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Title: Countering Positive Confirmation Biases in Command Teams: An Experiment with Different Interventions

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Countering Positive Confirmation Biases in Command Teams: An Experiment with Different Interventions

Abstract

As part of the larger sensemaking effort in the Singapore Armed Forces (SAF), the Singapore Armed Forces Centre for Military Experimentation (SCME) continuously strives to challenge our C2 status quo. This has generated a number of C2 ideas that are currently undergoing experimentation within SCME. One such idea is the Command Post Anywhere (CPA) concept which experiments with the idea of a highly survivable future command post capable of full distributed collaboration in a networked environment. In the middle of last year, SCME went further and posed herself the question of whether other useful concepts could be built on top the fundamental idea of distributed collaboration. This led to a research in psychological/technological and social concepts such as groupware awareness, groupthink, insight/creativity and decision making biases. Decision making biases, in particular positive confirmation bias, would eventually become the focus of the experiment conducted in October 2004. For the military, there could be dire consequences as a result of positive confirmation bias. It could leniently mean a need to re-plan or the catastrophic loss of units at the other extreme. In this paper, the question of how positive confirmation bias could be addressed and mitigated in a command team setting with different C2 interventions was investigated.

Introduction

As part of the larger 3rd Generation SAF sensemaking effort, SCME continuously strives to challenge our C2 status quo. This endeavor has generated a number of new C2 ideas that are currently undergoing experimentation. One such idea is the Command Post Anywhere (CPA) concept which experiments with the concept of a highly survivable future command post capable of full distributed collaboration in a networked environment. In July 04, SCME went further and posed herself the question of whether other C2 concepts could be built upon the fundamental idea of distributed collaboration. Several areas were looked at in the ensuing research. In chronological order, they were: group awareness, insight/creativity, groupthink and decision making biases.

The work of Gutwin (1997), Ellis, Gibbs, & Rein (1991), Gutwin, Roseman, & Greenberg (1996), Lococo & Yen (1998), Migliarese & Paolucci (1995), Pendergast & Hayne (1999) and Poltrock & Engelbeck (1999) were reviewed under groupware awareness. Although research in this area appears to be very interesting, they are deemed more suitable and applicable to SCME's experimentation in distributed collaboration. It will likely do less in facilitating SCME's desire to break out into uncharted C2 territory. For this reason, groupware awareness was left to be pursued by SCME's experimenters working on distributed collaboration.

Under insight and creativity, the work of Gilson & Shalley (2004), Mayer (1995), Seifert, Meyer, Davidson, Patalano, & Ilan (1995), Schooler, Fallshore, & Fiore (1995), Dunbar (1995), Davidson (1995) were reviewed. There is a lack of evidence to show that insight and creativity could be generated on a consistent basis. Further, there also seems to be a lack of consensus on the metaphor that could illuminate all facets of insights. Justifiably, the interest to experiment and develop C2 interventions for insight and creativity waned. These two areas were however flagged as watch areas so that SCME could harvest successful research in the future.

In groupthink, the work of McCauley (1998), Hogg & Hains (1998), Park (2000), Raven (1998), Turner & Pratkanis (1998b), Fuller (1998), Hart (1998), Whyte (1998), Moorhead, Neck, & West (1998), Esser (1998), Kramer (1998), Turner & Pratkanis (1998a) and Peterson, Owens, Tetlock, Fan, & Martorana (1998) were reviewed. As a concept, groupthink appears weaker than all previous concepts that were researched because there is still a controversy that surrounds its existence even as a phenomenon. It was therefore decided that this may not be a fruitful area for further exploration in the immediate future.

After rounding off the research on Groupthink, there was an inkling that past research in the area of decision making might potentially be useful. A research approach was conceived to identify those psychological phenomena that have been found to work against the estimate of "truth" and see if C2 interventions could be developed to counter them. In warfare addressing this issue is still pertinent even in the age of network centricity because it has been recognized that the fog of war whether created by the enemy or by your own forces will continue to exist. Wickens & Hollands (2000) identified three of such phenomena in overconfidence bias, anchoring heuristic and positive confirmation bias. All three of them could work against the effort to gather a true picture for the purpose of problem solving. As a result of this research, these have been deemed to be potentially useful areas for future research and experimentation in SCME along with other "cognitive biases" that are found in the literature (Kahneman, Slovic, & Tversky (1982) and Fischoff (1988)).

The experiment in this paper describes SCME's nascent effort in addressing one of them; positive confirmation bias.

Literature Review

What is Positive Confirmation Bias?

Positive confirmation bias is the tendency, that have been observed in many situations, for people to seek information and cues to confirm the tentatively held hypothesis, rather than seek information to disprove them (Wickens & Hollands, 2000). It has also been found (Einhorn & Hogarth (1978), Mynatt, Doherty, & Tweney (1977), Schustack & Sternberg (1981) and Wason & Laird, 1972) that there are high likelihoods that cues whether certain or uncertain will be interpreted in a manner that supports the tentatively held hypothesis. This then produces a "cognitive tunnel vision" (S. D. Woods, Johanensen, Cook, & Starter (1994), D. Woods & Cook (1999)), in which there will be failure to encode or process information that is contradictory to or inconsistent with the tentatively held hypothesis. This "cognitive tunnel vision" can be disastrous during warfare, especially when situations are complex or even chaotic. There could also be other dire consequences as a result of positive confirmation biasness; notably when the hypothesis is wrong. It could leniently mean a need to re-plan or the catastrophic loss of units at the other extreme; extremes that no military can afford.

Examples of Confirmation Bias leading to Catastrophes

There are many examples in history where positive confirmation bias has resulted in the wrong decisions. The author highlights two of them found in Wickens & Hollands (2000). They are: (1) the USS Vincennes incident in which an Iranian commercial airliner was erroneously shot down over the Persian Gulf in 1988 and (2) the 1979 Thee Mile Island incident in which led to a nuclear reactor meltdown. For more information on these two incidents, the interested reader can refer to Klein (1996) and U.S. Nuclear Regulatory Commission (NRC) (2005).

The investigations into the USS Vincennes incident revealed that the tentatively held hypothesis of the approaching aircraft being hostile was erroneous (U.S. Navy, 1988). The captain seemingly failed to take into account the alternate hypothesis that the aircraft could have been a commercial aircraft even though that alternate hypothesis was floated on more than one occasions in the minds of the crew from its initial detection until its final engagement. During the investigation, it was also found that a visual identification option through the vectoring of two F-14s on Combat Air Patrol (CAP) to the aircraft in question was not exercised. Through extrapolation of the positive confirmation bias explanation, it is imaginable that the instruction to the two pilots would have been "Confirm Hostile" instead of "Confirm Friendly".

The investigations into the Three Mile Island nuclear power incident also revealed the existence of positive confirmation bias in play. On the fateful day of March 28, 1979, the crew at the Three Mile Island nuclear plant received an alert of a plant failure at 0400 hours. They focused their attention on a display that erroneously indicated that a relief valve had closed and held the tentative hypothesis that the water level was too high in the plant and was approaching danger levels. The crew then chose an incorrect action to override an emergency relief pump that provided cooling water to the reaction. The truth was that the water level was actually dangerously low and was in the danger causing a reactor meltdown. According to the investigation, the crew apparently did not attend to the many other cues indicating low water level but instead counter-interpret them as evidence for the high water hypothesis (Rubenstein & Mason, 1979). The accident at the Three Mile Island was the most serious in U.S. commercial nuclear power plant operating history. Even though it led to no deaths or injuries, it brought about sweeping changes involving emergency response planning, reactor operator training, human factors engineering, radiation protection, and many other areas of nuclear power plant operations.

It should be apparent that if positive confirmation bias can exist in a well trained and tightly knitted unit such as that in the USS Vincennes Combat Information Center (CIC) and nuclear power plant, the

possibility of it occurring among combat teams of the future where they are going to be highly composable and more modular remains high. The seriousness of its repercussions as illustrated by the previous examples therefore warrants its deeper examination as a phenomenon and more importantly how it could be addressed with training and C2 interventions.

What is the Issue in Addressing Confirmation Bias?

According to Klayman & Ha (1987), there is some evidence that the confirmation bias is not altogether a bad strategy. At the very least, maintaining a "working hypothesis" is valuable because it provides a guide to the search for new information and this is more efficient than a random search.

The issue therefore is not one where nobody should hold any hypothesis about the situation but rather how to force the simultaneous entertainment of alternative hypotheses and to seek disconfirming evidence, or at least attend to it, if it arrives.

Given that our future forces will likely fight in more modular units and in a more plug and play manner, it was also clear that the issue of positive confirmation bias needs to be addressed not in an individual but a team setting.

A series of questions regarding the actual results of past positive confirmation studies conducted and their methodologies used surfaced. The guiding question in this part of the research was whether there are results from past research that could be consumed by SCME directly. Through further research, an opinion was formed that dedicated experimentation on positive confirmation bias had to be conducted for SCME to move on.

Results and Methods of Past Research in Positive Confirmation Bias

The original selection task used for positive confirmation bias research was developed by Wason (1968b) and Wason & Laird (1972). A typical experiment uses a layout of four double-sided cards. Subjects are told that each card has a letter on one side and a number on the other, but they can see only the upper faces of the four cards. These show 'A', 'D', '4' and '7'. Each subject is asked to consider the following 'rule', as applied to the four cards: 'If a card has a vowel on one side, then it has an even number on the other side'. The instruction takes the form: 'Your task is to say which of the cards you need to turn over to find out whether the rule is true or false.'

The two most common responses are the 'A' card alone, and the 'A' and '4' cards in combination. The correct answer to the question posed is the combination of 'A' and '7'. This is because the frequently chosen '4' card can provide no information relevant to the issue of whether the rule is true or false. Notice however, that the 'A' and '4' cards are the ones that are capable of providing evidence which confirms the rule, the '7' card can only disconfirm the rule (i.e. by revealing a card which has a vowel on one side but not an even number on the other). According to Wason, the evidence from the selection task can be interpreted as consistent with positive confirmation bias.

Since the original experiments were published, many replications and variations of the same task have been conducted (Griggs & Cox (1982) or Klayman & Ha (1987)). These psychological experiments have shown that humans often fail to search for and use negative information and instead relying heavily on seeking out positive information.

This tendency has turned up in e.g. matching problems Donaldson (1959), formal logic problems Anderson (1985), and in concept attainment or hypothesis evaluation tasks (Anderson (1985), Wason (1960)). Other evidence were from further studies by Wason and his collaborators (Wason (1966),

Wason (1968a), Wason & Shapiro (1971), Wason & Laird (1972) using the well known four-card selection task to further demonstrate this tendency.

The foremost question on the mind of the author was whether such results are directly translatable even though there are ample studies on it. The other concern that the author had with all these research was that they are often conducted in non-military academic settings. An exception is Tolcott, Marvin, & Bresoick's (1989) study of military intelligence analysts. It is one of the rare examples of positive confirmation bias done in a military setting. In one part of their studies, analysts were offered their choice to seek enemy information that would confirm or refute their initial hypothesis. Consistently, analysts sought information which would confirm the hypothesis rather than that which would give them the greatest resolution of uncertainty.

The concern over the translatability of the results from past research also stems from studies such as Davidsson & Wahlund's (1992). Their study concluded that the performances of the experimental participants are extremely sensitive to variations of even the same abstract problem similar to the original Wason selection task. This therefore provided the impetus for dedicated positive confirmation bias experimentation to be conducted in SCME. The results of Davidsson & Wahlund (1992) also suggested that experimentation task specifically designed in a military context should be used.

There are also other interesting findings in positive confirmation bias research such as in Jones & Sugden (2001). In their study, using variations of the original Wason Selection Task, it was also found that learning, i.e. experience, is not likely to address the issue of positive confirmation bias. It is found that even people with experience tend to seek out information that confirms their tentative held hypothesis and, to a certain extent, other information that has little value in resolving uncertainties. This provides valuable information for the design of future experiments. More importantly, it highlights that alternate hypotheses generation is not a function of experience and there may be times when opinions from the most inexperienced crew counts.

Research Questions

The review of the positive confirmation bias literature helped SCME nail down the following focus questions for the experiment:

a. Can positive confirmation bias be addressed with no C2 intervention in a team setting?

b. Is positive confirmation bias more acute when command teams are put under stress or pressure?

c. What kind of C2 interventions can potentially address positive confirmation in a command team setting?

Experimental Methodology

The experiments were conducted over 4 days from Oct 25 to 28 2004 with 96 graduates of the 35th Singapore Command and Staff College Course. The first two days were used primarily for pilot experimentation as well as to brainstorm for possible C2 interventions. The last two days were used for formal experimentation and the results will be discussed in detail.

Each experimental unit consists of a team of 4 members for all days. They were asked to come to individual decisions based on the scenarios presented before discussing and making a team decision. With

no C2 interventions on the first day, observations and analysis showed that team decisions were biased especially in the presence of dominant character or characters. Many team discussions were often not focused and went round in circles despite given a seemingly a simple task of deciding the sortie plan of an Unmanned Aerial Vehicle (UAV). More specifically, the decision consists of deciding 10 grid squares for a UAV to perform an intelligence collection task.

At the end of the brainstorming session on the first day, a SCSC graduate suggested to display the differences in individual plans for team discussions. This idea of a C2 intervention was tested on the second day. The team discussions became more focused. In fact, it became overly focused as team members merely discussed only differences in their plans and often neglecting the considerations (which might be different even for similarities in plans) behind the similarities in their plans. This phenomenon led the experimentation team to propose another intervention in which an aggregated version of all the individual plans was displayed so that discussions could hopefully focus on both similarities and differences.

The following sections describe the formal experimentation carried out over the last two days with the remaining 48 students.

Participants

48 Graduates of the 35th SCSC participated in experiment. The participants were of different background and services. All of them were at the level of at least senior staff officer or executive officer level. Majority held the major rank while a small number were lieutenant colonels. Their Myers-Briggs Type Indicator (MBTI) scores were used to distribute them evenly in teams of fours so that no particular personality types would dominate each team. They were not paid in token or kind for the entire experiment.

Scenario

Figure 1 shows a typical scenario (8 x 8 grid squares situation picture) presented during each of the experimental run. Each of the 4 team member is a battalion commander of an armor brigade. In the narrative, the brigade commander was killed in action. The 4 participants were told that they were in charged of the brigade and were to make all decisions concerning its operations. All the scenarios presented were varied from a template. The narrative was designed in such a way to skew the participants towards the hypothesis that blue had numerical superiority and the enemy tanks presented were the only ones out there. Participants were then told that they had one last UAV sortie they could execute to determine whether to order a commit or a retrograde operation based on the outcome of this UAV sortie. For simplicity, the UAV sortie plan consist of choosing 10 grid squares in which the UAV would take a spot photograph of one grid square. Individual planning precedes team discussion for the final decision on the UAV sortie plan. The outcome of the UAV intelligence collection sortie was not played.

Apparatus

A system known as Missionmate© (developed indigenously by SCME) based on the Service-Oriented Architecture (SOA) was used for the experiment. In the experimentation setup each participant was given access to a laptop to view the situation picture as well as to enter their personal decisions. The leader, a fixed but arbitrarily selected position, was asked to enter the team decision in his or her laptop at the end of the team discussion.

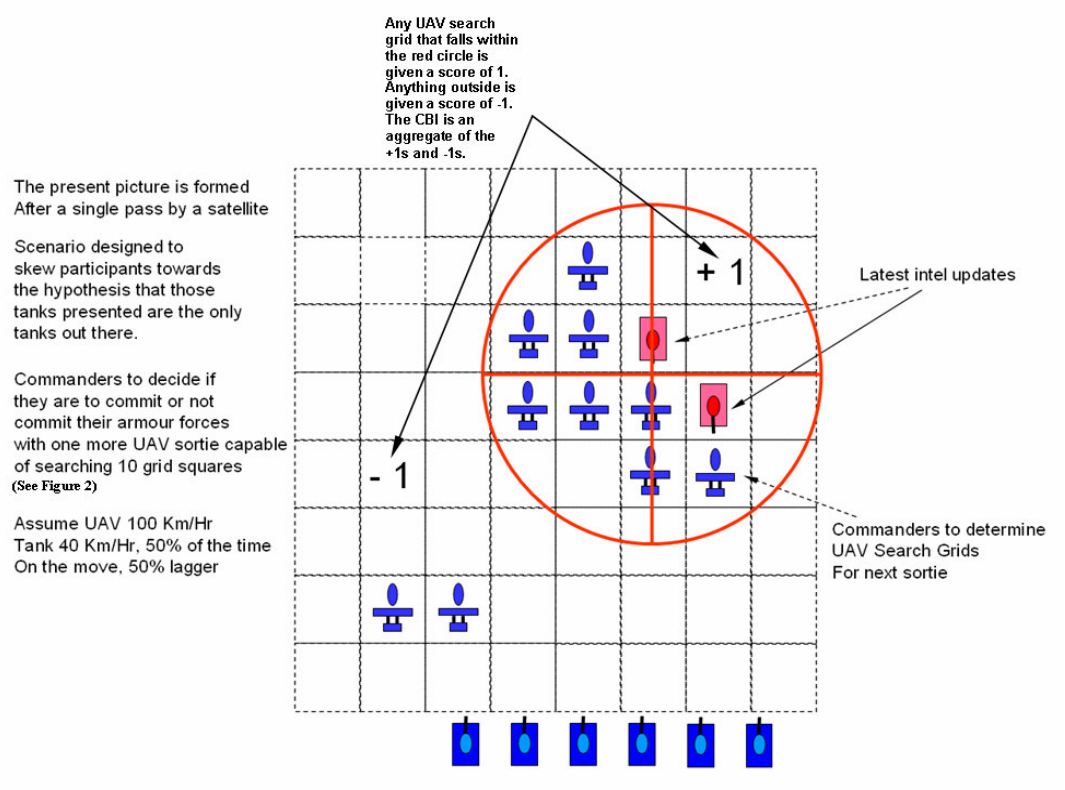

Figure 1. Scenario and Scoring Plan

Procedure

The exposure of the participants to the various combinations was randomized. Participants turned up in two batches daily with about 12 participants for each session. For each session, the team assignments were announced prior to the start of the experiment. Teams were rotated in and out of the experimentation laboratory (SCME conference room) depending on how quickly they completed their designated experimentation runs. The experiment took place with the participants sitting around a conference table. The author and an assistant experimenter took the chairman positions. At the start of each run, a standardized verbal protocol was used to provide instructions on background, scenario information and other accompanying instructions. Individuals were then asked to come to an individual decision (see Figure 2 for an example) followed by a team decision through a team discussion.

Design of Experiment

Two factors were considered: (1) Proximity of enemy tanks and (2) Interventions. Proximity has 2 levels: (1) near and (2) far. Interventions has 3 levels: (1) No Intervention (2) Overlap with Degrees (see Figure 3) and (3) Aggregate (see Figure 4). A D-optimal design was used yielding 24 data points on 27 Oct 2004 and 12 data points on 28 Oct 2004.

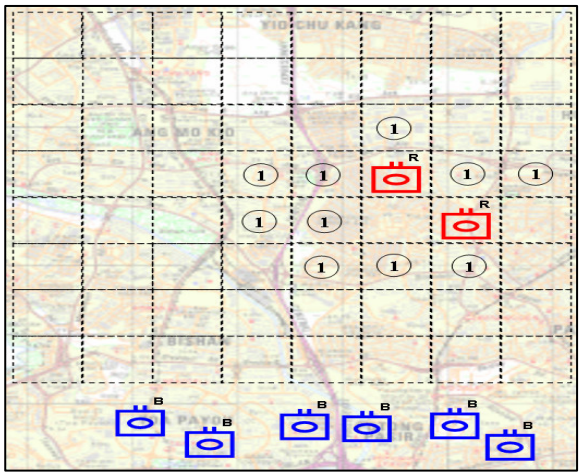

Figure 2. An Example of an Individual UAV Sortie Plan.

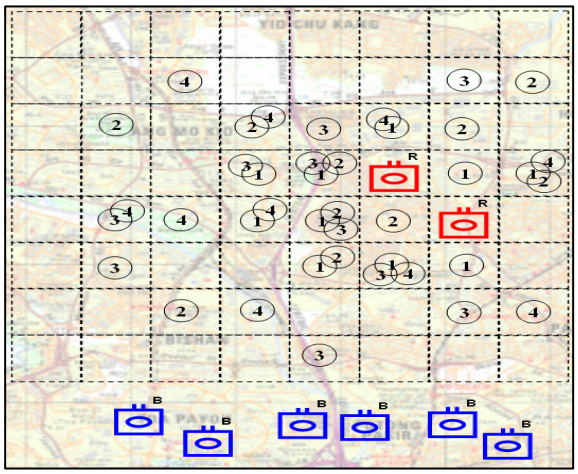

Figure 3. An Example of the C2 Intervention which shows all the overlap in Individual Plans.

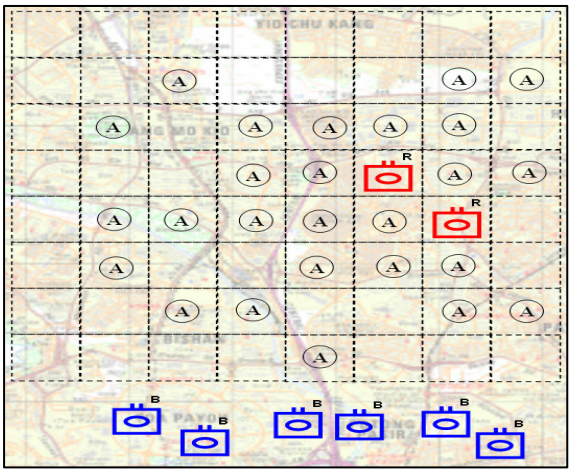

Figure 4. An Example of the C2 Intervention which shows the aggregate of all Individual Plans without Depicting Differences.

Measures of Performance

There were two measures of performance used in the experiment. The Confirmation Bias Index (CBI) adapted from Betsch, Haberstroh, Glockner, Haar, & Fiedler (2001) which represents the aggregate score based on the scoring plan assumptions depicted in Figure 1. The normative team CBI score known as the Rational Mid Point Team (RMPT) CBI was calculated from the individual CBI scores. It assumes that the logical output of a team decision would be the median between the highest and lowest score of the individual CBIs. The effectiveness of the interventions was determined by the difference between the eventual team CBI and the calculated RMPT CBI.

Hypotheses

The hypotheses of the experiments were:

a. Positive confirmation bias exists among SAF commanders.

b. Positive confirmation bias is more acute when decisions are made under stress.

c. Interventions, i.e. like those in Figure 3 and 4, would result in more negative CBIs or reduce positive confirmation Bias.

Findings and Discussions

Hypothesis 1: Existence of Confirmation Bias in SAF

Table 1.
One-Tail Simple T-Test for Individual CBIs.

	N	*M*	*t- statistic*
CBI	144	3.78	5.53*

Note: *$p < .05$

A one-tail simple t-test was performed on the individual CBI scores to determine if there is statistical evidence that positive confirmation bias exists among SAF commanders. A CBI score of more than 0 indicates presence of positive confirmation bias while a CBI score of less than 0 does not.

From Table 1, the t-statistic of 5.53 is significant at $p < 0.05$. Although this result may not be surprising to the reader, one has to bear in mind the findings of Davidsson & Wahlund (1992) who found that the performance of participants were very sensitive to even variations of the original Wason selection task. Further, during the course of this research it was also revealed that relatively few applied military research has been done in the area of addressing positive confirmation bias. This piece of result therefore allows SCME to set out on a surer footing that the interventions designed subsequently is addressing an existing problem rather than one that may not exist.

The histogram plot of the individuals CBI provides further resolution of the results in Table 1. A CBI score of 10 corresponds to a UAV sortie plan where one hundred percent emphasis is on the red targets presented during each run. A CBI score of -10 corresponds to a UAV sortie plan where one hundred percent emphasis is on other red targets that have not been detected but might be out there.

One can see from the histogram plot that a great number of individual decisions (over 40 out of the 144) tend to the extreme score of 10. The proportion of individual decisions tending to a CBI scores of -10 is proportionately lesser. The majority of the individual decisions fell in between these two extremes. Invariably, this was the result of two opposing hypotheses: (1) the tanks presented were the only ones out there and (2) there are more tanks than those presented. Specifically for this experiment, a C2 intervention will be effective if those with hypotheses at either end can be made to entertain the alternate hypothesis. This result therefore provides first evidence that the interventions to be tested in Hypothesis No. 3 have a chance of working because opposing hypothesis are being held in the teams. The question then is to see how interventions tested under Hypothesis No. 3 can be used to flash out the alternate hypothesis during team discussions.

This is opposed to the case where there are no alternate hypothesis alive among team members, i.e. we will see the spread of CBIs all above 0 or vice versa, the design of the C2 intervention would have called for the need to have an intelligent system that can generate alternate hypotheses based on the current situation.

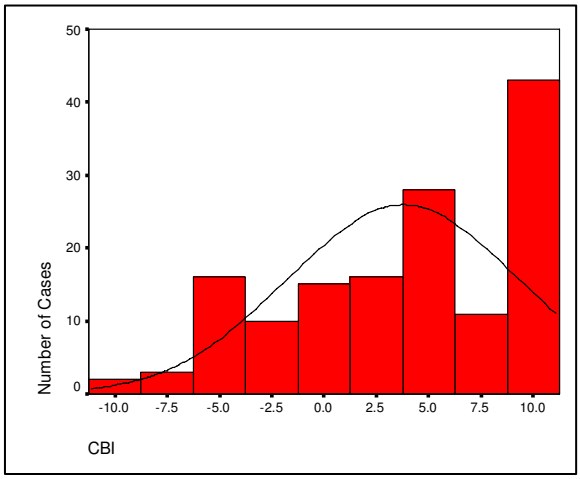

Figure 5. Histogram of Individual CBI Landscape.

Hypothesis 2: Effects of Stress on Positive Confirmation Bias

A one-way ANOVA was performed to determine the effects of proximity of threat, used as a surrogate for stress, on the individual CBIs. From Table 2, the F-statistic of 94.69 is significant at $p < 0.05$. One could also see the profound effect of having near threats and far threats in Figure 6. The mean CBI value is above 6 for near targets while that for far targets is just above 2. In terms of the UAV intelligence gathering emphasis, it means that 80% versus 20% of the UAV sortie was allocated to the near targets presented and 60% versus 40% of the UAV sortie was allocated for far targets. It is not difficult to postulate that in real operations the effects of stress on positive confirmation bias is going to be multiplied many times over. Operationally, friendly forces must therefore guard against this cognitive weakness while attempting to exploit a similar phenomenon on the adversary end.

Table 2.
ANOVA Table: Effects of Proximity on Individual CBIs.

	df	*F*
CBI	1	94.69*
error	142	(26.23)

Note: Values enclosed in parentheses represent mean square errors. *$p < .05$

More importantly, this simple result raises the question of whether there are other cognitive weaknesses that could be similarly studied and exploited. This is especially important when one talks about concepts such as Effects-Based Operations which centers heavily around the exploitation of the adversarial cognitive and social domains from the prevalently used network centric warfare model found in Alberts, Garstka, Hayes, & Signori (2001)

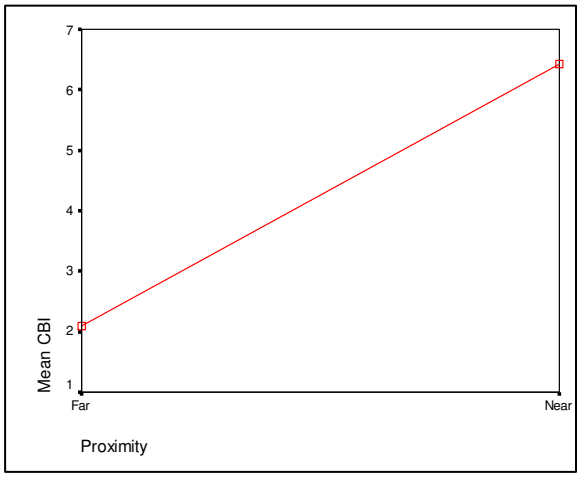

Figure 6. Effects of Proximity on Individual CBI

Hypothesis 3: Effects of Different Interventions on Team Positive Confirmation Bias

Table 3.
ANOVA Table: Effects of Interventions on Distance Moved from RMPT CBI

	df	*F*
Intervention	2	4.37
Proximity	1	1.48
Intervention*Proximity	2	9.30*
error	30	(6.29)

Note: Values enclosed in parentheses represent mean square errors. *$p < .25$

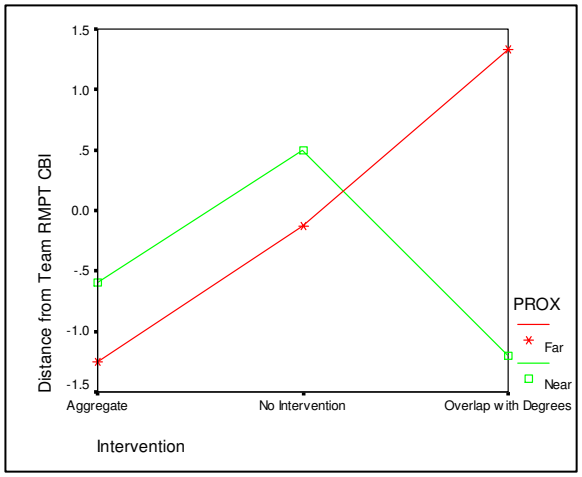

Figure 7. Effects of Different Interventions on Distance from RMPT CBI

A two-way ANOVA was performed to determine the effects of proximity of threat and different interventions had on the difference vector between the Rational Mid-Point Team CBI and the final CBI of the team decision. From Table 3, the F-statistic of 9.30 is significant at $p < 0.25$. While the use of $p = 0.25$ deviates from the statistical norms of at least $p = 0.10$, the author feels that even with a 25 percent chance of committing a Type I error, the result presents the merits for discussion because it really points towards a future possibility that positive confirmation bias could be better controlled and mitigated.

From the graph in Figure 7, it is clear that when there are no interventions, i.e. the middle case, there were no real difference between the rational mid-point team CBI and the final team decision. This augurs well for this measure as this was the expected result under the circumstances where there were no interventions. From the same figure, the C2 intervention where the aggregate plans were presented shows the tendency to be able to influence the prevalently positive CBI scores in the negative directions whether it is for near or far targets. A surprising result was found for the C2 intervention that displayed the differences of the individual plans. From Figure 7, it seems that it is able to more precisely influence the positive confirmation bias taking into account the situations where targets are near or far. Recall from Figure 6 that near targets elicited extremely positive CBI scores while far targets elicited slightly positive ones. Without prescribing any theoretically correct team CBI scores, this C2 intervention seems to be able to influence the CBI scores in exactly the right direction assuming that a 70% emphasis on presented targets and 30% emphasis on others not presented is adequate; i.e. lowering the CBI scores for presentation of near targets and raising the CBI scores of far targets.

Future Research

With the preceding discussions, the future research in the area of positive confirmation bias would centre round answering the following questions:

a. Is there a possible development for a possible operational framework for exploitation of cognitive and social weaknesses? Will this framework be mirrors of each other when considering friendly and adversarial perspectives?

b. What other psychological weaknesses are out there for similar studies to be conducted and C2 interventions to be developed?

c. How would the development of deceptive tactics be now devised given the results from the examination of Hypothesis 2?

d. Operational plans are invariably more complex. How can simple interventions developed for applied military research of this kind be translated operationally?

e. Are there some other fundamentally different interventions that could be developed other than those tested in this experiment?

Conclusions

This experiment was conducted at a very low cost and is possibly one of those few looking at positive confirmation bias in a military setting for both individuals and teams. Overall this whole exercise has provided very useful insights that will contribute to SAF's effort in sensemaking as well as future C2 systems design. What began as a fuzzy journey looking at across the board concepts such as groupware awareness, groupthink, insight/creativity and decision making biases turned out to be an extremely beneficial and fruitful exercise. Although it may be some years before an operational C2 intervention of this nature is really developed, this research and experiment brings forth new found confidence that interesting concepts can indeed be built upon the fundamental concept of distributed collaboration.

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