Impact of the Contrast Effect on Trust Ratings and Behavior with Automated Systems

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The current study examines the effect of positive and negative images on trust. Experiment 1 was conducted to determine how images can influence trust ratings of others. Results indicated that trust could indeed be manipulated by presenting prior images. Experiment 2 was conducted to determine if these same images could not only influence trust ratings, but would also correlate with actual trust behaviors towards others. The findings clearly show that behavior was dramatically altered for an extended period of time simply by presenting positive or negative images prior to the behavioral task. Experiment 3 was conducted to determine whether positive and negative images also influenced basic visual search behavior. The data indicated that visual search behavior was not influenced when trust in automation was not involved.

Keywords: Trust, Positive, Negative, Behavior, Automation

There is a large literature on trust that has expanded in recent times. As Lee and See (2004) pointed out, it is important to be aware of the similarities and differences in trust research across various fields of psychology. In light of this advice, we discuss both basic social psychology research that primarily deals with trust attitudes and more applied cognitive research that deals with trust behaviors during human-automation interactions.

Researchers have studied the role that trust plays in in-group and out-group interactions (Choi, 2006; Klimoski & Karol, 1976; Messick, 1983; Rosen, 1977), marital relations (Franklin, Janoff-Bulman, & Roberts, 1990; Kelly & Floyd, 2006; Tallman & Hsaio, 2004; van de Rijt, & Buskens, 2006), work-place relations (Ergeneli, Saglam, & Metin, 2007; Nugent & Abolafia, 2006; Poon, 2006; Spector & Jones, 2004; Watson, Scott, Bishop, & Turnbeaugh, 2005), automation (Dixon & Wickens, 2006; Lee & See, 2004; Parasuraman & Riley, 1997; Sheridan, Parasuraman, & Wickens, 2000; Wickens & Dixon, 2007), and many others (Ertiurk, 2007; Majolo, Ames, Brumpton, Garratt, Hall, & Wilson, 2006; Silvester, Patterson, Koczwara, & Ferguson, 2007; Zak, Brewer, Clark, Deangelis, Nielsen, & Turek, 2000). Researchers have also studied the factors that predict trust, such as emotions (Anderson & Thompson, 2004; Dunn & Schweitzer, 2005), personality characteristics (Butler, 1991; Kochanska, Aksan, Penney, & Boldt, 2007; Lewicki & Wieghoff, 2000; Mayer, Davis, & Schoorman, 1995), and others (Buckingham, DeBruine, Little, Welling, Conway, Tiddeman, & Jones, 2006; Rotte, Chandrashekaran, Tax, & Grewal, 2006).

One way of conceptualizing trust is as a mental state that is actually a predisposition for behavior. That is, if one trusts an entity, then this implies that one behaves differently towards that entity than if there was no trust involved. One example could be a person's trust in one's accountant to properly prepare a tax return, which implies that the person would be likely to actually hire that accountant to prepare it. However, scale ratings of trust are limited because they might not reflect such actual behavior.

Another way of conceptualizing trust is as a mental state that varies along a continuum (e.g., from extreme distrust to extreme trust) which may or may not influence actual behavior. From this perspective, it is perfectly reasonable to measure trust via some kind of rating scale. However, given that it may be easier to influence responses on scales than to influence behavior, it is questionable whether these manipulations would influence actual behavior. It is even more questionable whether long-term *repeated* behaviors (conducted frequently over an extended period of time) would be influenced by these types of manipulations, or whether the effects would fade quickly.

Trust in Automation

Automation is typically defined as a machine that augments or replaces a human operator (Wickens & Hollands, 2000). This can include everything from alarm clocks to the complicated set of controls on an Air Force fighter jet. As the modern world becomes increasingly more automated, it is not surprising that this issue is gaining increased attention (e.g. Dixon & Wickens, 2006; Dixon, Wickens & McCarley, 2007; Lee & See, 2004; Parasuraman & Riley, 1997; Sheridan, Parasuraman, & Wickens, 2000). In recent years, some progress has been made regarding theoretical predictions of human-machine performance (e.g. Bainbridge, 1983; Endsley & Kiris, 1995; Kaber & Endsley, 1997; Lee & Moray, 1994; Molloy & Parasuraman, 1996; Parasuraman & Riley, 1997; Parasuraman, Sheridan, & Wickens, 2000; Sheridan, 2002). However, much remains to be discovered to allow accurate predictions of human-machine performance when humans must interact with automation.

Sheridan, Parasuraman, and Wickens (2000) outlined four stages of automation, which roughly correspond to the four stages of information processing: a) selective attention (sensory input), b) diagnosis (perception and situation assessment), c) response selection, and d) response execution. Each stage of automation offers a different type of assistance to the human operator interface, and thus augments (or damages) performance differently. For our purposes, the current study focuses primarily on diagnostic automation (Stage 2); that is, aids that inform the operator of a 'state of the world.'" For example, when one is searching through an aerial image, a diagnostic aid would provide a recommendation regarding whether or not a target is present. It is critical to note that when diagnostic aids are employed, the operator may or may not have access to the raw data that the aid is interpreting. When raw data are available, the operator has the option of determining the validity of the automation's recommendation, instead of having to blindly accept or reject it (Sorkin & Woods, 1985).

Although much of the automation literature focuses on imperfect automation and its ramifications on operator trust and behavior (e.g. Parasuraman & Riley, 1997; Parasuraman, Molloy & Singh, 1993; Dixon & Wickens, 2006), there is also literature which focuses on perfectly reliable automation. These studies suggest that perfectly reliable automation may not always be as beneficial as anticipated. In some cases, particularly during low workload levels, automation may not be beneficial at all (Galster, Bolia, & Parasuraman, 2002; Merlo, Wickens, & Yeh, 2000; Muthard & Wickens, 2001; Rovira, McGarry, & Parasuraman, 2002), suggesting that automation may sometimes only be useful when resources are scarce (Dixon, Wickens & Chang, 2005). In other cases, automation may actually harm performance by narrowing attention to only the cued events (Davison & Wickens, 2001; Yeh & Wickens, 2001; Yeh, Wickens & Seagull, 1999). Thus, one cannot blindly assume that perfectly reliable automation will result in perfect human-automation performance, even if that goal seems rationally attainable.

In the present paradigm, participants are asked to search for target objects in aerial photographs, while an automated aid gives recommendations as to whether or not the target is present. The measure of trust used is how often, and how quickly, the participant agrees with the automated aid (Wickens & Colcombe, 2007; Dixon & Wickens, 2006; Dixon, Wickens & Chang, 2005; Dixon, Wickens & McCarley, 2007). High trust in the automated aid will naturally result in high agreement rates with the aid and quick responses. Lower trust will result in lower agreement rates and slower responses. Thus, by using trust towards an automated aid, it is possible to assess trust both in terms of the usual rating scales typically employed by social psychologists, and by actual repeated behaviors.

Contrast Effects

In the current study, we developed two goals that would combine knowledge from social research on trust attitudes and more applied research on trust behaviors. First, we wished to find a well supported manipulation in the social psychology literature that could be demonstrated to influence trust ratings. Second, and more important, we wished to test whether this manipulation would influence actual behavior and, in particular, repeated behaviors, over a significant period of time. For our purposes, we chose to focus on contrast effects.

There is a large literature on contrast effects (Becker & Miller, 2002; Bohner, Ruder, & Erb, 2002; Brewer & Chapman, 2003; Cheng, Lee, & Benet-Martinez, 2006; Dijksterhuis, Spears, Postmes, Stapel, Koomen, Knippenberg, & Scheepers, 1998; Geers & Lassiter, 1999; Geers & Lassiter, 2005; Moskowitz & Skurnik, 1999; Palmer, Maurer, & Feldman, 2002; Tormala & Clarkson, 2007; Wyer, Sadler, & Judd, 2002). In essence, contrast effects occur when two conditions are met. The first condition is that a person must make a judgment about something or someone, which we will call variable X. The second condition is that prior to judging X, the person is first presented with an exemplar that typifies one pole (negative in comparison to) or the other (positive in comparison to) of the judgment dimension. If the judgment about X is shifted in the direction opposite of the presented exemplars, then a contrast effect has occurred.

For an early example, consider a study by Herr, Sherman, and Fazio (1983) where participants were presented with names of animals that were moderately or extremely ferocious, or moderately or extremely large. Subsequently, as part of an ostensibly different study, participants were presented with more animals and asked to judge either their ferocity or their size. Compared to the conditions where participants had been presented with moderate exemplars, the extreme exemplars caused judgments to shift in the opposite direction; animals were judged as less ferocious or less large after being presented with extremely ferocious or extremely large exemplars.

Contrast effects have been demonstrated to reliably influence people's scale ratings in a wide variety of judgment domains. Whether contrast effects would be effective in influencing trust, as measured by scales or by repeated behaviors, has not yet been determined. The current study analyzes this possibility.

The Current Study

Three experiments will be presented. In the first experiment, participants were presented with positive or negative exemplars of automation and then proceeded to rate their trust in a hypothetical diagnostic aid used in luggage screening (e.g. Weigmann, McCarley, Kramer & Wickens, 2006). In the second experiment, participants were again presented with positive or negative exemplars of automation and then proceeded to search through aerial images for the presence of enemy targets (e.g. Dixon & Wickens, 2006; Dzindolet, Pierce, Beck, & Dawe, 2002; Maltz & Shinar, 2003). The main dependent variable in both experiments was trust; it was measured via a typical social psychology scale in Experiment 1, and via actual behavior in Experiment 2.

In Experiment 1, we predicted a contrast effect; that is, trust judgments would go in the opposite direction of the presented exemplars. In Experiment 2, we predicted that the contrast effect would have long-lasting influence on actual repetitive behavior; that is, presenting positive and negative images prior to interactions with automation would influence trust in a much more profound way than by merely inducing a response bias. Finally, in Experiment 3, participants were asked to perform the same visual search task used in Experiment 2 but in the absence of a diagnostic aid. We predicted that the exemplars would have no noticeable effect on visual search behavior, because the exemplars were playing primarily on operator trust and not the ability to search satellite images.

Experiment 1

Method

Participants. One hundred and fifteen participants from the New Mexico State University community took part in the experiment for course credit. All participants reported normal or corrected to normal vision.

Apparatus and Stimuli. The experimental display was presented via PowerPoint slides, on a Dell computer with a 17" monitor, using 1024 x 768 resolution. Participants recorded their answers on a sheet of paper which was provided prior to beginning of the experiment.

Eighteen pictures of automated devices were used as the stimuli for the experimental conditions. Prior to the main experiment, naïve participants rated nine of the pictures as positive and nine as negative, and the ratings of the two types of pictures differed significantly ($p < .0001$). Figure 1 shows an example of a positive picture and a negative picture.

Figure 1. Example of a positive picture and a negative picture.

Procedure. Participants first signed a consent form, and were then seated in a comfortable chair approximately 21" from the display. The PowerPoint presentation began with a welcome slide that stated, "Welcome to our lab! We are interested in automation." Instructions were then given about how to maneuver through the experiment via mouse clicks. In the experimental conditions, the second slide stated, "The following slides will give you examples of automation." Subsequently, the next nine slides presented either 9 positive pictures of automation or 9 negative pictures of automation. Following the pictures of automation, participants were asked, "How do you feel about the automation in the pictures?" Participants then wrote down their answer on a sheet of paper based on a Likert scale from -3 to 3 (Extremely negative – Extremely positive). In the control condition, participants did not view any pictures.

The next slide presented a brief paragraph describing a potential new form of automation that was being employed at airports to assist in luggage screening. The story read:

Imagine that you are a luggage screener in a major airport. Your job is to inspect x-ray images of each piece of luggage and find potential weapons. If you see a weapon in an x-ray image, you must order the bag to be stopped and searched manually. Also imagine that you are provided with an automated aid that will help you search each bag. This aid is programmed to search through the x-ray image and provide a recommendation to you regarding the presence or absence of any potential weapon. Because this aid is based on an algorithm designed by the programmers, it may or may not be perfectly accurate.

Following this story, participants were asked how much trust they had in the automation described in the story. Participants then wrote down their answer on a sheet of paper based on a Likert scale from -3 to 3 (Extremely untrustworthy – Extremely trustworthy). Following this, the experiment ended automatically and participants were debriefed.

Design. A mixed design was employed, in which participants either viewed the positive pictures, the negative pictures, or no pictures prior to the presentation of the story. Each participant gave a rating of Feeling towards the pictures and a rating of Trust towards the automation in the story.

Results

Data from Experiment 1, which includes the means for the ratings of Feeling and Trust for all three conditions, are presented in Table 1. The factor Rating refers to the ratings of Feeling and Trust that participants provided after viewing the pictures and reading the story, respectively. The factor Picture refers to whether the pictures were positive or negative. The neutral condition was not included in the overall two-way ANOVA since that condition did not include ratings of Feeling towards pictures.

Table 1. Mean ratings of Trust and Feeling from Experiment 1 across Positive, Negative and Neutral picture conditions.

	Positive	Negative	Neutral
Ratings of Trust	0.00	1.30	0.52
Ratings of Feeling	1.96	0.39	

A two-way mixed-design ANOVA revealed a significant interaction between Picture and Rating, $F(1, 44) = 21.17$, $p < .001$, with no main effect for Picture, $F(1, 44) < 1.0$, or for Rating, $F(1, 44) = 2.80$, $p > .10$. These data are presented in Figure 2. Post hoc comparisons revealed that there was a significant difference between the positive and negative pictures for ratings of Feeling, $t(44) = 3.93$, $p < .001$, $d = 1.18$, and ratings of Trust, $t(44) = 2.89$, $p < .01$, $d = .87$. These data indicate that ratings of Feeling were higher for the positive condition relative to the negative condition, whereas the ratings of Trust were higher for the negative condition relative to the positive condition. Further comparisons revealed a significant difference between ratings of Trust for the negative condition and the neutral condition, $t(44) = 1.96$, $p = .02$, $d = .59$, with a non-significant trend between ratings of Trust for the positive and neutral conditions, $t(44) = 1.21$, $p = .12$, $d = .36$.

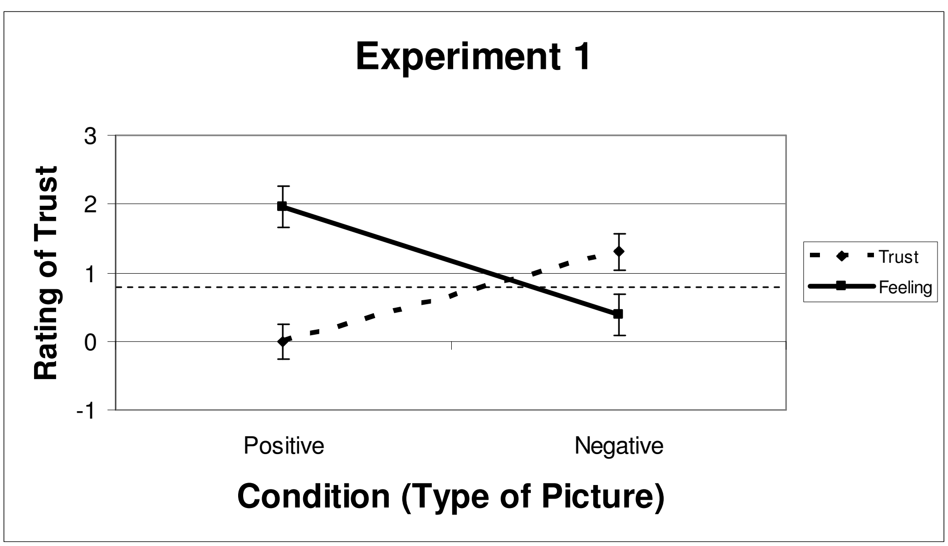

Figure 2. Experiment 1 ratings. SE bars are included. The dashed horizontal line indicates ratings of trust in the neutral condition

Discussion

The data support the hypothesis that using the contrast literature to make predictions about trust ratings is an appropriate application of that literature. As Figure 2 clearly demonstrates, although the affect induced by the positive pictures was significantly more positive than the affect induced by the negative pictures, trust ratings were in the opposite direction. Prior exposure to positive pictures decreased trust relative to prior exposure to negative pictures, thereby resulting in a contrast effect on trust ratings. It is, of course, possible that the obtained contrast effect is the result of a process that influences the way people make ratings on scales but does not actually influence behavior. Alternatively, it is possible that trust—as defined in terms of behavior—is influenced. Experiment 2 was designed to test these possibilities.

Experiment 2

In Experiment 2, we made use of the automation paradigm that was discussed earlier. Participants were presented with a series of pictures and their task was to determine whether or not each picture contained a tank. The task was made potentially easier by an automated aid that indicated, for each picture, whether it contained a tank or not. Trust in the automated aid was assessed via response times and agreement rates (Dixon & Wickens, 2006; Dixon, Wickens & Chang, 2005; Dixon, Wickens & McCarley, 2007; Wickens & Colcombe, 2007; Wickens & Dixon, 2007). To the extent the participants trusted the automated aid, they were expected to exhibit shorter response times. Since the automation was perfectly reliable, and never failed, trust in this automated aid should have increased agreement rates, and subsequently increased response accuracy.

Method

Participants. Fifty-four participants from the New Mexico State University community took part in the experiment for course credit. The mean age was 20.1 (*SD* = 4.83) with a range from 18 – 38. There were 35 females and 19 males. All participants reported normal or corrected to normal vision.

Apparatus and Stimuli. The experimental display was presented via E-Prime 1.1 on a Dell computer with a 20” monitor, using 1024 x 768 resolution. Accuracy and response times were recorded by E-Prime. The 18 pictures used in Experiment 1 were again used in Experiment 2. Each picture was presented for exactly 5 seconds within the E-Prime program prior to the visual search task. The visual search images were created using 50 aerial photographs of Baghdad. These were used as target-absent trials. A small image of a tank was digitally blended onto each of the 50 photographs using Photoshop CS2. These were used as target-present trials. Thus, there were 100 photographic stimuli—50 with tanks and 50 without tanks.

Procedure. Participants first signed a consent form, and were then seated in a comfortable chair approximately 21” from the display. Similar to Experiment 1, the E-Prime presentation began with a welcome slide. Instructions were then given about how to maneuver through the experiment via mouse clicks. In the experimental conditions, the second slide stated, “The following slides will give you examples of automation.” Subsequently, the next nine slides presented either 9 positive pictures of automation, or presented 9 negative pictures of automation. In the control condition, participants did not view pictures.

Following the pictures, participants were given instructions regarding the visual search task. They were told that they would be presented with 100 aerial photographs of Baghdad, in which some of the photographs contained an enemy tank. They were instructed that if they detected a tank, they should press the “J” key on the provided keyboard. If they determined that no tank was present, they should press the “F” key. Participants were told to go as quickly as they felt comfortable with, but to maintain as high accuracy as possible. Participants were also informed that they would be assisted by an automated diagnostic aid that would give them a recommendation on whether or not a tank was present. Participants were not informed that the automation was perfectly reliable.

Once participants read through the instructions, they could press any key to begin the experiment. Each of the 100 trials began with a slide presenting the recommendation of the automation in a text message. It would either state, “The automation has detected a tank!” or “The automation has determined that there is no tank present!” This slide remained for 1000 ms, followed by the aerial photograph. Each photograph remained present until the participant responded by pressing either the “J” key or “F” key. Following a response, a feedback slide was presented. This slide either stated, “Correct!” in green letters or “Incorrect!” in red letters, with the response time for that trial and a running total of percentage correct throughout the experiment. This slide remained present for 1000 ms, followed by the next trial.

Design. A between-participants design was employed, in which participants either viewed the positive pictures, the negative pictures, or no pictures prior to the visual search task.

Results

Data from Experiment 2, which includes the means for RT and accuracy for every 10 trials (epoch) across all conditions, are presented in Table 2. Planned comparisons between conditions were employed to test the hypotheses (Keppel, 1982).

Response Times. Only response times (RT) during correct trials were included in the following analyses. Figure 3 presents these data in terms of epochs (Chun & Jiang, 1998). Planned comparisons revealed that the Negative condition differed significantly from the Neutral condition, $t(34) = 1.96$, $p < .05$, and the Positive condition, $t(34) = 3.82$, $p < .001$. The difference between the Positive and Neutral conditions was marginally significant, $t(34) = 1.61$, $p = .058$. In a trial-by-trial binomial analysis, it was revealed that the Positive condition resulted in longer RTs relative to the Neutral condition 85% of the time, $p < .001$. The Negative condition resulted in slower RTs relative to the Neutral condition 98% of the time, $p < .001$. The Positive condition resulted in longer RTs relative to the Negative condition 100% of the time, $p < .001$.

Accuracy. Accuracy was measured by how many trials out of 100 were correct. Figure 4 presents these data in terms of epochs across all conditions. Planned comparisons revealed that the Negative condition differed significantly from the Neutral condition, $t(34) = 2.04$, $p < .05$, and the Positive condition, $t(34) = 2.16$, $p < .05$. The difference between the Positive and Neutral conditions was not significant, $t(34) < 1.0$. In a trial-by-trial binomial analysis, it was revealed that the Positive condition resulted in lower accuracy relative to the Neutral condition 78% of the time, $p < .001$. The Negative condition resulted in higher accuracy relative to the Neutral condition 68% of the time, $p = .06$. The Positive condition resulted in lower accuracy relative to the Negative condition 94% of the time, $p < .001$.

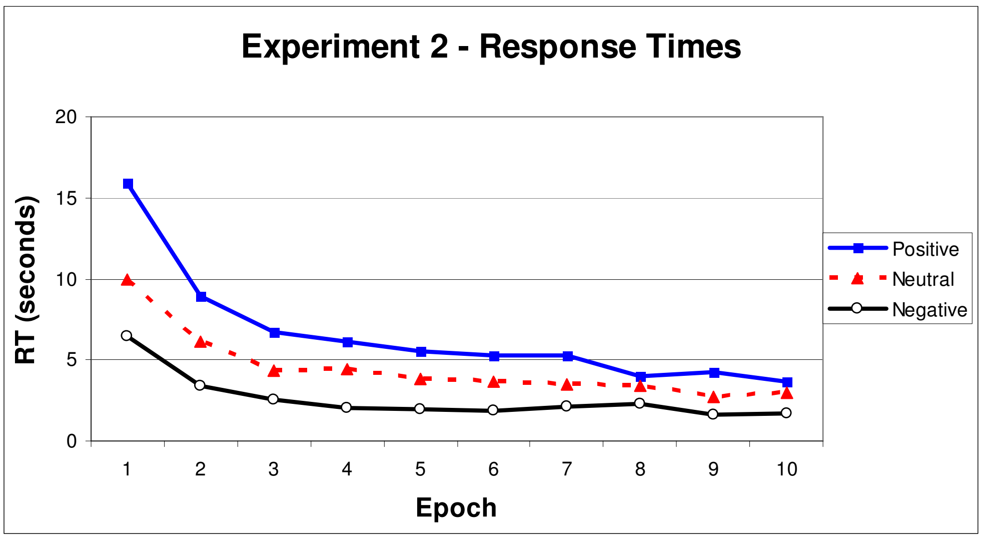

Figure 3. Experiment 2 response times by epoch. An epoch included ten trials.

Table 2. Means for response time (RT) and accuracy from Experiment 2 for every 10 trials (epoch) across Positive, Negative and Neutral picture conditions.

		Epoch									
		1	2	3	4	5	6	7	8	9	10
Target-Present RT	Negative	4.80	3.35	3.04	2.10	2.17	2.03	2.58	2.66	1.63	1.83
	Positive	10.94	6.54	5.36	5.22	4.33	4.51	4.90	2.69	4.05	2.39
	Neutral	6.86	4.29	3.32	3.50	2.70	2.83	3.13	2.81	2.25	2.66
Target-Absent RT	Negative	8.43	3.39	2.12	1.90	1.73	1.82	1.90	1.64	1.61	1.51
	Positive	21.93	11.85	7.96	7.14	6.20	5.34	6.07	5.60	4.96	4.59
	Neutral	13.50	7.34	5.37	5.51	4.69	4.63	3.93	3.65	3.24	3.16
Accuracy	Negative	92.8	95.0	99.4	97.8	97.8	99.4	97.2	96.1	98.3	99.4
	Positive	75.6	89.4	88.3	91.7	92.8	95.6	92.2	93.9	90.0	92.2
	Neutral	81.1	88.9	95.0	92.2	94.4	93.3	96.7	95.0	95.6	94.4

Discussion

The Experiment 2 data clearly contradict the notion that contrast solely influences the way people respond to scales. Effects were obtained on both of the behavioral measures RT and accuracy—indicating that the prior presentation of positive examples of automation decreased trust and the prior presentation of negative examples of automation increased trust.

Although the data from Experiment 2 provide strong evidence that positive and negative exemplars affect operator trust in a diagnostic aid, it is possible that an underlying improvement in visual search behavior is the real cause for overall improvement. In other words, it could be that participants simply became more or less proficient at searching the images as a function of viewing negative or positive images, respectively, prior to the search task. Since the automation was 100% reliable, the human performance would correlate nicely with automation performance, and one can never be sure which process (trust or visual search) is responsible for the behavioral changes. Thus, Experiment 3 was conducted to test whether viewing negative or positive images affects visual search behaviors.

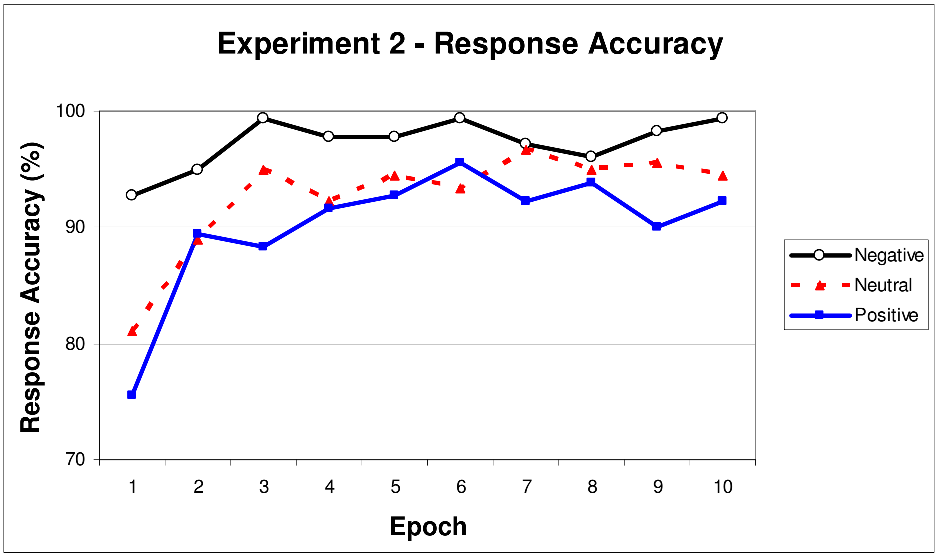

Figure 4. Experiment 2 response accuracy by epoch. An epoch included ten trials.

Table 3. Means for response time (RT) and accuracy from Experiment 3 for every 10 trials (epoch) across Positive, Negative and Neutral picture conditions.

		Epoch									
		1	2	3	4	5	6	7	8	9	10
Target-Present RT	Negative	6.49	5.21	4.79	5.71	4.12	4.38	3.95	3.87	4.16	3.99
	Positive	9.27	5.32	6.36	4.47	4.52	4.59	4.68	3.78	3.93	3.67
	Neutral	6.09	4.85	5.33	4.32	4.08	4.09	3.85	3.33	3.46	3.56
Target-Absent RT	Negative	10.44	9.46	10.64	10.21	10.04	10.17	11.03	9.77	8.99	8.58
	Positive	17.63	13.57	11.18	11.52	11.56	10.98	10.72	10.07	10.27	10.86
	Neutral	15.33	10.93	10.45	11.15	9.99	9.56	9.25	9.42	9.22	9.53
Accuracy	Negative	70.0	70.0	76.7	78.6	74.8	81.4	85.2	82.9	83.8	82.4
	Positive	67.5	75.0	75.8	81.7	80.4	85.8	85.0	87.9	84.2	87.9
	Neutral	75.5	79.5	79.5	89.0	84.5	83.5	85.0	89.5	89.0	89.0

Experiment 3

In Experiment 3, we again made use of the automation paradigm that was discussed earlier. This time, however, participants were not aided by diagnostic automation and had to come to their decision based solely on visual search. We predicted that the positive and negative exemplars would have no noticeable effect on operator performance, and that the experimental groups would not differ from the control group (no exemplars).

Method

Participants. Sixty-five participants from the New Mexico State University community took part in the experiment for course credit. The mean age was 19.1 (SD = 1.45) with a range from 18 – 25. There were 31 females and 34 males. All participants reported normal or corrected to normal vision.

Results

Data from Experiment 3, which includes the means for RT and accuracy for every 10 trials (epoch) across all conditions, are presented in Table 3. Planned comparisons between conditions were employed to test the hypotheses (Keppel, 1982).

Response Times. Only RTs during correct trials were included in the following analyses. One participant did not get any correct answers in Epoch 5, and the missing cell was replaced with the mean of the row/column (Hays, 1994). Planned comparisons revealed that none of the conditions differed significantly from each other (all ps > .10).

Accuracy. Accuracy was measured by how many trials out of 100 were correct. Planned comparisons revealed that none of the conditions differed significantly from each other (all ps > .10).

General Discussion

Based on the literature on contrast effects, we predicted an effect that follows intuitively from this literature, while being non-intuitive from any other perspective. Put briefly, exposure to negative exemplars of automation increased trust whereas positive exemplars decreased it. This effect was obtained with trust ratings (Experiment 1) and with actual repeated long-term behaviors as exemplified by performance RTs and accuracy scores (Experiment 2). Finally, when there was no automation recommendation in Experiment 3, so that trust was irrelevant, the prior exposure of positive or negative exemplars of automation had no effect on performance. The Experiment 3 data indicate that the effects obtained in Experiment 2 were not due to the positive or negative exemplars influencing visual search. Thus, contrast effects on trust remain as the only plausible mechanism that fits all of the data.

In addition, the data contradict hypotheses that could be derived from the affect and assimilation literatures. Affect, as defined by the literature, is a person's current state of mood which can be either positive (e.g. happy), negative (e.g. depressed) or neutral (Bodenhausen, Sheppard, & Kramer, 1994; Forgas, 2002; Forgas & Bower, 1987). Numerous affect researchers have argued that negative affect induces a more critical mindset than positive affect (Bodenhausen et al., 1994; Chartrand, van Baaren, Bargh, 2006; Forgas, 2002; Moreno & Bodenhausen, 2001). From this perspective, then, one might argue that prior exposure to positive stimuli should have caused positive affect and a less critical mindset which, in turn, should have increased rather than decreased trust. And, prior exposure to negative stimuli should have caused negative affect and a more critical mindset which, in turn, should have decreased rather than increased trust. Although the data in Figure 2 support that the pictures influenced feelings in the obvious ways, these feelings influence trust in a way that is inconsistent with this hypothesis. In a similar vein, although there is a voluminous literature documenting assimilation effects, which are judgments in the direction of the presented exemplar (e.g. Aarts & Dijksterhuis, 2002; Dijksterhuis et al., 1998; LeBoeuf & Estes, 2004; Meyers-Levy & Sternthal, 1993; Quellar, Schell, & Mason, 2006), the present effects go clearly in the opposite direction.

Implications for Research on the Contrast Effect. It has often been stated that social psychologists are clever at recommending ways to influence scale ratings, and the contrast literature would be an example of this. But social psychology manipulations have rarely been demonstrated to influence real behaviors (see Eagly & Chaiken, 1993, for a review). The present research addresses this criticism because a seemingly common social psychology phenomenon—the contrast effect—was demonstrated to influence real behaviors over an extended period of time. Clearly, contrast is not trivial. The fact that one social psychology phenomenon has been demonstrated to influence repeated behaviors for a significant number of trials strongly implies that there may be others as well. This implication is particularly strong because we purposefully chose what seemed to be one of the most common of all of the social psychology manipulations. We hope and expect that other standard social psychology effects will be subjected to similar scrutiny. Such research efforts may demonstrate that social psychologists are not just clever but profound as well.

Practical Implications. The practical and applied implications of this study are no less significant than the theoretical implications. It is common to analyze the effects of imperfect automation on operator trust (e.g. Meyer, 2001; 2004; Maltz & Shinar, 2003; Parasuraman

& Riley, 1997; Parasuraman et al., 1993; Dixon & Wickens, 2006; Dixon et al., 2007) but an argument can be made that eventually diagnostic aids will reach perfect, or close to perfect, levels of performance. Even if the automation is not perfectly reliable over the course of its usefulness, it may go for long periods of time without making an error, causing designers (and possibly operators) to *believe* it is perfectly reliable. It is not unreasonable to assume that technological advances will eventually render research on imperfect automation obsolete, at least for some types of automation. Thus, it is important to augment the research on imperfect automation with research on perfectly reliable automation as well.

The fact that positive exemplars decrease trust and that negative exemplars increase it has meaningful ramifications, particularly when one takes into account the amount of times a typical person encounters automation during the course of a workday. Say for example, that a UAV operator has a negative experience with daily automation prior to a UAV mission. It is not unbelievable that this same operator's trust might be affected by these chance encounters, causing over-trust in the diagnostic aid which leads to marking a friendly target as an "enemy." Similarly, an air traffic controller who experiences a positive encounter with some form of automation might tend to under-trust the automated aids that signal the convergence of two aircraft in a sector under that operator's control.

Because of the applied and theoretical issues involved here, and the paucity of prior research on this particular topic, it is important to continue along these lines in order to determine how people interact with seemingly perfectly reliable automation after having an experience which presumably has little to do with the task at hand. We have found one unusual outside force that deeply affects operator trust in automation. There is every reason to believe that other influences exist.

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