assistance presented on a fixed schedule. Finally, Experiment 6 looked at the impact of different types of assistance as a function of the skill level of the person embedded in the situation. Thus, the person providing assistance is taking the role of an augmented cognition device, providing assistance based on the current state of the situation in which the person finds him or herself.

Experiment 4

In Experiment 4, we paired 30 people to form 15 player–coach teams. Each person was randomly assigned to each role. The two were seated in different rooms. The coach had a monitor to watch the game as it was played. In addition, both people wore headsets with microphones so they could hear the game and talk to each other. The game was played for three 45- to 60-minute sessions. Game play and conversations were recorded to DVD for later coding.

Comment Types

The coaches' comments were grouped into 10 categories. These categories segregated different types of information provided by the coach. A listing of these categories and examples of each are provided in Table 2.7. These 10 categories include the following: (a) *Episodic reminders* were comments that referred to a previous event or action in the game; (b) *misinterpretations* were comments in which the coach corrected a player's misinterpretation of the ongoing situation; (c) *knowledge gap* comments provided the player with general information about the situation that the player had forgotten; (d) *spatial attention* comments directed the

TABLE 2.7
Example and Proportions of Comments
of Each Type of Category for Experiment 4

Comment Category	*Example Quote*	*Proportion*
Episodic reminder	"Remember when you . . ."	.03
Misinterpretation	"Those are shells, not bullets."	.02
Knowledge gap	"Press 4 for the shotgun."	.08
Spatial attention	"It's to the left."	.11
Action suggestion	"Drop a bomb."	.20
Status attention	"Two targets remaining."	.29
Emotion control	"Calm down."	.01
Positive statement	"Good job Huggy-Bear!"	.11
Negative statement	"Stop crashing."	< .01
Other comments	"That shotgun is cool."	.15

player's attention to a location in the unfolding situation; (e) ***action suggestions*** were suggestions for movement or action within the situation; (f) ***status attention*** comments directed the player's attention to information about the status of the current situation (that were not spatial); (g) ***emotion control*** comments typically involved calming or comforting the player; (h) ***positive statements*** were supportive comments, typically after a successful action; (i) ***negative statements*** were comments that focus on negative actions or outcomes; and (j) ***other comments*** included anything that did not fit the first nine categories. Although most comments were easily classified into one category, some utterances contained information that could be placed in two categories. For example, "Fly to your left" provides both an action suggestion and spatial attention information.

The proportions of comments for each category type are listed in Table 2.7. As can be seen, the majority of comments were action suggestions, status attention, and spatial attention. These are important because they all focus on dynamic aspects of the ongoing situation. This suggests that the coaches were aware of the important components of the situations and could identify pieces that could be provided as assistance to the players.

Assistance and Success. Let us now look at whether comments are related to performance success. Comments were given more often for successful (M = .067 comments/s) than unsuccessful missions (M = .056 comments/s), *Wilcoxon* $z = 2.04, p = .041, t(14) = 2.17, p < .05$. Looking at the various comment types, there was either no difference or comments occurred more often for successful than failed missions. However, the only statistically significant difference was for Status Attention comments, *Wilcoxon* $z = 2.445, p = .014, t(14) = 2.76, p = .02$. Thus, comments that augment a person's understanding of the ongoing situation provided the greatest benefit. An important further point is that comments were more beneficial for missions with goals of destroying ground targets ($M_{Success}$ = .072 comments/s, M_{Fail} = .058 comments/s), *Wilcoxon* $z = 1.676, p = .094, t(14) = 1.75, p = .10$, than for destroying enemy planes ($M_{Success}$ = .063 comments/s, M_{Fail} = .082 comments/s), *Wilcoxon* $z = 1.704, p = .088, t(14) = 1.82, p = .09$. This suggests that, although comments are helpful overall, the goal and type of situation affects whether comments help or harm performance. This is explored in more detail in Experiments 6 and 7.

Mission Types

The data were then analyzed in terms of the different types of missions people flew. These were classified as (a) single target, (b) multiple target, and (c) enemy plane missions. For single-target missions, the comments associated with success, other than positive reinforcement, *Wilcoxon* $z = 3.045$, $p = .002$, were increases of misinterpretations, *Wilcoxon* $z = 1.577$, $p = .115$, and action suggestions, *Wilcoxon* $z = 1.306$, $p = .191$. Thus, people benefited from corrections and ideas proposed by the coach. In addition to these relations, spatial attention comments were more likely to occur when the target was not destroyed, *Wilcoxon* $z = 2.072$, $p = .038$. It may be that directing the pilot's attention to regions of space other than the target is distracting or missions that a pilot is doing particularly poorly on are ones more likely to require a redirection of attention.

The pattern for multiple target missions differed from that for single target missions. Specifically, the comments associated with success, other than positive reinforcement, *Wilcoxon* $z = 3.170$, $p = .002$, were spatial attention, *Wilcoxon* $z = 2.080$, $p = .038$, and status attention, *Wilcoxon* $z = 2.292$, $p = .022$. The need to coordinate a plan of attack to take out targets in different locations placed different demands on the situation, which in turn affected the information provided by the coaches.

For missions that included no targets, only enemy planes, the only types of comments associated with success were positive reinforcement, *Wilcoxon* $z = 3.296$, $p = .001$, and emotion comments, *Wilcoxon* $z = 1.890$, $p = .059$. There were, however, fewer episodic, *Wilcoxon* $z = 1.418$, $p = .156$, and action suggestion comments, *Wilcoxon* $z = 1.420$, $p = .156$. Apparently, when the situation is extremely intense (these missions were described in the game as "Onslaughts"), coaches prefer to remain quiet. However, if they do provide information, it tends to hinder performance.

Comment Locations. Our analysis of when the comments occurred was based on the parsing of the events into five-second bins. That is, we considered what was happening in the situation, including whether comments occurred, for every 5-second interval of game play. To simplify things, we broke our variables down into three categories: (a) time-based, (b) pilot-based, and (c) external situation. Here we looked at whether there were any differences in when comments occurred.

Overall, comments were made by coaches in 26.8% of the bins. The *time-based variables* were day of testing, mission number, attempt within a mission, serial position of the attempt (from the start of the study), and bin within an attempt. Comments were more prevalent earlier in time, being more frequent during earlier days of testing, missions, attempts of a given mission, and overall. However, more comments were provided as the pilot progressed into a given mission. Thus, coaches provided less assistance as the pilots became more expert in this task, while providing increasing assistance as a given situation developed.

The *pilot-based variables* were gunfire, bomb/rocket launching, and taking a hit. Pilots were less likely to receive comments when they were actively engaged in firing their machine guns, *Wilcoxon* $z = 2.783, p = .005$. Episodic, *Wilcoxon* $z = 2.273, p = .023$, knowledge gap, *Wilcoxon* $z = 2.982, p = .003$, emotion, *Wilcoxon* $z = 1.684, p = .092$, negative, *Wilcoxon* $z = 1.524, p = .128$, and other comments, *Wilcoxon* $z = 2.731, p = .006$ all decreased during gunfire. The only two categories to show an increase in comments during gunfire were misinterpretations and positive statements, but neither were significant. An increase in misinterpretations is because the most common error was when the player mistakenly shot at an ally. An increase in positive statements is because the coach would praise the player just after successfully shooting down an enemy plane or target. There was no difference when they were dropping a bomb/shooting a rocket (usually at some ground-based target) or being hit by enemy gunfire.

The situation variables were number of other allied planes, number of enemy planes, number of enemy targets, and presence of anti-aircraft guns. Comment production was influenced by the number of allied planes. Specifically, when there were allied planes within the zone of interaction, there were more misinterpretations, knowledge gap, and emotion comments, *Wilcoxon* $z = 2.955, p = .003$, *Wilcoxon* $z = 2.783, p = .005$, and *Wilcoxon* $z = 2.492, p = .013$, respectively. As mentioned earlier, this is most likely due to instances when players mistakenly fired at an allied plane.

For the other comment categories, there was a general tendency for there to be fewer comments when allied planes were in the zone of interaction. However, the decrease only approached significance for spatial comments, *Wilcoxon* $z = 1.790, p = .07$. This suggests that coaches felt the players did not need to be as concerned with entities in other locations when there were allied planes to assist the player.

For enemy planes, there were fewer overall comments when enemy planes were in the zone of interaction than when they either were not in the zone, *Wilcoxon* $z = 2.556, p = .011$, or were absent from the situation, *Wilcoxon* $z = 1.915, p = .056$. Fewer comments occurred when enemy planes were in the zone of interaction for action suggestion, status attention, and other comments, *Wilcoxon* $z = 2.50, p = .012$, *Wilcoxon* $z = 1.875, p = .061$, and *Wilcoxon* $z = 1.789, p = .074$, respectively. These results are noteworthy because they demonstrate that comments decrease with the presence of dynamic agents that can potentially harm the pilot. Thus, it appears as if the coach recognizes that the player needs to focus at those times and should not be distracted.

For both targets and anti-aircraft guns, which are static entities, there tended to be a pattern in the opposite direction. That is, there were more comments when these entities were inside the zone of interaction than when they were not, although these differences were not significant. There were more status attention comments when both targets and anti-aircraft guns were in the zone of interaction, *Wilcoxon* $z = 1.874$, $p = .061$, and *Wilcoxon* $z = 1.761$, $p = .078$, respectively. Also, there were more positive comments when targets were in the zone, *Wilcoxon* $z = 3.181$, $p = .001$.

Experiment 5

The purpose of Experiments 5 and 6 was to explicitly manipulate comment types and assess their effects on performance. In both of these experiments, assistance was provided by an experimenter rather than another participant. In Experiment 5, there were 36 participants. After a brief practice period with one of the missions (4–6 minutes), subjects moved on to the experiment proper. In this study, we explicitly manipulated the types of comments people received on a particular mission, with the order of comment type and mission number counterbalanced across subjects. There were four comment-type conditions used (a) episodic reminders, (b) spatial directions, (c) status indicators, and (d) suggestions. Assistance falling into each of these categories was provided every 5 to 10 seconds during the ongoing event. In addition, there was a control condition in which no assistance was provided to serve as a baseline of performance. Within each condition, there were three missions flown, one of each of the following types: (a) destroy one or more targets, and (b) destroy enemy planes only (i.e., no targets). Each block lasted from 6 to 7 minutes, and the missions were rotated until the time had expired for that block.

The results are presented in Table 2.8. As can be seen, most assistance conditions did not differ from the control, except for a few spatial direc-

TABLE 2.8
Mean Performance for the Different Comment Conditions for Different Types of Measurement of Performance in Experiment 5 of the Augmented Cognition Series. Standard Deviations Are Listed in Parentheses

Variables	*Control*	*Episodic*	*Spatial*	*Status*	*Suggest*
E-planes destroyed	3.3 (2.5)	4.0 (2.9)	3.4 (3.2)	2.6 (1.9)	3.5 (2.7)
% Targets destroyed	29.5 (28.0)	21.4 (22.7)	17.1 (17.1)*	27.3 (27.7)	24.5 (27.3)
Wins	0.9 (1.0)	0.7 (0.9)	0.6 (0.6)*	0.7 (0.8)	1.0 (1.0)
Crashes	4.3 (2.0)	4.0 (1.6)	4.4 (1.7)	4.2 (1.6)	3.8 (1.7)
Hits	30.2 (8.2)	33.1 (10.9)	32.3 (8.6)	29.3 (10.6)	27.4 (8.5)

Note. $^{*}p < .05$.
$^{**}.05 < p < .10$ for comparisons to the Control condition.

tions conditions, which were in the wrong direction. Thus, if comments were affecting performance, they were having a negative effect. This is in marked contrast to what was observed in Experiment 4.

To further explore this, we examined the effects of assistance as a function of pilots' skill level. The specific idea was that it might be that the assistance would be helpful to less-skilled players relative to skilled players, and that this relationship was obscured when all of the people were considered together. To classify people based on skill, *z* scores were computed for each of the performance measures in the control condition. These values were then used to calculate an average *z* score across the five performance measures (the inverse scores were used for crashes and hits). Based on this method, 20 people were classified as ***unskilled*** (i.e., below the mean) and 16 as ***skilled*** (i.e., above the mean).

For the control condition, relative to skilled players, unskilled players destroyed fewer enemy planes ($M_U = 2.2$, $M_{SK} = 4.5$), had a smaller percentage of targets ($M_U = 18.3$, $M_{SK} = 43.4$), had fewer wins ($M_U = 0.3$, $M_{SK} = 1.8$), and had more crashes ($M_U = 5.4$, $M_{SK} = 2.9$), but did not differ for number of hits taken ($M_U = 32.2$, $M_{SK} = 27.8$), $F(1, 34) = 2.47, p = .13$.

The data separated on skill are listed in Table 2.9. As can be seen, there were cases for the unskilled group in which performance was significantly better when there was assistance provided. Interestingly, in contrast, for the skilled group, performance was worse for most measures when assistance was provided, especially for number of wins and crashes. In addition, the influence of comment type differed depending on the goal. Stat-

TABLE 2.9
Mean Performance for the Different Comment Conditions for Different Types of Measurement of Performance in Experiment 5 for the Unskilled and Skilled Players. Standard Deviations Are Listed in Parentheses

Variable	*Control*	*Episodic*	*Spatial*	*Status*	*Suggest*
Unskilled					
E-planes destroyed	2.2 (1.9)	3.0 (2.3)	2.7 (2.3)	2.3 (1.7)	3.1 (2.8)
% Targets destroyed	18.3 (16.2)	18.5 (21.0)	15.5 (15.6)	17.3 (22.5)	16.8 (19.8)
Wins	0.3 (0.4)	0.5 (0.7)**	0.5 (0.5)	0.4 (0.6)	0.8 (0.9)*
Crashes	5.4 (1.5)	4.1 (1.9)*	4.6 (1.8)	4.3 (1.6)**	4.1 (1.8)*
Hits	32.2 (8.1)	34.6 (12.7)	33.5 (9.8)	28.7 (10.4)	28.3 (8.4)
Skilled					
E-planes destroyed	4.5 (2.9)	5.2 (3.2)	4.3 (3.9)	3.0 (2.2)**	4.0 (2.6)
% Targets destroyed	43.4 (33.6)	25.0 (24.9)*	19.0 (19.0)*	39.8 (29.1)	34.1 (32.7)
Wins	1.8 (0.8)	0.9 (1.1)*	0.8 (0.8)*	1.1 (0.9)*	1.3 (1.1)**
Crashes	2.9 (1.7)	3.9 (1.3)**	4.2 (1.6)*	4.0 (1.6)*	3.6 (1.5)
Hits	27.8 (8.3)	31.4 (8.2)	30.8 (7.2)	30.2 (11.1)	26.3 (8.7)

Note. $*p < .05$.
$**.05 < p < .10$ for comparisons to the Control condition.

us attention comments assisted performance the most for target missions. However, for destroying enemy planes, status attention comments improved performance the least (or impaired performance the most).

These analyses suggest that frequent assistances of all types can impair performance in skilled individuals. In contrast, it can be somewhat beneficial to unskilled people. Experiment 6 explored this idea further, along with a manipulation of the quality of comments relative to the nature of the ongoing situation.

Experiment 6

Experiment 6 was similar to Experiment 5 with the following changes. First, instead of providing assistance every 5 to 10 seconds, people were only given assistance at times when it seemed apt. This turned out to be about every 12 to 15 seconds. Furthermore, people were divided into two groups. The first group (n = 36) heard comments that were related to the primary mission goal and were components of the situation that were important to the mission goal(s), but were not in the foreground of the situation (what the pilot was currently interacting with). For example, assistance was not provided about the number of bombs or rockets remaining until the player had five or fewer left. The second group (n =36) was given information related to secondary goals (e.g., indicating distant enemy aircraft during a multiple ground target mission) or was already in the focus of the situation (e.g., advising the player to shoot at enemy planes directly in front of the pilot). As in Experiment 5, groups were further divided according to playing skill based on performance in the control condition.

The results from Experiment 6 are shown in Table 2.10. As can be seen, the unskilled group that received the helpful comments showed improvement relative to the control condition for both types of mission goals. The skilled group either showed no effect or a slight decrement in performance. For the obvious, or secondary goal, comments, performance for the unskilled group was unaffected, but with a slight improvement in terms of crashing and getting hit by enemy fire. This is because these comments tended to include warnings or locations of enemy planes for missions with targets. In contrast, the skilled group showed a dramatic decrease in performance with assistance.

In addition, consistent with Experiment 5, the types of comments, particularly status attention comments, had different levels of influence depending on the goal. Specifically, status attention comments are much more beneficial for goals dealing with static entities (e.g., targets) than with dynamic entities (e.g., enemy planes).

TABLE 2.10
Scores on Performance Measures in Experiment 6 Compared to the Control Condition for Good Versus Bad Comments and Unskilled Versus Skilled Players

	Control	*Episodic*	*Spatial*	*Status*	*Suggest*
Helpful Comments					
Unskilled					
E-Planes destroyed	1.18	2.34*	2.09**	1.62	2.26*
% Targets destroyed	0.11	0.15	0.27*	0.27*	0.14
Wins	0.09	0.50*	0.68*	0.55*	0.55*
Crashes	5.64	4.73**	4.36*	4.86	4.77**
Hits	36.50	34.86	33.05	29.86*	29.23*
Skilled					
E-Planes destroyed	3.35	2.74	3.36	2.40	3.38
% Targets destroyed	0.25	0.23	0.21	0.31	0.32
Wins	1.00	0.71	0.64	0.64	0.79
Crashes	3.43	3.93	5.36*	4.21	4.07
Hits	28.21	31.50	38.00*	34.57	35.43**
Obvious Comments					
Unskilled					
E-Planes destroyed	1.20	1.81	1.48	2.00	1.63
% Targets destroyed	0.15	0.13	0.13	0.18	0.12
Wins	0.30	0.25	0.50	0.40	0.30
Crashes	5.55	5.20	4.40*	4.60	4.65
Hits	41.40	38.90	30.85*	31.80*	30.65*
Skilled					
E-Planes destroyed	3.20	3.38	2.92	2.98	3.19
% Targets destroyed	0.32	0.18	0.21	0.33	0.22
Wins	1.38	0.63*	0.44*	0.75	0.31*
Crashes	3.19	4.25**	4.94*	4.25**	4.75*
Hits	30.25	34.13	38.06*	34.81	35.13

Note. $^{*}p < .05$.
$^{**}.05 < p < .10$.

EXPERIMENT SUMMARY

Overall, these results suggest that this sort of assistance can be beneficial to a person. However, this assistance should be provided strategically. This study illustrated at least three important aspects of providing comments. First, the skill level of the person is important. In Experiment 4, coaches provided more comments earlier in the situation, when it was assumed people were at a lower skill level. This was supported by the results of Experiments 4 and 5, where unskilled people benefitted from assistance. A second aspect is that the quality of the assistance affects performance with regard to how the assistance relates to the structure of the dynamic situation and the person's place within that situation. In Experiments 5 and 6, people showed more improvement when assistance was aimed at important, but peripheral, information, rather than information that was more likely to be in the foreground of the situation. A related idea is that assistance needs to be provided at the appropriate time. In Experiment 4, coaches provided fewer comments in more intense situations involving dynamic entities. Also, people showed a larger benefit (i.e., unskilled people) and a smaller impairment (i.e., skilled players) when the assistance were not provided constantly, but only as needed.

Finally, and most important, there was evidence that different types of assistance were more beneficial in different situations. For example, in all three experiments, the frequency or impact of status attention comments varied depending on the situation. Thus, the type of situation and the resulting goals show an important interaction with the types of assistance.

CONCLUSIONS

In this chapter, we have shown the value of using situation model theory as an approach for developing ideas and procedures within an augmented cognition framework, and the effectiveness of augmented cognition in ongoing situations. More specifically, we have shown that situation model theory can be used to develop protocols for identifying the situations in which a person is embedded. This would be important to an augmented cognition system, in the sense that the system needs to understand the environment a person is operating in, the functional structure of that environment, and what sorts of information will be useful to that person in that situation. We have also shown that people are affected by the structure of a dynamic situation. This is important to augmented cognition because the system needs to understand how the situation is structured and what consequences changes in the situation have on a person's ability to function effectively in the world. Finally, we have shown that providing assistance to a person as a surrogate for an augmented cognition system can boost performance. Much of this assistance was oriented around events occurring in the situation and did not refer to more general knowledge. Furthermore, we observed that this assistance was not uniformly beneficial. Instead it was only helpful when the person had lower skill in a task, and the comments were oriented toward components of the situation that were less likely to be in the foreground of a person's thinking. When these conditions were not met, the augment cognition either had no effect or was detrimental to performance.

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APPENDIX

Imagine someone you don't know approaches you to **<GOAL>**. Think of one possible situation. We would like you to image the encounter in great detail and answer the following questions about it. Please consider each question carefully and list all the possibilities. For some of these items, you may not have anything to fill in. In those cases, please write "not relevant" (NR).

PART 1: Please think about the location of this situation and answer the following questions.

1. Where are you when the stranger approaches? Describe the location.
2. What time is it?
3. What day is it?
4. What season of the year is it?
5. Are you alone? If not, who may be with you?
6. Is the stranger alone? If not, who may be with the stranger?
7. What other activities or events are going on around you?
8. Please list anything that might have happened immediately prior to the event.
9. Are there any other descriptions that you think are important?

PART 2: Describe yourself in this situation. We need to know a basic description of you before the event takes place.

1. Describe how you are dressed (e.g., jacket, pants, skirt, hat, shoes).
2. Describe your appearance (e.g., clean, disheveled, tidy).
3. Describe how you feel (e.g., nervous, excited, angry, happy, fearful, relieved, disgusted).
4. What specific facial expression, if any, do you have?
5. What gestures or movements, if any, are you making?
6. List any of your characteristics that you believe are relevant to the situation (e.g., gender, race, age, hair).
7. What, if anything, are you holding?
8. What may be the stranger's impression of you?
9. Mention anything else you think is relevant.

PART 3: Describe the stranger in this situation. We need to know a basic description of the stranger before the event takes place.

1. Describe how the stranger is dressed (e.g., jacket, pants, skirt, hat, shoes).
2. Describe the stranger's appearance (e.g., clean, disheveled, tidy, stocky).
3. Describe how the stranger may feel (e.g., nervous, excited, angry, happy, fearful, relieved, disgusted).
4. What specific facial expression, if any, does the stranger have?
5. What gestures or movements, if any, is the stranger making?
6. List any of the stranger's characteristics that you believe are relevant to the situation (e.g., gender, race, age, mustache).
7. What, if anything, is the stranger holding (e.g., weapon, purse, map, food)?
8. What is your impression of the stranger?
9. Is the stranger a member of an organization or profession related to the encounter? If so, what is that?
10. Mention anything else you think is relevant (e.g., speech, mannerisms).

PART 4: Listing the stranger's goals, plans, and actions.

1. List all of the reasons you can think of for why the stranger wants to **<GOAL>**.
2. List all of the ways you can think of that the stranger plans to **<GOAL>**.
3. List out the sequence of actions taken by the stranger and by you over the course of the interaction.

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