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The Impact of Remote C^2 on Soldiers' Performance and Trust in their Leader

Topic 7: Network-Centric Experimentation and Analysis

Topic 4: Cognitive and Social Issues Topic 6: C2 Assessment Tools and Metrics

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Abstract

An extreme implementation of remote command and control (C2) for the dismounted infantry would extract the platoon leader from the platoon and rely on mediated communication between foot soldiers and their leader(s). A review of Social Impact Theory predicts that extracting the platoon leader would produce decrements in soldier performance. This paper discusses an experiment that tests the prediction that immediacy (proximity) matters and the claim that trust partially mediates its impact in a simulated C2 setting. There are three findings. First, active duty soldiers completed oral commands more quickly when collocated with an unfamiliar leader than when that leader was sheltered at a remote location. Second, a questionnaire on trust in the leader revealed greater levels of trust in the collocated condition. Third, a set of regression equations reveal that trust mediates the influence of immediacy on the speed with which soldiers executed direct orders. These findings support arguments against plans that would extract platoon leaders from the field and replace them with remote C2 of platoons.

The Impact of Remote C^2 on Soldiers' Performance and Trust in their Leader

With the advent of 'Network-based defense', the armed forces of the United States and Sweden are planning to change the organization and training of the dismounted infantry in a fundamental way. One of the cornerstones of their plans is a reliance on remote C2. Platoons of dismounted infantry may no longer receive orders in battle from a leader within visual range. Instead, their only connection with their commanding officers may be their radios and other portable information devices. The foot soldier may receive orders from a remote and unknown leader or a group of leaders.

Remote C2 is a structure for distributed work in hierarchical organizations. The leader or a group of leaders (officers) sit out of harm's way in a control center. The work teams (platoons of infantrymen) find themselves in geographically remote and potentially hostile locations. One advantage of remote C2 is that it makes it relatively easy to change leaders as the situation facing the team evolves (Brehmer, 1992). This flexibility is becoming increasingly critical because modern urban warfare is highly dynamic and rarely predictable. The environmental complexity and uncertainty of urban warfare and the criticality of the leader's decisions have long been cited as the major desiderata for adopting remote, rather than collocated, C2 (Adelson, 1961; Brehmer & Sundlin, 2000). In addition, modern C2 centers are designed to give the leader(s) access to multiple sources of information that are not routinely available on the battlefield (Friman, 2000; Hébert, 2003). The centralization of decision making and of the flow of information facilitates the selective deployment of limited resources and speeds the cycle of decision making.

One implication of the proposed organizational change is that platoons of dismounted infantry may not take the field with their leaders. In the language of Social Impact Theory (Latané, 1981; Latané, Liu, Nowak, Bonevento, and Zheng, 1995; Sedikides and Jackson, 1990), remote C2 should substantially reduce the impact of immediacy. Social Impact Theory maintains that the influence experienced by a target (the soldier) is an inverse function of the distance (immediacy) to the influencing source (the leader). Like a light bulb, a source has its greatest influence when it is close to its target. Social Impact Theory would predict that remote C2 should reduce the immediacy (both psychological and proximal) and impact of the leader on the soldier. The other two factors of Social Impact Theory are the strength of the source - wattage in the light bulb

analogy - and the number of sources. A source's strength is like . In the experiment described here, both strength and number were held constant.

Following Social Impact Theory, the hypothesis that drives this research claims that a collocated leader is more immediate and has a greater impact than a remote leader. It is also proposed that immediacy will facilitate the development of a greater level of trust in a collocated leader than a remote leader. Because trust will partially mediate the impact of immediacy, the soldier will respond more quickly when receiving commands from a collocated leader than a remote leader. Response times to direct orders should reflect the impact of immediacy.

Trust is the willingness of one party to be vulnerable to the actions of another based upon positive expectations of the other's behavior (Rousseau, Sitkin, Burt, and Camerer, 1998). One of the critical elements for its formation is reciprocal vulnerability (Berg, Dickhaut, & McCabe, 1995; Hoffman, McCabe, & Smith, 1998). Where there is no vulnerability and no familiarity, levels of trust are likely to be low (Jones & George, 1998; McAllister, 1995; Meyerson, Weick, & Kramer, 1996).

Remote C2 removes the leader from the field of fire. In contrast, a collocated leader assumes the same risk as the soldier. A collocated leader and soldier are reciprocally vulnerable. A tacit awareness of reciprocal vulnerability is proposed to the be foundation for the generation of trust in a collocated leader that is absent under remote C2. By this account, a leader who retreats out of harm's way removes the foundation for the formation or maintenance of trust. By codifying the leader's retreat, remote C2 eliminates a cornerstone for trust.

The experiment tested the prediction of Social Impact Theory that social pressure – the immediacy of the platoon leader – matters to members of the dismounted infantry. The issues to be tested are whether two categorical levels of immediacy are associated with differences in soldiers' behavior and levels of trust in their leader.

Method

Participants

Three platoons of privates in the Swedish Army serving a voluntary term of service took part in the experiment in the role of 'soldier'. The ages of these 52 men and 2 women ranged from 18 to 22 years. An additional platoon of 18 privates served as confederates. Their responsibilities were to interact with the soldiers and to run the experiment. The confederates acted as time-keepers, data recorders, and the sniper. These young people are a sample taken directly from the population to which the results are intended to generalize.

Three officers in the Swedish Army, two majors and a captain, volunteered to participate in the role of leader. The officers were not known to any of the soldiers and were not in their direct chain of command. In the terms of Social Impact Theory, their 'strength' was real but relatively low and constant. All participants - soldiers, confederates, and officers - signed informed consent forms, were issued protective clothing consisting of a face shield, knee pads, elbow pads, and coveralls and were treated in accordance with the standards set by the ethical review board of Linköpings University. All were naïve to the experimental hypothesis.

Experimental setting

The experiment posed a pair of challenges. The first was to create an experimental setting that simultaneously captured much of the look and feel of the battlefield and met the relevant standards for the ethical treatment of human subjects. The technology that made it palatable to run an experiment that exposed our participants to live fire is called paintball. Paintball is a game that many young adults, mostly but not exclusively male, choose to play for fun. The source of fun is shooting non-lethal projectiles at your friends while trying to avoid being shot by them.

The purpose of the live paintball fire was to generate some anxiety so that the measures would more readily generalize to the battlefield. The major sources of anxiety were the fear of being shot and actually being hit by paintballs. The pain associated with being struck by a paintball is transient but real. Protective gear minimized the risk of injury. None of our participants received more than a few small bruises.

The experiment was conducted inside a 30 x 10 m hewn-timber barn on the training facility for the dismounted infantry at Kvarn, 25 km northeast of Linköping, Sweden. The assault lane and its layout, sketched in Figure 1, are based upon a training paradigm used extensively by the U. S. Army. The lane was delineated by five barriers constructed from surplus materials (1.0 m wide by 1.5 m high). The down-lane distance between barriers was 5 m; the cross-lane distance was 6 m. A small cup containing five paintballs was placed behind each barrier. At the far end of the lane stood a protective wall with two horizontal slots (0.5 m long by 0.2 m high) at shoulder height. The wall formed the sniper's bunker. The slots allowed the sniper to shoot at (and be shot by) the soldier. Nine targets, standard-issue human-head targets, four red and five blue, were stapled randomly on the face of the bunker. The confederates acting as time keepers stood in an observation area outside the barn where they could readily observe the soldier work his or her way up the lane.

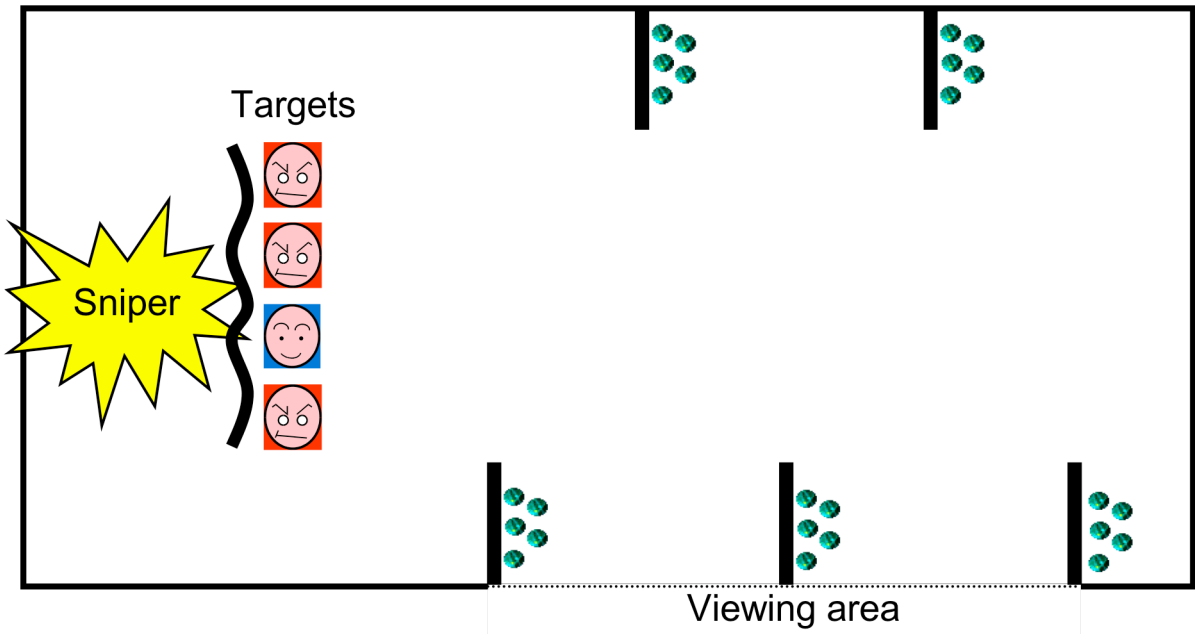

Figure 1. Layout of the paintball assault lane. Soldiers started behind the barrier closest at the bottom right and, on command, advanced from barrier to barrier toward the sniper to obtain ammunition with which they, on command, shot at the targets. In the remote and buzzer conditions, the leader stood hidden in the viewing area.

Apparatus

The second challenge was to counter the potential for demand characteristics (Orne, 1962), contextual cues that may lead participants in an experiment to surmise what the experiment is

about and, as a result, to modify their behavior. The experimental manipulation was the level of immediacy of the leader (collocated vs. remote). The contrast between a collocated leader in one condition and a remote leader in another was expected to be a strong contextual cue that might lead some soldiers to modify their behavior and swamp any impact of immediacy. To counter this possibility, an apparatus – a buzzer – was designed to be sufficiently salient to create the expectation that it, and not the manipulation of immediacy, was the focus of the experiment. The rationale for adding the 'buzzer' condition was that if demand characteristics were a driving force, then an advantage should be seen in the buzzer condition.

The buzzer package had two parts, a communications unit and a tactile-stimulus unit. The communication unit consisted of two radios, tuned to the same frequency, and a sound-activated relay. One of the radios was the remote leader's sending unit and the other the soldier's receiving unit. The leader issued orders to the soldier by pushing the 'call' button on the sending unit. In the buzzer condition, this also initiated a tactile stimulus. The command was received by the soldier's radio and headset. In the buzzer condition, this signal was also sent electronically to a sound-activated relay. The receiving unit and the relay were worn on a waist belt by the soldier. The relay was, in turn, connected by wire to the tactile-stimulus unit.

The tactile-stimulus unit was a small metal box containing an electric motor driving an eccentric cam. The stimulus was a mild buzzing rumble that lasted for 2 seconds. The box was fastened to a vest so that the box sat between the shoulder blades. The buzzer package and the vest were designed to be visually and tactilely salient in order to appear to be the focus of the experiment.

The paintball rifle was the armament used in the experiment. Ammunition consisted of varicolored paintballs. The soldier's radio was voice activated. The soldier's, the leader's, and the time-keepers radios were equipped with headsets.

Tasks

The soldier's task was to move forward from barrier to barrier and to fire at the targets upon receiving orders to do so. Each soldier completed the mission three time. As far as the soldier's mission was concerned, the collocated, remote, and buzzer trials were identical.

A member from the platoon of confederates played the role of sniper. The sniper's task was to shoot the soldier, that is, to instill anxiety and to slow his or her advance up the assault lane, while giving the soldier chances to move up the lane. The leader's task was to issue verbal orders to the soldier using the radio. The actual words used to issue the orders were "Move!" (Framåt!) and "Fire!" (Eld!).

Design

There were three conditions of immediacy in a repeated-measures design. In the collocated condition, the leader was present in the assault lane one barrier behind the soldier. The leader was under fire and, on occasion, got in harm's way. In the remote-leader and buzzer conditions, the leader joined the time-keepers in the observation area, positioning himself so he could see but not be seen by the soldier. In the 'buzzer' condition, the remote-controlled buzzer package vibrated whenever the remote leader issued a command. The soldier wore the package in all three conditions but it was activated only in the buzzer condition.

Procedure

Pairs of soldiers were released from training exercises for approximately an hour to participate in the experiment. On arrival at the assault lane, the soldiers were met by a member of the platoon of confederates who gave them a paper copy of their mission brief and answered their questions. Upon signing consent forms, the soldier was issued protective clothing and given instructions on the use and safety features of the paintball rifles.

The soldier then met the (male) leader for the first time. The leader said he would be giving two types of orders, (1) to advance up the assault lane from one barrier to the next and (2) to shoot at the targets in front of the sniper's bunker. He instructed the soldier to obey all orders as quickly as possible and that he or she would be running the course three times. During the experimental trials, the leader's only communication with the soldier was to issue commands to move and to fire. After the trials, he often commiserated about paintball impacts and bruises.

Soldiers were sent down the lane individually. The soldier's initial position was behind the barrier furthest from the sniper. After loading his or her rifle with the five paintballs from the small cup located behind the barrier, the soldier informed the leader, by radio, that the rifle was

"loaded." On the leader's order "Fire!", the soldier attempted to shoot the red (hostile) targets on the sniper's bunker without hitting the blue (friendly) targets. When out of ammunition, the soldier used the radio to inform the leader that the rifle was "out of ammo." On the leader's order "Move!", the soldier advanced to the next protective barrier on the other side of the lane. The cycle was repeated at each of the barriers. The 25 paintballs, 5 at each barrier, were the soldier's only ammunition. The soldiers risked exposure to the sniper's fire when they aimed at the targets or moved between barriers.

The order of conditions was counterbalanced. Nine soldiers participated in each of the six possible sequences of three conditions. Immediately after finishing the third trial, the soldier completed the trust instrument three times, first answering for the first trial, then for the second trial, and finally for the third trial. The trust instrument was issued once, after the three trials, rather than after each trial in order to avoid cueing the demand characteristic that might emerge if the soldier were to learn that trust in the leader was a key experimental measure.

Dependent measures

The purpose of the red and blue targets was to give structure to the mission and the soldier something to do. Because the sniper was quite effective at shooting the soldier, the soldiers' shooting accuracy was uniformly poor and is not discussed further.

The behavioral variable was the time it took for the soldier to obey orders to move and to shoot as measured by two hand-held stop watches. The time interval began when the confederates serving as timekeepers heard the leader's command. For an order to fire, the time interval ended when they saw the first puff of 'smoke' (CO_2) coming from the barrel of the soldier's rifle. For an order to move, the time interval ended with the soldier came to a full, controlled stop behind the next barrier. Procedures for coming to a controlled stop varied across soldiers. The within-subjects design controlled this inter-participant variability. Any errors associated with fallible operation of the stopwatches are assumed to be randomly distributed within and across participants.

Trust was assessed using an eight item questionnaire. The basic template for the questionnaire was an instrument developed by the Swedish Defense Research Agency for the express purpose

of assessing trust in leaders (Svenmark, 2005, personal communication). A few of the questions were modified to fit the paintball task. The instrument uses a 7 point scale with anchors in the middle and on both ends. Half the questions were reverse-scored. The soldier's score is the average response to the eight questions.

The mediating effect of trust was assessed using the series of regressions described by Baron and Kenny (1986). The potential for demand characteristics is assessed by comparing the dependent measures across the remote and buzzer conditions.

Results

In line with Social Impact Theory, we hypothesized that immediacy matters, that is, that both the behavioral and trust measures would show an advantage when the leader was collocated in the assault lane with the soldier. The hypotheses tested by the experiment were (A) the remote condition is associated with lower self-reported trust in the leader than the collocated condition, (B) the remote condition is associated with slower response time to commands to "Move!" and to "Fire!", (C) there is a significant inverse association between the decrements in trust and response time, and (D) trust mediates the impact of immediacy. Further, if demand characteristics were in play, then both trust and response times should improve in the buzzer condition.

Questionnaire data

A two-factor mixed-effects repeated-measures ANOVA was conducted to assess the significance of the manipulation of immediacy and the possibility of sequence effects. The sequence of data acquisition was the blocking variable at six levels. Cronbach's alpha for the soldiers' responses to the survey is .78, indicating an acceptable level of consistency across the eight items.

Figure 2 is a graph showing the self-report data across the manipulation of immediacy. The ANOVA indicates that only the main effect for immediacy was significant, $F(2, 96) = 16.56$, $p < .001$, power =.80. Neither sequence nor the interaction of sequence and immediacy was significant. The Tukey HSD procedure indicates that the collocated condition is significantly different from the remote-leader and buzzer conditions and that the latter two are not different from each other. These results support the hypothesis that remote C2 is associated with a

decrement in soldiers' self-reported trust in their leader. Further, there is no indication in these data of a 'learning effect' and no sign of demand characteristics associated with the buzzer.

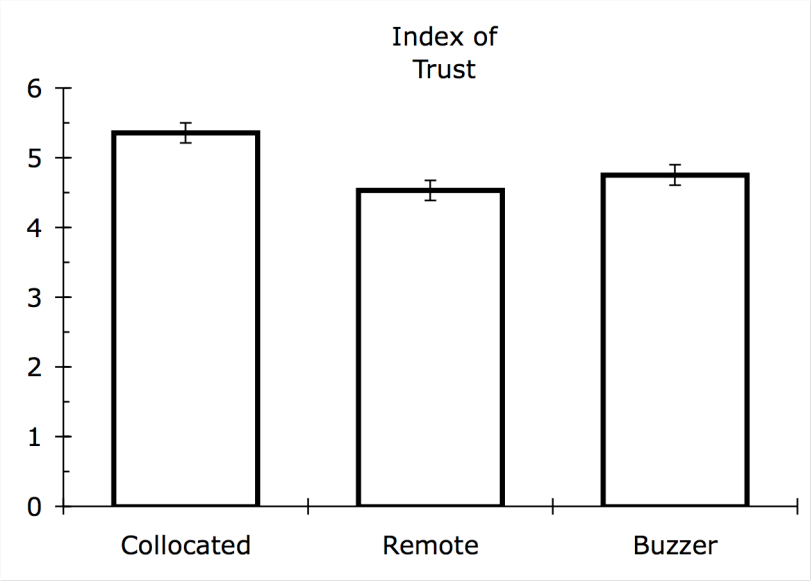

Figure 2. Means and standard errors of the soldiers' self-report data on the relative level of trust experienced in the collocated, remote, and buzzer conditions showing higher levels of trust in the collocated condition.

Move data

A second ANOVA was conducted for the move time data shown in Figure 3. The raw data were the average of the soldier's four responses to the command to "Move!" The ANOVA indicates that the main effects for immediacy is significant, $F(2, 96) = 6.76$, $p < .002$, power =.32. Neither sequence nor the interaction of sequence and immediacy was significant. Once again, the Tukey HSD procedure indicates that the collocated condition is significantly different from the remote-leader and buzzer conditions and that the latter two are not different from each other. These results support the hypothesis that remote C2 is associated with slower performance. Further, there is no indication in these data of a 'learning effect' and no sign of demand characteristics associated with the buzzer. There was however a small (0.69 s) but significant, $F(3, 159) = 3.9$, $p < .01$, slowing in move time as the soldier approached the bunker and took more hits from the sniper.

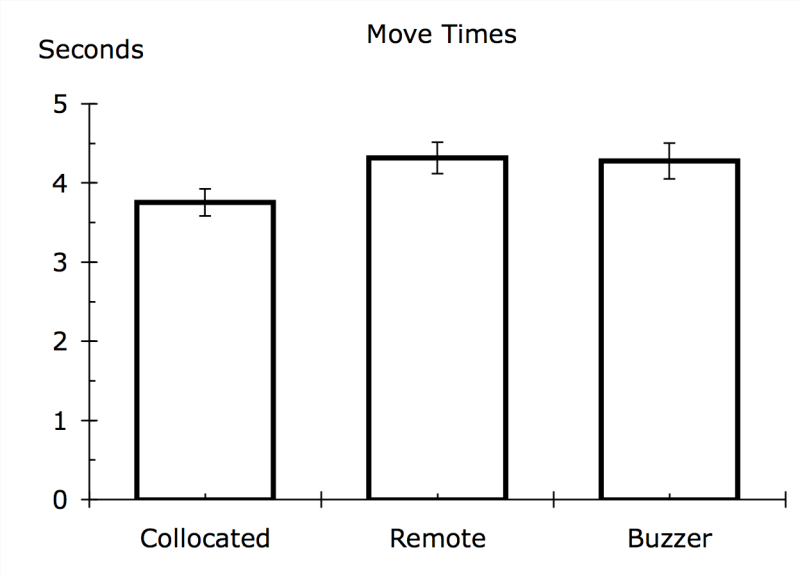

Figure 3. Mean and standard errors of response times to the order to move collapsed across trial sequence.

Fire data

The ANOVA for the fire time data found no significant differences across the three conditions. The data appear to contain a floor effect that precludes the detection of significant differences. The null result suggests that these active duty soldiers began to fire their weapons as quickly as possible.

Linear association between trust and response time

The horizontal axis of Figure 4 plots the difference between the soldier's assessments of trust in the remote condition and the collocated condition. The vertical axis shows the corresponding difference between move times. Greater trust in the collocated condition generates negative numbers on the horizontal axis. Faster times in the collocated condition generate positive numbers on the vertical axis. Thus, the hypothesis posits a downward sloping trend in the cross-plot.

To test that hypothesis, we conducted a simple, linear regression analysis. The resulting model is: Difference in time = 0.40 - 0.30 (Difference in trust). A one-sided t-test for the slope parameter (β_1, -0.30) is significant, $t(52) = -2.312$, $\underline{p} < .012$. Analysis of residuals indicates no deviation from normality and satisfactorily constant variance at all levels of the predictor

variable (trust). While trust explains only 9% of the variance, the model supports the hypothesis that there is a significant association between trust and performance, with soldiers trusting less and responding more slowly in the remote condition.

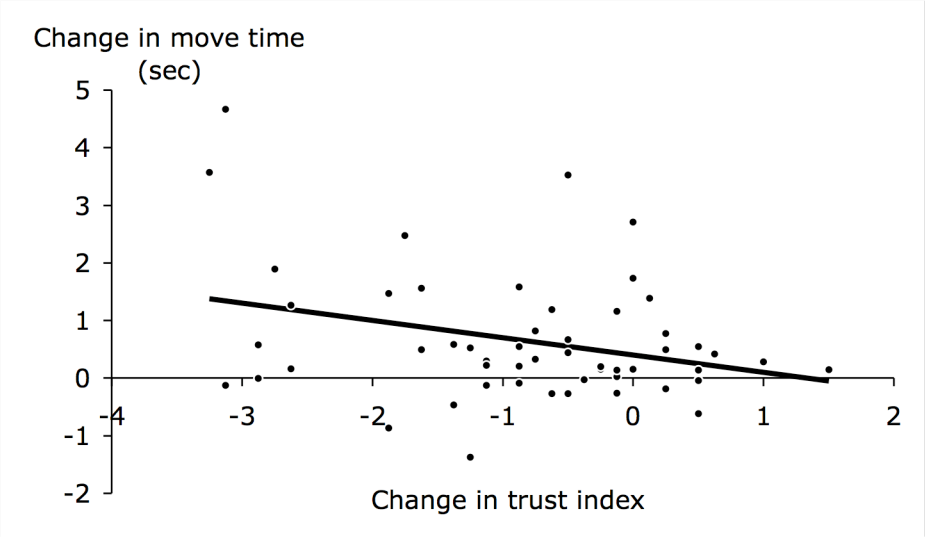

Figure 4. Scatter plot and best-fit linear regression function showing the significant negative association between the difference in experienced trust and the difference in move time between the remote and collocated conditions.

Trust as a mediator variable

To test the hypothesis that trust mediates the effect of immediacy on the speed with which the soldiers executed direct orders, we conducted the set of three regressions prescribed by Baron and Kenny (1986). First, we regressed the mediator (trust, a continuous variable) on the independent variable (immediacy, a dichotomous categorical variable). The regression coefficient for immediacy (0.412) was significant, $p < .0001$. Second, we regressed the dependent variable (move time, a continuous variable) on the independent variable. The regression coefficient (-0.325) was significant, $p < .03$. Finally, we regressed the dependent variable on both the independent variable and the mediator. The regression coefficient for the independent variable (-0.382) was not significant, $p < .12$, but the coefficient for the mediator (.241) was, $p < .01$. Thus the influence of immediacy on move times when controlling for trust is diminished but is far from eliminated. The reduction in the level of significance of the coefficient for immediacy reveals that, in this C2 setting, trust partially mediated the impact of immediacy.

Discussion and Conclusion

The experiment was designed to eliminate the potential confound of demand characteristics. Debriefing interviews with many of the soldiers indicated that the buzzer and its vest were sufficiently salient that they could be expected to have elicited demand characteristics. A platoon of active duty soldiers acted as confederates who recorded response time. Three active duty officers acted as leaders. Even though the officers and confederates assumed the buzzer was the focus of attention, data in the buzzer condition were statistically identical to those in the remote condition. Thus there is no evidence for demand characteristics.

This study assessed and supports the claim of Social Impact Theory that the impact of a source on an individual is a function of immediacy. Active duty soldiers responded to commands to "Move!" faster when the leader was collocated in the lane. The dichotomous manipulation of immediacy matches the proposed transition from collocated to remote C2 of the dismounted infantry. Soldiers responded to direct verbal commands faster when those commands are issued by a collocated leader than by a remote leader. Soldiers trusted a collocated leader more than a remote leader. In this context, immediacy clearly matters and its effect is partially mediated by trust in the leader. Remote C2 appears to be associated with a decrement in soldier performance and at least a portion of that decrement is associated with a decrement in trust. These findings support arguments against any proposal that would extract the platoon leader from the field.

To some, the findings reported here might appear obvious. Why then are the armed forces of several nations dedicated to the transition to remote C2? Perhaps they believe that the impact of immediacy may be tempered by the other social forces posited by Social Impact Theory - number and strength. It is entirely possible that the strength of a strong but remote leader could offset the negative influence of his remoteness. Two likely sources of such strength are familiarity and training. If the remote leader were to be someone the soldier already knows and trusts, the influence of immediacy would be expected to diminish. Alternatively, a seasoned professional soldier might be sufficiently unlike the conscripts we studied to be willing to heed a remote leader as quickly as a collocated leader. These issues suggest opportunities for continuing to explore the limits of remote C2 using the paintball paradigm.

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