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An Examination of the Social, Cognitive, and Motivational Factors that Affect Automation Reliance

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Abstract

In a series of laboratory studies in which students performed a target detection task, human operators consistently made suboptimal automation reliance decisions both overly relying (misusing) and underutilizing (disusing) an automated target identification tool. This paper will review the findings from these studies in terms of Dzindolet, Beck, Pierce and Dawe's (2001) Framework of Automation Use, which predicts automation reliance decisions are determined by cognitive, social, and motivational factors. Although this work was performed within the context of a target identification task, its results have implications for automation use across domains. In addition, recommendations for system designers of combat identification tools and suggestions for future research will be presented.

An Examination of the Social, Cognitive, and Motivational Factors that Affect Automation Reliance

One U.S. Army's analysis of fratricide concluded that nearly one-third of the incidents were caused by target identification errors (OTA, 1993 as cited in Wilson, Salas, Priest, & Andrews, 2007). According to Wilson et al. (2007), the most common approach to reducing fratricide is the development of combat identification systems. The automated decision aids provide Soldiers the ability to "interrogate" a potential target by sending a signal that, if returned, identifies the target as a "friend." Unanswered signals produce an "unknown" response. The underlying assumption in providing these automated aids to military personnel is that the human-computer "team" will commit fewer fratricide errors than the human working alone. However, this assumes that the human operator will appropriately rely on the automated combat identification aid. Research has found human operators often under-utilize (disuse) or overly rely on (misuse) automated systems (cf. Parasuraman & Riley, 1997). Technology must be considered as an aspect of the human system team. This paper will review some of the laboratory studies designed to understand human operator's automation use decisions in terms of the Framework of Automation Use Model (Dzindolet, Beck, & Pierce, 2006; Dzindolet, Pierce, Beck, & Dawe, 2001).

When the hardware on the combat identification system is working properly, Soldiers should rely on the automated aid's "friendly" decisions; the combat identification system's reliability rates far exceed the reliability of human's identification rates. However, human operators must be careful not to interpret the automated aid's "unknown" decision as "enemy." The probability that an "unknown" response identifies an enemy is very high when all the friendlies in the area are equipped with properly functioning systems. However, the hardware may not always function properly; it may be lost or damaged in battle. In addition, a large number of allied forces not supplied with combat identification systems entering the battle area will drastically increase the probability that an “unknown” response is not an enemy. Therefore, the combat identification system's reliability will, to some extent, vary based on the situation. Most likely, when the aid reaches a "friendly" decision, the vehicle transmitting the response will be a friendly, and Soldiers should rely on the combat identification system. However, when the aid reaches an "unknown" decision, the likelihood that the responding vehicle will be friendly will vary based on a number of factors. Under these conditions, Soldiers should ignore the combat identification system. Unfortunately, human operators may have difficulty adjusting to the varying reliability of an automated decision aid (Dzindolet, Pierce, Pomranky, Peterson, & Beck, 2001; Parasuraman, Molloy, & Singh, 1993; Singh, Molloy, & Parasuraman, 1997, but see Wiegmann, Rich, & Zhang, 2001). Several laboratory studies indicate that sub-optimal use of the combat identification system has the potential of increasing, rather than decreasing, fratricide (Dzindolet, Pierce, Beck, Dawe, & Anderson, 2001).

In one laboratory study (Dzindolet, Pierce, Pomranky et al., 2001) specifically designed to determine if human operators could adjust automation reliance to varying levels of automation reliability in the Battlefield Combat Identification System (BCIS) or the Individual Combat Identification System (ICIDs), participants viewed 300 slides displaying pictures of Fort Sill terrain on a computer screen (see Figure 1). Half of the slides contained one Soldier in various levels of camouflage; the remaining slides were of terrain only. Participants were told that sometimes the Soldier would be rather easy to spot; other times he would be more difficult to find. Each slide was presented on the computer screen for about ¾ of a second. After viewing each slide, the participants had the option of viewing the slide a second time or making their decision as to whether or not they believed the Soldier was in the slide. Participants were given three seconds to make their decision.

Some participants performed the task without an automated aid. However, other participants were told that a computer routine had been written to assist them in performing their task. They were told that the routine performed a rapid scan of the photograph looking for contrasts that suggested the presence of a human being. The decision of the contrast detector appeared on the computer screen.

One-half of the aided participants received training that paralleled that of the BCIS and ICIDs. Specifically, participants who received training were informed that whenever the target was present, the aid was always correct. However, when the target was absent, the aid would reach the correct answer only half the time; the aid would operate no better than chance on the target-absent trials. Therefore, on the slides for which the aid reached an "absent" decision, the probability of the aid being incorrect was zero; on the slides for which the aid reached a "present" decision, the probability of the aid being incorrect was .33 (see Figure 2).

For the first 200 trials, the contrast detector's decision was provided to participants only after they had made their decision; participants were not able to rely on the aid's decision. These 200 trials provided the aided participants with experience with their aid.

However, for the last 100 trials, aided participants were given the opportunity to rely on their automated aid. For these trials, the decision reached by the aid was provided after the viewing of the slide but *before* they were given the opportunity to view the slide a second time or make their absent-present decision.

Results indicated that although aided participants were less likely to ask to re-examine a slide after the aid reached a decision known to be perfectly reliable than unaided participants, the aided participants were unable to adjust their reliance strategy to the reliability of the automated aid. Aided participants made *more* errors than the unaided ones. The participants explicitly trained that the aid was always correct when it reached an "absent" decision but only correct 2/3 of the time when it reached a "present" decision were *not* more likely to rely on the aid when it reached an "absent" decision than when it reached a "present" decision. Experience with the automated aid, alone, was sufficient to produce the superior re-examination strategy; explicit training of the aid's reliability did not improve this strategy.

Clearly an understanding of human-automation decision-making is necessary. The purpose of this paper is to review the Framework of Automation Use (Dzindolet, Beck, & Pierce 2006; Dzindolet, Pierce, Beck, & Dawe, 2001) we believe will be useful in guiding research to understand human operators' reliance on automated decision aids. We will discuss the results from many studies using a paradigm similar to that described above that support the framework and provide suggestions for the design of future automated decision aids and training procedures for operators relying on such aids.

Disuse

A rational decision-maker will rely on an automated aid when doing so will maximize gains and/or minimize losses. Failure to rely on an aid in this situation constitutes disuse (Parasuraman & Riley, 1997). Disuse is defined as “underutilization of automation" (p. 233). Anecdotal evidence supports disuse; Parasuraman and Riley (1997) described many real-world incidences in which disastrous results occurred due to people ignoring automated warning signals. Ignoring automated alarm systems that have previously signaled in error has been dubbed the cry wolf effect (Bliss, 1997; Bliss, Dunn, & Fuller, 1995). Further, laboratory experiments have found disuse in paradigms in which the aid's decisions are provided only after the human operators have indicated their decision (Dzindolet, Pierce, Beck, & Dawe, 2002, Study 2; Moes, Knox, Pierce, & Beck, 1999). For example, Moes et al. (1999) found the majority of college students (67%) chose to ignore the decisions of an automated aid even after being provided with feedback that their automated aid made half as many errors as they did during 200 prior trials. In addition, Riley (1996, Study 1) found students favored manual operation over automated control, even when doing so was clearly not an optimal strategy.

Misuse

When ignoring an automated aid will maximize gains and/or minimize losses, the rational decision-maker will ignore the aid and rely on his or her decisions. Relying on the automated aid in this circumstance would constitute misuse (Parasuraman & Riley, 1997). Misuse is defined, "as overreliance on automation" (p. 233). Parasuraman, Molloy and Singh (1993) and Singh, Molloy, and Parasuraman (1997) found misuse among operators performing monitoring functions. They labeled this behavior complacency, “a psychological state characterized by a low index of suspicion" (Wiener, 1981, p. 117). Misuse has also been found with automated decision aids (Dzindolet, Pierce, Beck et al., 2001; Layton, Smith, & McCoy, 1994; Mosier & Skitka, 1996).

Framework of Automation Use

What are the processes leading to appropriate use, disuse, and misuse of an automated aid? The Framework of Automation Use hypothesizes that cognitive, social, and motivational processes combine to predict automation use (Dzindolet, Beck & Pierce, 2006; Dzindolet, Beck, et al., 2001). A discussion of each process as it relates to inappropriate use is presented in the next three sections.

Cognitive Processes

Mosier and Skitka (1996) hypothesized that faulty cognitive processing may lead people to overly rely on automated systems. In addition to the large body of literature examining errors due to flawed cognitive processing in individual decision-making (Tversky & Kahneman, 1973), the social cognition literature is replete with examples of less-than-ideal cognitive processing while working in teams or groups. Errors and biases have been identified in various domains of social psychology (e.g., attributing causality (Doosje & Branscombe, 2003; Jones & Nisbett, 1972; Karasawa, 1995; Ross, 1977) and impression formation (Frey & Schulz-Hardt, 2001; Karasawa, 2003)). Rather than logically processing relevant pieces of information, people often adopt effort-saving strategies called heuristics. Mosier and Skitka (1996) coined the term “automation bias” to refer to, “the tendency to use automated cues as a heuristic replacement for vigilant information seeking and processing" (p. 205).

The fact that the automated system provides a decision may lead the decision-maker to rely on this information in a heuristic manner (see Figure 3). Rather than going through the cognitive effort of gathering and processing information, the information supplied by the automated systems is used (Mosier & Skitka, 1996; Mosier, Skitka, Dunbar, & McDonnell, 2001). Conceivably, this may occur in various degrees. In its most extreme form, the decision reached by the automated aid is immediately adopted. In a less extreme form, the decision reached by the aid may be given an inappropriately large role in the human’s decision-making process. For example, Layton, Smith, and McCoy (1994) found many pilots provided with an automated aid’s poor en-route flight plan did not explore other solutions (e.g., they did not generate actual flight plans on screen) as much as pilots not provided with the automated aid’s decision.

The automation bias will lead participants to rely on the automated aid. Oftentimes, this strategy will be appropriate. However, under certain conditions, this reliance may be inappropriate leading to misuse.

Indirect evidence to support the existence of automation bias can be found by examining automation reliance across studies with paradigms similar to that described at the beginning of this chapter (e.g., Dzindolet, Pierce, Beck, et al., 2002, Study 2; Dzindolet, Pierce, Beck et al., 2001). In one of the studies (Dzindolet, Pierce, Beck et al., 2001), participants were provided with the absent-present decision of the contrast detector known to be accurate either 60%, 75%, or 90% of the time (based on the condition to which the participant was randomly assigned) before making their own absent-present decision. To examine misuse and disuse, the probability of error was determined for two subsets of the data. Misuse, or overreliance on the contrast detector, was operationally defined as the p(error | aid error). Disuse, or underutilization of the contrast detector, was operationally defined as the p(error | aid correct). Analyses indicated that regardless of the reliability of the automated aid, participants were more likely to err by relying on their decision aids than by ignoring them, p(error | aid error) = .27; p(error | aid correct) = .13. Therefore, when provided with the aid's decisions first, thereby allowing the automation bias to occur, participants were more likely to misuse than disuse their automated aids.

However, in other studies (e.g., Dzindolet, Pierce, Beck et al., 2002, Study 2), the automation bias was eliminated. Participants were *not* provided with the decisions reached by the contrast detector until *after* they had indicated their decision and their level of confidence in their decision. Without the automation bias, would participants still be more likely to misuse than disuse their automated aids?

When participants in these studies had completed all 200 slides, they were told they could earn rewards for every correct decision made on ten trials randomly chosen from the 200 trials. Participants had to choose whether the performance would be based on their decisions or on the decisions of their automated aid. After making their choice, participants were asked to justify their choice in writing.

Rather than misusing the contrast detector, participants in these studies disused the automated aid. Even among participants provided with feedback that their aid's performance was far superior to their own, the majority (81%) chose to rely on their own decisions rather than on the decisions of the automated aid!

Therefore, when the automation bias could play a role in the decision to rely on automation, misuse occurred more than disuse. However, when the automation bias was eliminated by providing the automated aid's decisions only *after* participants recorded their decision, disuse, not misuse, was found on a subsequent task allocation decision.

Although we hypothesize that the automation bias plays a role in automation use and misuse, we do not believe it is the only important variable. It cannot account for disuse. Analyses of the justifications of the task allocation decisions provided by participants in one of the Dzindolet, Pierce, Beck et al. (2002, Study 2) experiments indicated that trust might play a role. For example, nearly one-quarter (23%) of the participants justified their disuse by stating they did not trust the automated aid as much as they trusted themselves.

Social Processes

According to the Framework of Automation, several social factors are also important in automation use decisions. One important social factor is trust. According to Mosier and Skitka's

(1996) authority hypothesis, people rely on the automated system's decision because they believe it to be more reliable, and thus place greater trust in it. Trust has been found to affect reliance in many domains (e.g., car's navigation system (Kantowitz, Hanowski, & Kantowitz, 1997), flight cockpits (Tenney, Rogers, & Pew, 1988), and with a teleoperated robot (Dassonville, Jolly, & Desodt, 1996)) and has been recognized by many researchers to be important in automation reliance decisions (Bailey & Scerbo, 2007; Cohen, Parasuraman, & Freeman, 1998; Jian, Bisantz, & Drury, 2000; Lee, 2001; Lee & Moray, 1992; 1994; Lee & See, 2004; Lewandowsky, Mundy, & Tan, 2000; Liu & Hwang, 2000; Moray, 2001; Moray, Inagaki, & Itoh, 2000; Muir, 1987; 1994; Rovira, McGarry, & Parasuraman, 2007; Tan & Lewandowsky, 1996; Wiegmann, Rich, & Zhang, 2001). Overly trusting an automated aid will lead human operators to misuse; lack of trust in a superior aid will lead to disuse.

According to the Framework of Automation, trust is determined from the outcome of a comparison process between the perceived reliability of the automated aid (trust in aid) and the perceived reliability of manual control (trust in self). We call the outcome of the decision process the perceived utility of the automated aid (see Figure 4). If one perceives the ability of the aid to be greater than one's own, perceived utility of the aid will be high. If one perceives the ability of the aid to be inferior to one's own, perceived utility of the aid will be low. People may misuse an automated aid because the perceived utility of the aid is overestimated; they may disuse an aid when the perceived utility of the aid is underestimated.

Since accurately perceiving the utility of the aid will lead to appropriate automation use, it is very important that we gain an understanding of how this perception is formed. The perceived utility of the aid will be most accurate when the *actual* ability of the aid and *actual* ability of the manual operator are compared. However, the actual ability is often unknown.

Perceived ability is determined through a function of actual ability and error. The larger the error, the more likely misuse and disuse is to occur. We suspect that at least two types of errors occur.

One type of error occurs when human operators estimate their own performance. Human operators tend to overestimate their own ability. Social psychological literature is fraught with examples of biases in which people overestimate their ability (self-serving biases). For example, humans exaggerate their contribution to a group product (appropriation of ideas, Wicklund, 1989), overestimate the number of tasks they can complete in a given period of time (planning fallacy, Buehler, Griffin, & Ross, 1994), are overconfident in negotiations (Neale & Bazerman, 1985), and inflate their role in positive outcomes (Whitley & Frieze, 1985). Thus, according to the Framework of Automation Use, human operators will be likely to overestimate their manual ability.

The other type of error occurs when human operators estimate the performance of their aid. Prior to working with the aid, the human must rely on stereotypes formed concerning the performance of aid. Although individual differences exist, a bias toward automation leads many people to predict near-perfect performances from automated aids. Dzindolet, Pierce, Beck et al. (2002; Study 1) told half the participants they would be provided with the decisions reached by the contrast detector before they made their Soldier absent/present decision for each of 200 slides. Other participants were told they would be provided with the decisions reached by the prior participant before making their Soldier absent/present decision for each of the 200 trials. The instructions informed the participants that their aid (human or automated) was *not* perfect. When asked to estimate the number of errors the automated aid would make in the upcoming 200 trials, participants predicted, on average, the aid would make only 24.79 errors (i.e., correct nearly 88% of the time). When asked to estimate the number of errors the human aid would make, participants predicted, on average, 51.26 errors (i.e., correct only 74% of the time—only 24% better than chance!). Although prior researchers have reported people tend to have negative initial expectations of automation (e.g., Halpin, Johnson, & Thornberry, 1973), our studies reveal a strong bias toward automation.

For this reason, Madhavan and Wiegmann (2007a) suggest that one important variable in determining trust in automation is whether or not the human operator knows if the aid is an automated system or another human. There is evidence that there are individual differences in the bias toward automation. Singh et al. (1993) created a scale to determine individual differences in the propensity to misuse automated aids that we suspect is due to inflated estimates of the automation's reliability. The more inflated one's estimate of the automated aid's reliability, the more likely one is to trust the automated aid and rely on it.

The bias toward automation may exist because people expect automated aids to be experts (Dzindolet, Pierce, & Beck, 2006; Lerch, Prietula, & Kulik, 1997; Mosier & Skitka, 1996). To examine this hypothesis, Madhavan and Wiegmann (2007b) explicitly provided human operators with information about the pedigree of the automated and human aid. Whether described as a "novice" or "expert", automated aids were perceived to be more reliable than human aids *prior* to working with the aid.

Madhavan and Wiegmann (2007a) hypothesize that the visible "behavior" of the aid affects the perceived reliability of the aid. For example, conspicuity, easiness, the type of errors generated by the aid (FA vs misses), and the extent to which the reliability of the aid changes during a task will affect perceived reliability of the aid. In one study, Madhavan, Wiegmann, and Lacson (2006) found trust was lost in automated aids that made errors on easy slides more than on difficult slides. In addition, Dzindolet Peterson, Pomranky, Pierce, and Beck (2003) found that trust was better calibrated for participants who could not view errors made by their automated aids. In summary, the perceived reliability of the automated aid is determined by the actual reliability of the automated aid and by the bias toward automation and the visibility of the aid's behavior. The perceived reliability of manual operation is determined by the actual reliability of the human operator and by self-serving biases.

According to the Framework of Automation Use, what is important in determining automation use, though, is not the perceived reliability of the aid or the perceived reliability of manual control, but the result of a comparison process between the two, perceived utility. Increasing the reliability of the aid will not increase automation use unless the aid's perceived reliability surpasses that of manual operations.

In summary, we hypothesize that Soldiers may misuse their combat identification system when the perceived utility of the combat identification aid is overestimated and disuse it when its perceived utility is underestimated. The perceived utility of the combat identification system results from a comparison between the combat identification system's perceived ability and one's own perceived ability. Perceived ability is hypothesized to be affected by actual ability and various biases (self-serving and bias toward automation).

Reducing the biases should decrease inappropriate automation use. Beck, Dzindolet and Pierce (2007) found that disuse could be reduced by providing participants multiple forms of feedback of the aid's performance. Behaving in expected ways is important and has been researched within the context of "etiquette" by Miller (2002) and others.

Miller (2002) defined etiquette in this way:

> By 'etiquette', we mean the defined roles and acceptable behaviors and interaction moves of each participant in a common 'social' setting—that is, one that involves more than one intelligent agent. Etiquette rules create an informal contract between participants in a social interaction, allowing expectations to be formed and used about the behavior of other parties, and defining what counts as good behavior (p. 2)."

Understanding the "informal contract" the human operators have with their automated decision aids should help researchers to predict when operators will trust their automated aids (Parasuraman & Miller, 2004). Understanding why an automated aid might err has also been found to affect trust and reliance (Dzindolet, Pierce, Dawe, Peterson, & Beck, 2000).

In addition to trust (through perceived utility) affecting automation use, we conjecture that two other social processes may affect automation use: feelings of control and moral obligation to rely on self. Analyses of the justifications of the task allocation decisions provided by participants in one of the Dzindolet, Pierce, Beck et al. (2002; Study 2) experiments revealed that 71% of the students, who were provided cumulative feedback that indicated that the aid made about an equal number of errors as the participant, justified self-reliance with statements indicating they would not earn more rewards if they relied on the aid. Since the task allocation decision would not affect the size of their reward, why did participants opt for self-reliance? We hypothesize that self-reliance provides participants with an illusion of control. Langer (1983) has found that people often behave illogically in order to have an illusion of control.

In addition, many participants (though more working with human aids (n=24, 43.64%) than automated aids (n=9, 16.67%), $X^2 = 8.58$, $p < .01$) justified self- reliance with statements concerning a moral obligation to rely on oneself. One student wrote, "I would rather the amount of coupons I receive be based on my performance-it seems more ‘fair’ to myself.” Another wrote, “I feel anything earned should be based on how well I did or didn’t do.”

Beck, Dzindolet, and Pierce (2002) explain that these action errors (misusing an aid when one is aware that the aid is inferior or disusing an aid when one is aware that the aid is superior) may be due to a John Henry Effect; the aid is thought of as a competitor rather than a teammate (Beck, Dzindolet, & Pierce, 2007). Beck, Dzindolet, Pierce, and McKinney (2003) recently found that students taking a multiple choice test who *could* request help from an automated aid known to be correct about 70 percent of the time performed better than those who could not request to view the automated aid’s responses. What is surprising about this result was that the performance difference existed *even for the trials in which the students did not view the aid’s help*. Just knowing that one could be aided by automation led to better performance! Whether this was due to social facilitation, motivation, or other factors has yet to be explored. Only with a more clear understanding of these processes will we be able to suggest ways that misuse and disuse can be reduced. The variables which affect perceived utility are of special interest to us because perceived utility is not only predicted to affect trust, but also to affect the last of the processes, motivational processes.

Motivational Processes

A third explanation of the over-reliance on automation discussed by Mosier and Skitka (1996) involves the idea that when working in a group, the responsibility for the group’s product is diffused among the group members. Several researchers have thought of the human-computer system as a dyad or team in which one member is not human (Bowers, Oser, Salas, & Cannon-Bowers, 1996; Scerbo, 1996; Woods, 1996). Thus, the human may feel less responsible for the outcome when working with an automated system than when working without one. The person may not be as motivated to extend as much effort when paired with an automated system as when working alone. In the social psychological literature, this phenomenon has been dubbed social loafing (cf. Latane, Williams & Harkins, 1979) or free riding (Kerr & Bruun, 1983).

One theory which has been successful in accounting for much of the findings in the social loafing literature is Shepperd's Expectancy-Value Theory (1993; 1998). According to this theory, motivation is predicted from a function of three factors: expectancy, instrumentality, and outcome value.

Expectancy. The first factor, expectancy, is the extent to which members feel that their efforts are necessary for the group to succeed (see Figure 5). When members feel their contributions are dispensable, or when one's individual contribution is unidentifiable or not evaluated, one is likely to free ride, or work less hard (Kerr & Bruun, 1983; Williams & Karau, 1991).

With a human-computer system, individual contributions tend to be identifiable and evaluated, thus these variables are not thought to affect motivational processes. However, when the perceived utility of a system is high, one is likely to feel his or her efforts are more dispensable when working with a system low in perceived utility. Thus, we would expect human operators to be likely to misuse a combat identification system deemed more reliable than themselves in the same way people free ride on group members deemed more reliable than themselves.

Task difficulty, which is predicted to affect perceived utility (see Figure 5), has also been found to directly affect dispensability. In fact, one of the methods researchers have used to make group members feel their efforts are indispensable has been to imply that the difficulty of the task makes the demands on each group member particularly high (Shepperd, 1993). For example, Harkins and Petty (1982) asked participant to generate as many uses as they could for either a knife (easy task) or for a detached door knob (difficulty task) either alone or in nine-member groups. Although they found social loafing with the easy task (group members did not generate as many ideas as those working alone), they did not find social loafing with the difficult task.

In summary, the more dispensable the human operator is made to feel, the lower expectancy will be; effort will likely be low and the likelihood that the automated aid will be relied upon will be high. In some instances, this will lead to automation misuse.

Instrumentality. The extent to which members feel that the group's successful performance will lead to a positive overall outcome (instrumentality) is also predicted to affect effort. Members who feel the outcome is not contingent on the group's performance are less likely to work hard. Thus, inappropriate use should be high among members who feel their group's performance is irrelevant. In one study, Shepperd (1998) varied instrumentality. Half the participants were told that the seven groups with the highest number of ideas generated (out of ten groups) would earn a reward. Other participants were told that the members of the four groups with the highest number of ideas generated (out of 40 groups) would have their names entered into a lottery. One name would be drawn and that person would earn a reward. Thus, in the former condition, members had a 7 in 10 chance of attaining the reward; in the latter condition, there was only a 1 in 200 chance of attaining the reward. In addition to the optimistic bias (participants estimated their chance of winning to be about 1 in 4), he found that performance suffered when instrumentality was lowered.

On the battlefield, there will be many Soldier-computer teams. If the human determines that the overall outcome is not contingent on his or her human-computer team (either because he estimates other teams are more able to do the task or that his human-computer team is dispensable), then the human will put little effort into the task.

Outcome Value. Finally, the value of the outcome is predicted to affect motivation. Outcome value is the difference between the importance of the outcome and the costs associated with working hard. Increasing the costs or minimizing the importance of the reward will lead members to put forth less effort. More effort will be extended toward tasks that lead to valuable outcomes without requiring much cost. Costs vary with the number of other tasks one must perform, fatigue, intrinsic interest of the task, and cognitive overhead. Importance is predicted to be affected by the rewards of successful task completion and the penalties of task failure. Given the lethal effects of misidentification on the battlefield, outcome value is assumed to be extremely high and the amount of effort expended on the task is predicted to be high. Thus, the likelihood for automation use is low and the potential for disuse will be great. Among such highly motivated people, misuse may not exist at all! This is consistent with findings from some interviews with Gulf War Soldiers, who indicated they turned off their automated systems.

For this reason, it is imperative that some of the research testing the model be performed in more combat-like environments. At the very least, researchers should examine automation reliance while varying the consequences for successful task performance.

Conclusions

Understanding automation usage decisions for even a very simple target detection task is complex. Such decisions are often counter-intuitive. For example, providing people with a highly reliable automated decision aid does not always improve the performance of the human-automated team. Increasing the reliability of the automated aid does not always improve the performance of the human-automated team. Training humans to know the conditions under which the automated aid's performance will be perfect does not always improve the performance of the human-automated team.

The Framework of Automation Use predicts that cognitive, social, and motivational processes work together to cause misuse, disuse, and appropriate automation use. Many factors affect each of the processes, and may therefore, affect automation use. The reliability of the automated aid, the reliability of manual operation and several cognitive biases (including self-serving and the bias toward automation) combine to affect the perceived utility of the aid. When the perceived utility of the aid is high, the operator is likely to trust the aid and feel dispensable; his or her efforts are not necessary for the task to be completed. Automation use is predicted to be high through both social and motivational processes. Fatigue, number of tasks, intrinsic interest in the task, cognitive overhead, penalties for task failure, and rewards for task completion combine to affect the outcome value, which also will affect the effort the human will expend on the task and the likelihood he or she will rely on the automated aid.

Future research needs to determine the effect of each of the cognitive, social, and motivational processes on automation use. In addition, the interaction of the three processes must be examined. Specifically, the relative importance of each process needs to be determined and understood within a military context. Clearly, much research is needed to examine this framework. We believe the framework will prove useful to researchers interested in reducing automation misuse and disuse.

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Author Notes

Portions of this paper were presented in a previous technical report: Dzindolet, M. T., Beck, H. P., Pierce, L. G., & Dawe, L. A. (2001). *A framework of automation use* (Rep. No. ARL-TR-2412). Aberdeen Proving Ground, MD: Army Research Laboratory and at a conference: Dzindolet, M. T., Pierce, L. G., & Beck, H. (2003, May). *Understanding the Human-Computer Team*. Paper presented at the North Atlantic Treaty Organization's (NATO) Critical Design Issues for the Human-Machine Interface, Prague, Czech Republic.

Figure 1. Sample Slide Containing Soldier

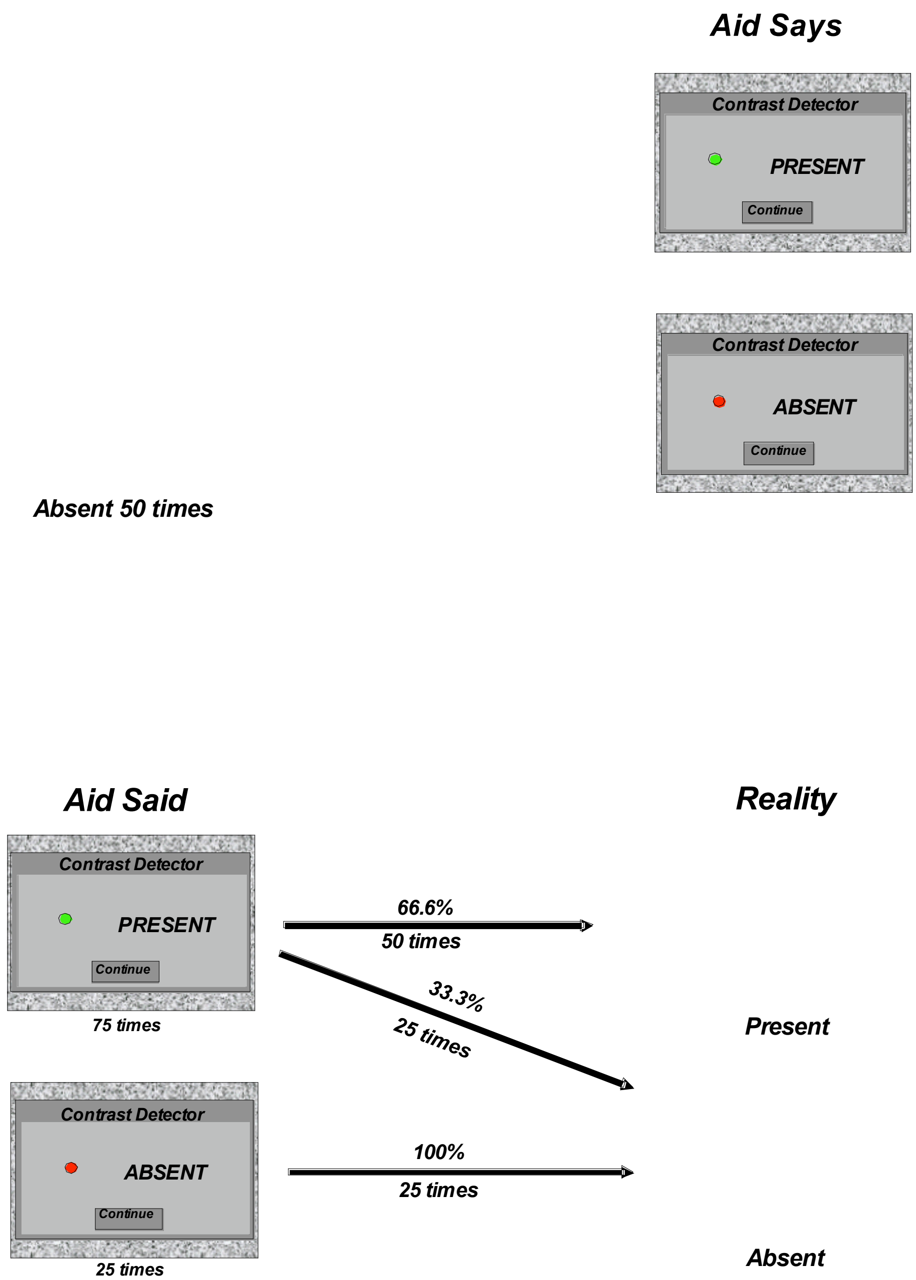

Figure 2. Reliability Rates

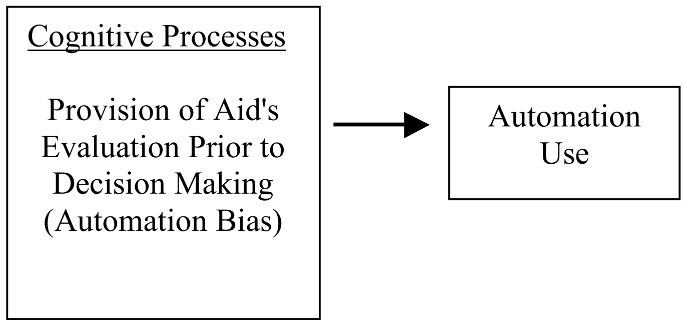

Figure 3. Cognitive Processes

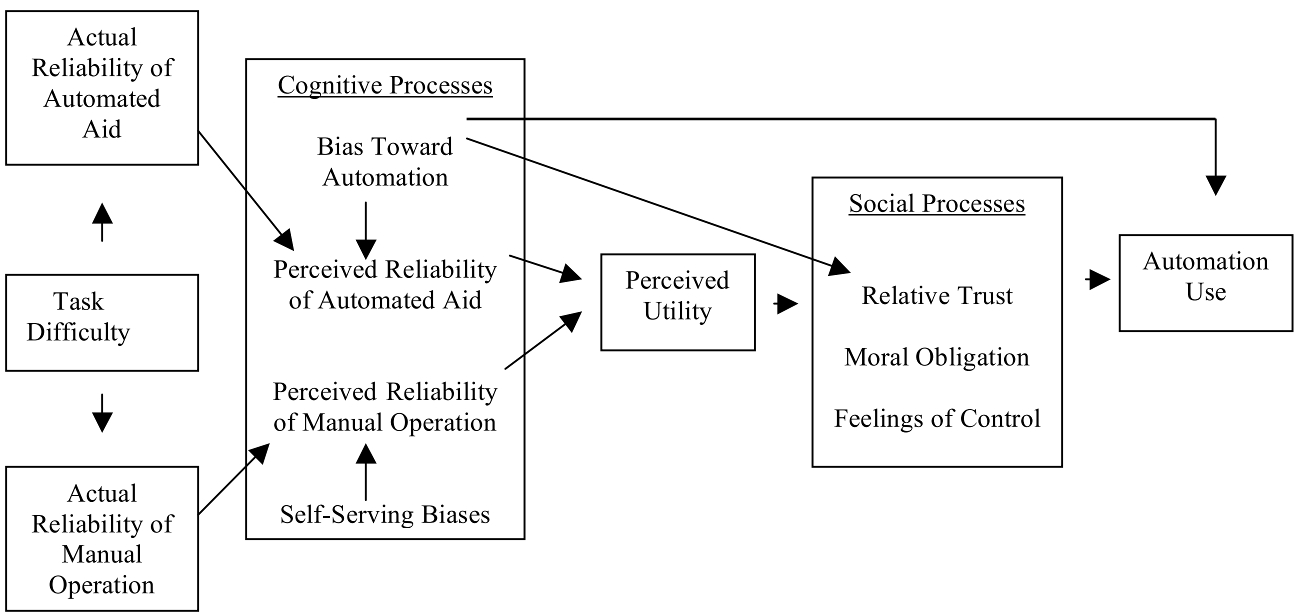

Figure 4. Social Processes

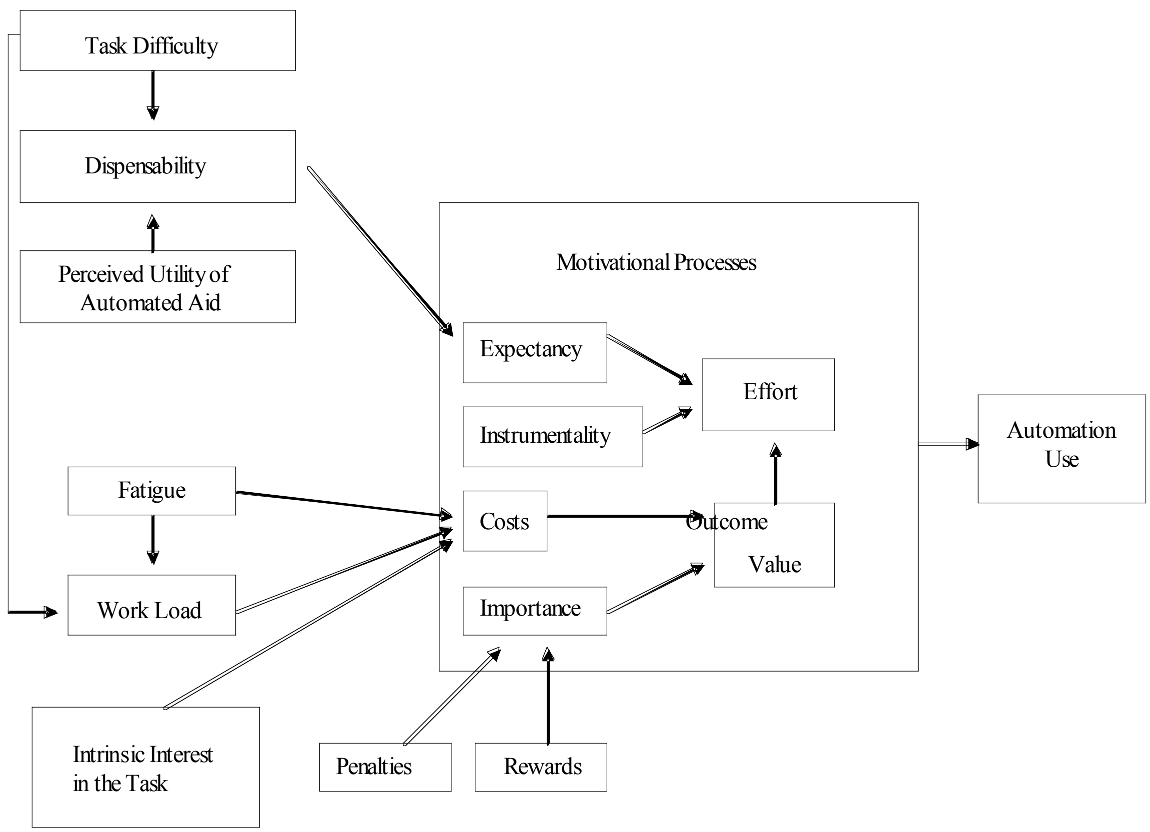

Figure 5. Motivational Processes

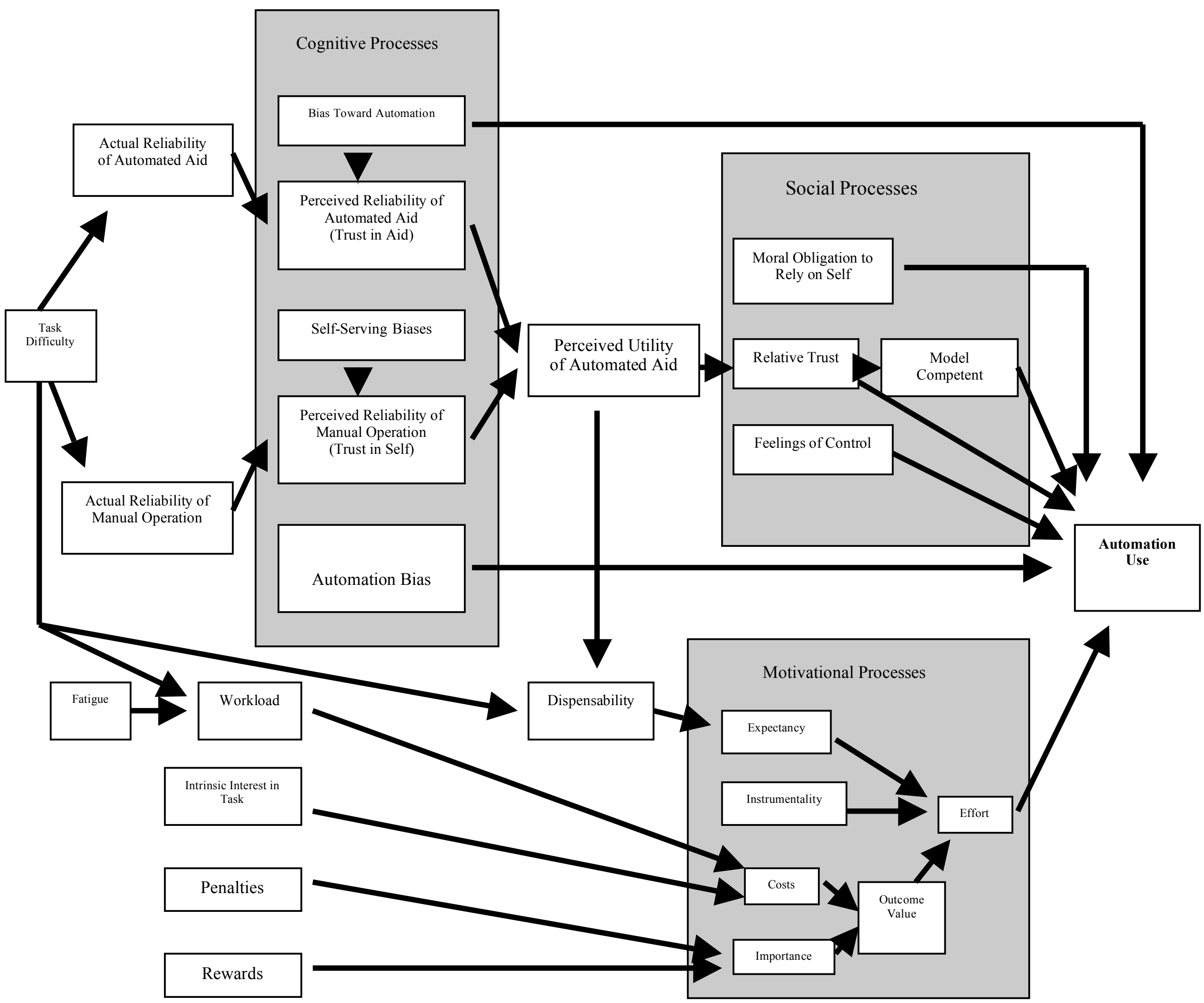

Figure 6. Framework of Automation Use