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The influence of time stress and location on behavioral warning compliance

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Abstract

Stress has been shown to affect perceptual processing and decision making in various domains. Two experiments examined the effect of stress on compliance behavior. The first experiment also examined the effect of warning location. In Experiment 1, participants were assigned randomly to one of four conditions in a 2 (stress)×2 (warning placement) between-subjects design. Participants performed a chemistry task in which they weighed and measured various chemical substances that appeared potentially hazardous, but were actually safe. In the high stress condition, participants were given a time limit to complete the task, and the experimenter stood immediately adjacent to the participant, appearing to be monitoring the participant's performance. In the low stress condition, participants were given as much time as they needed to complete the task and the experimenter stood at a distance, out of the participant's field of view. A warning to wear mask and gloves was present in one of two locations, either as a posted sign or placed within a set of task instructions. Compliance with the warning (wearing of protective equipment) was significantly higher among participants who were under low stress and exposed to the within-instructions warning. In Experiment 2, the stress manipulation was separated into two factors: time pressure (absence vs presence) and social monitoring (absence vs presence). Results showed that time pressure significantly reduced compliance compared with its absence, but social monitoring produced a small but non-significant compliance enhancement. The results point to the need to consider external factors in warning systems.

1. Introduction

In recent years, researchers have examined various factors influencing warning compliance behavior. Much of this research has focused on variables that are internal to the physical design of the warnings themselves such as the presence of

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pictorials, color, size, and the use of signal words. Internal design factors can affect the warning's salience (conspicuousness or prominence) which in turn tends to influence the early information-processing stages, such as attention or noticeability (Wogalter and Young, 1992). However, relatively few behavioral compliance studies have examined the influence of external factors. These variables do not pertain to the physical design aspects of the warning itself; instead they relate to other situational (person–environment) factors that are not directly part of the warning—but like the warning's physical design, external factors can affect compliance. Examples of external warning variables include social influence (Wogalter et al., 1989), cost of compliance (Wogalter et al., 1987), and location (Wogalter et al., 1987, 1994).

Wogalter et al. (1989) showed that compliance to a warning is affected by compliance or lack of compliance of another person (i.e. social influence). When the other person (a confederate) complied with a warning, research participants tended to comply, and when the other person did not comply, the participants also tended not to comply. Wogalter et al. (1987, 1989) found that when the warning directive required a modicum of effort to comply, compliance was reduced compared with a warning requesting less effortful compliance behavior. This research suggests that when other people fail to comply and the cost of complying is high, people are less likely to follow the warning's instructions.

Further, location or placement of the warning has been found to have substantial effects on compliance. Wogalter et al. (1987) demonstrated that a warning positioned at the beginning of the written instructions was more frequently complied with than a warning at the end of the instructions. Frantz and Rhoades (1993) and Wogalter et al. (1995) showed that strategically placing a warning so that it draws attention to itself while individuals perform a task enhances compliance. Further, Wogalter et al. (1994) found that a warning located in a set of task instructions produced greater compliance than a warning in a separate location as a much larger posted sign. Also, there is evidence that a warning in the form of a posted sign is perceived to be less relevant than a warning included as part of a set of task instructions (Wogalter et al., 1994). Perceived relevance is based on whether individuals realize the sign is directed at them and whether they believe the message is applicable to the task to be performed.

The results of the above-mentioned research indicate that external factors can have large effects on compliance. Because external factors can substantially influence compliance behavior, these variables would appear to deserve more attention by researchers than has thus far been realized.

One potentially important external factor that has not previously been investigated in warning research is stress. Stress has been shown to affect people's perceptions and the quality of their judgments and decisions in other domains, and may also affect warning compliance. Manipulations of psychological stressors such as time pressure, potential for electric shock, and noise, indicate that peripheral vision is narrowed, attentional focus is restricted, and the extent or scope of information reviewed is reduced. Under conditions of high stress, available and possibly important information may not be noticed or used (Wright, 1974; Ben Zur and Breznitz, 1981; Janis, 1982; Williams et al., 1990; Mireille and Wickens, 1994). Stress is

associated with increased errors on cognitive tasks and greater reliance on simplified, non-analytical information-processing strategies such as heuristics ('rules of thumb') and stereotypical judgments (Zakay and Wooler, 1984; Keinan, 1987). Research on automated vs controlled information processing suggests that familiar, simple tasks would be less disrupted than less familiar, complex tasks. The latter more difficult tasks require controlled processing which ties up a greater proportion of cognitive resources than familiar, simpler tasks. Having adequate resources (in terms of time, energy, and information) is critical for making high quality analytical decisions (Janis and Mann, 1977).

Social monitoring or the presence of another person evaluating the target individual's performance has been shown to affect task performance. Salas et al. (1996) and Wickens et al. (1998) provide an overview of the effects in terms of stress on performance. This material shows detrimental effects on task performance by (1) the mere presence of another person, (2) the addition of an evaluative element, and (3) attentional conflict or distraction. With high task demands, the added processing elicited by the presence of others could exceed cognitive capacity and would be more likely to degrade performance than their absence. A similar effect is shown in electronic monitoring studies (Aiello and Kolb, 1995) where observation could occur in a remote location or in a delayed time frame.

In recent years, laboratory-based methodologies have been developed that enable measurement and experimental research on behavioral warning compliance. One of these involves a task that might be performed in a high school or college chemistry laboratory class, where participants measure and mix a set of potentially hazardous chemicals. Participants are not told before or during the task that the exercise actually concerns warnings (i.e. the warning is exposed incidentally as part of the task; participants are led to believe that the main concern is their chemical measuring and mixing performance). In this context one can see whether participants comply with the warning—the donning of personal protective equipment (PPE). This methodology is employed in the present research.

Two experiments examined the effects of stress on behavioral compliance with warnings. In the first experiment, the stress manipulation employed a combination of two kinds of stressors (time pressure and social monitoring). This variable was manipulated simultaneously with another external warning variable, location. Previous research discussed earlier has shown this factor to exert powerful effects on compliance. In the second experiment, the stress manipulation of the first experiment was broken into two distinct factors and manipulated separately.

2. Experiment 1

The stressor employed in the present research was a combination of two kinds of stress: time pressure and social monitoring. Previous research on time pressure has shown performance decrements under various conditions and tasks (e.g. Leon and Revelle, 1985; Klein et al., 1989; Moray et al., 1991; Verplanken, 1993; Mireille and Wickens, 1994). Also, social monitoring by another person has been shown to

induce stress and decrease performance in tasks such as motor (Innes and Gordon, 1985) and computer learning (Schneider and Shugar, 1990). The purpose of combining both time pressure and social evaluation was to create a situation that would induce an adequate level of stress to determine whether this potential factor does or does not affect compliance. It was expected that under higher stress, participants would be less likely to comply with the warning than under lower stress.

This experiment also examined the effect of warning location. Location was manipulated in a similar way to that in a study described by Wogalter et al. (1993). In that study, the warning was either posted as a large sign on a wall directly in front of the participant or it was present in a set of task instructions. Despite the fact that the posted warning sign had an area over 40 times larger than the within-instructions warning and produced a larger visual angle on the retina from the participants' standing positions, participants more frequently complied with the smaller within-instructions warning. A similar result was expected in the present research.

However, the main reason for including the location factor in the present study was to determine whether it interacts with stress. Research has indicated that under higher stress peripheral vision narrows, attention becomes restricted, and relatively less information that is available is used (Wright, 1974; Janis, 1982; Williams et al., 1990). Thus, it was expected that under higher stress people would be less likely to notice a posted sign, and as a consequence, compliance might be lower for the posted sign under higher stress than under lower stress. Under lower stress (compared with higher stress), people would be more likely to look around the environment and to notice the posted sign, and as a consequence, there might be no (or a smaller) difference in compliance between the two warning locations. In other words, there might be a larger difference between the two stress conditions for the posted sign than the within-instructions warning, suggesting that two factors combine to produce a non-additive, two-factor interaction effect.

3. Method

3.1. Participants

Eighty North Carolina State University undergraduates participated for research credit in their introductory psychology courses. The participants ranged in age from 17 to 50 years ($M = 21.4$, SD = 5.2), and included 50 males (63%) and 30 females (37%) who had, on average, 2.3 years of college education.

3.2. Design

Participants were randomly assigned to each of the four between-subjects conditions as a function of stress (lower vs higher) and warning location (posted sign vs within-task instructions): (1) lower stress—posted sign, (2) lower stress—within-instructions,

(3) higher stress—posted sign, and (4) higher stress—within-instructions. There were 20 participants in each group.

3.3. Materials

The chemistry laboratory materials were similar to those described in Wogalter et al. (1987, 1989, 1993). Actual chemistry laboratory equipment was used such as a triple-beam balance, beakers, flasks, and graduated cylinders. A supply of plastic gloves and face masks was also available on a laboratory table next to the equipment. A set of written instructions directed participants to weigh, measure, and mix several substances and solutions in a certain order. The substances and solutions were available in large glass containers and labeled by a letter (A, B, or C) to disguise their true nature. The chemicals were actually harmless: flour, salt, powdered sugar, water and cooking oil that were dyed with food coloring.

In the posted-sign conditions, a warning placard measuring 21×21 cm (8.3×8.3 in) was mounted on the wall above the laboratory table which contained the chemistry materials, at a location 46 cm (18 in) above the work surface and 91 cm (36 in) in front of the person performing the task. The warning consisted of black lettering on a white background that stated: "CAUTION: Skin and Lung Irritant. Improper mixing may result in a compound that can burn skin and lungs. Wear rubber gloves and mask." A signal icon (an exclamation mark surrounded by a triangle) was located to the left of the signal word in the first line of the warning. The sign dimensions were similar to the posted sign used in Wogalter et al. (1993) having heights of 3 cm (1.2 in) for the signal word and 1.5 cm (0.6 in) for the print characters in the remainder of the message. In the within-instructions condition, an identical but overall much smaller warning, 3.3×3.3 cm (1.3×1.3 in), was inserted within the written instructions containing the specific procedures that the participants were to follow in measuring and mixing the chemicals. In the within-instructions conditions, the warning was located on the top of the sheet just after a short paragraph of general information about the study and immediately before the specific steps of the chemistry task. In the posted-sign conditions, the warning was mounted directly in front of the participant on an otherwise bare partition wall. In the posted-sign conditions, there was no warning within the task instruction sheet—the area of the sheet occupied by the warning in the within-instruction conditions was left blank.

Participants were given a set of questionnaires requesting demographic information such as name, age, gender, year in school, and chemistry course experience. Post-task questionnaires asked if they saw and read the warning, and if they saw the masks and gloves on the laboratory table. They were also asked if they were bothered by the presence of the experimenter evaluating their task performance. In addition, several subjective stress-related measures were collected. Participants were asked the degree to which they: (1) were careful while handling the substances in this demonstration, (2) perceived the substances they were working with as potentially harmful, and (3) found the demonstration stressful. They rated these items on nine point scales with the following numerical and verbal anchors: (0) "not at all",

(2) "somewhat", (4) "moderately", (6) "very", and (8) "extremely". Also included in the set of materials was the Cognitive Interference Questionnaire (Sarason and Stoops, 1978; Sarason et al., 1990) which has separate measures of cognitive workload stress attributed to internally focused attention, termed 'worry', and to outside interference, termed 'distraction'. Participants described their thoughts during the task by responding to 21 statements using a five-point scale with the following numerical and verbal anchors: (1) "never", (2) "once", (3) "a few times", (4) "often", and (5) "very often". A third measure of the scale represents the degree to which the person believed their mind wandered during the task and involved a single rating between (0) "not at all" and (8) "very much". Several additional questionnaire measures were collected, but they failed to show significant effects and are not described in this article.

3.4. Procedure

Participants were tested individually, and first entered a small room created by free-standing partitions within a larger room. This room contained only a triple-beam balance on top of a desk and a chair. The experimenter gave oral instructions describing the task as an engineering psychology study evaluating how people perform a chemistry demonstration procedure. Participants then completed a consent form. Use of a triple-beam balance was demonstrated for those who were not familiar with it. Participants were then asked to don a white laboratory coat, and were taken to the chemistry task work area. The work area was a separate enclosed location partitioned within the larger room that contained the chemistry materials and written task instructions on a laboratory table.

In the lower stress condition, the participants were told that they had as much time as they needed to perform the task. During the mixing procedures the experimenter moved away from the laboratory table to a doorway 3.7 m (12 feet) behind the participant, out of their field of view. The experimenter observed task performance from that unobtrusive location. In the higher stress condition, the participants were told that they had a time limit to complete the entire set of chemical mixing tasks. Specifically, they were told they had only 5 min to complete the task and that a rapid pace was necessary to complete it. During the mixing procedures, the experimenter holding a clipboard and stopwatch stood within 1.5 m (5 feet) of the participant. This placed the experimenter, who appeared to be collecting performance measures (e.g. subtask completion times) within the participant's peripheral visual field. Both groups were told that accuracy was important and that evaluation of their performance would be based on their final chemical product and time to complete the task. The experimenter recorded whether the participant complied with the warning (wore mask and gloves) before mixing the chemical materials.

Task performance by both groups was stopped after 5 min (irrespective of whether they had finished the task), and the experimenter led the participant back to the first partitioned area where they completed a set of questionnaires. After finishing the questionnaires, the participants were debriefed, thanked and dismissed.

4. Results

Compliance, defined as wearing both items of PPE as specified in the warning, was given a score of '1' and failure to comply (i.e. not wearing both or wearing only one of the two pieces) was given a score of '0'. The compliance dependent variable could also be defined as a function of other methods of coding. The donning of only one piece of PPE could be coded as being partial compliance. Previous research using the chemistry paradigm noted that if people don one piece of PPE they also tend to don the other (Wogalter et al., 1993). In the present experiment only 7 of the 80 participants (<9%) partially complied. The pattern of results was basically the same regardless of the method of coding compliance. For simplicity we only describe the strictest compliance criterion where participants needed to wear both PPEs to be recorded as compliers ('1'). If they wore one or neither they were noncompliers ('0').

Although it is more typical to use a chi-square test with bivariate data, Cochran (1955) asserts that use of analysis of variance (ANOVA) is appropriate when analyzing these kind of data, and endorses its use when the experimental design allows investigation of an interaction. Thus, a 2 (stress: lower vs higher)×2 (location: warning within-instructions vs on posted sign) between-subjects ANOVA was applied to these data. Table 1 shows the proportion of compliance means. ANOVA indicated a significant main effect of stress, $F(1, 76)=3.95$, $p=0.05$, and location, $F(1, 76)=8.88$, $p<0.001$. Participants under lower stress ($M=0.45$) complied significantly more often than participants under higher stress ($M=0.25$). Participants exposed to the within-instructions warning ($M=0.50$) complied significantly more often than participants exposed to the sign warning ($M=0.20$). No significant interaction effect between these two variables was shown ($p>0.05$) indicating that these two factors have a linear, additive influence on performance. As can be seen in Table 1, compliance ranged from a low of 0.15 in the higher stress, posted-sign condition to a high of 0.65 in the lower stress, within-instruction condition.

Similar ANOVAs were performed using the questionnaire data. Analyses showed that stress and location produced significant main effects for several of the measures. The higher stress condition produced higher ratings of perceived stress, Ms=2.03 vs 1.28, $F(1, 76)=5.00$, $p<0.05$, less frequent reports of seeing the PPE,

Table 1
Mean proportion compliance as a function of stress and location conditions

Stress	Location		
	Within-instructions	Posted sign	Mean
Low	0.65	0.25	0.45
High	0.35	0.15	0.25
Mean	0.50	0.20	

$Ms = 0.70$ vs 0.98, $F(1, 76) = 12.43$, $p < 0.01$, more frequent reports of the presence of the experimenter bothering them, $Ms = 0.63$ vs 0.35, $F(1, 76) = 6.37$, $p < 0.05$, and higher scores on the worry subtest of the cognitive interference scale ($Ms = 22.70$ vs 19.65, $F(1, 76) = 4.82$, $p < 0.05$), compared with the lower stress condition. The within-instruction warning produced higher ratings of perceived harmfulness of the materials, $Ms = 2.20$ vs 1.38, $F(1, 76) = 4.39$, $p < 0.05$, more frequent reports of seeing the warning, $Ms = 0.55$ vs 0.23, $F(1, 76) = 10.07$, $p < 0.01$, reading the warning, $Ms = 0.65$ vs 0.23, $F(1, 76) = 17.54$, $p < 0.0001$, seeing the mask, $Ms = 0.55$ vs 0.20, $F(1, 76) = 11.78$, $p < 0.001$, and seeing the gloves, $Ms = 0.58$ vs 0.28, $F(1, 76) = 8.29$, $p < 0.01$, than the posted-sign warning. In only one instance did the stress and location variables interact, and this was shown for the rating of feeling stress during the experiment, $F(1, 76) = 4.34$, $p < 0.05$. The Newman–Keuls multiple range test indicated that significantly less stress was felt in the lower stress, within-instructions condition ($M = 0.70$) compared with the other three conditions (for the lower stress, posted sign: $M = 1.85$; for the higher stress, within-instructions: $M = 2.15$; for the higher stress, posted sign: $M = 1.90$), which did not significantly differ among themselves. No other effects were found with the questionnaire data.

5. Discussion

In this experiment, high stress was operationally defined as a time restriction combined with evident evaluation by another person. The results showed that the higher stress condition produced significantly lower compliance compared with a lower stress condition in which there was less time pressure and less apparent social evaluation. Of the 28 out of 80 participants who complied with the warning, 18 were in the lower stress conditions. This result confirms the hypothesis that greater stress decreases warning compliance.

Warning placement was also found to produce a strong effect on behavioral compliance. In fact, warning location had a larger effect on compliance than stress. More participants complied with the within-instructions warning than the posted-sign warning, despite the sign being over 40 times larger in terms of area than the warning in the instructions. Although the posted sign was more distant from the participant than the within-instructions warning, the larger posted sign was not so remote as to produce a smaller visual angle on the retina than the within-instructions warning (for the position in which participants stood and handled the instruction sheet at the work area). This location effect confirms the findings of several studies including Wogalter et al. (1994, 1995) which showed that placing the warning in a location where participants are known to look (in this case the task instruction sheet) produces higher compliance than placing it in a location that participants are less likely to look (in this case, a posted sign).

Research (Wogalter et al., 1994) has also noted that the effectiveness of a sign can be influenced by its perceived relevance. The posted sign is somewhat ambiguous with respect to the intended target person and whether it is even

appropriate for the task. It is possible that some participants assumed the sign was for someone else (e.g. for participants of some other study)—that the sign was not directed at them. The same warning in the instructions is less ambiguous—the warning is a relevant part of the task.

No interaction between stress and location was found. It had been expected that these two variables might combine in a way that would reveal a non-additive effect as, for example, under greater stress the difference in compliance between the two locations would increase. Previous research had suggested that stress might produce a narrowing of perception and cognition. Also, it was hypothesized that under lower stress the difference in compliance between the two locations might decrease or disappear because under lower stress participants would have more time to look around. The failure to find an interaction suggests that these two independent variables produce linear, additive effects with respect to one another. It is also possible, however, that the low stress condition was still fairly stressful given that individuals in the study knew they were participating in a research study in a laboratory environment. Additional research would be necessary to determine whether other kinds of stress (different from those in the present experiment) produce an interaction of the type described above.

The questionnaire data provided a pattern of results that supported and extended the compliance findings. Participants in the higher stress condition reported feeling more stress, more worry, and that the experimenter's presence bothered them. These results provide verification that the experimental stress manipulation had the effect intended. In the higher stress condition, participants were less likely to see the PPE possibly because the stress restricted their focus to the specific task of mixing the chemicals. Participants in the within-instructions warning condition rated the chemical materials more harmful, and they more frequently reported seeing the warning and PPE than participants in the posted-sign condition. This pattern of results suggests that having the warning as part of the task instructions may provide a signal of the warning's importance because it (1) is integrated with the task directions which participants know they need to perform, and (2) appears to be directed at all individuals performing the task (including themselves). Lastly, the questionnaire ratings showed that significantly less stress was felt in the lower stress, within-instructions warning condition than the other three conditions. Perhaps participants in this condition believed that they were more in control and they were more certain of the situation because everything they needed to know to protect themselves was there on the sheet. There was greater uncertainty in the posted-sign condition (see the issues of perceived relevance discussed above).

The finding of stress effects provides impetus for further investigation that attempts to delineate the constituents of stress affecting compliance. Because the stress factor in this experiment comprised two components, time pressure and social monitoring, their unique contribution on compliance cannot be determined. It was, therefore, of interest to determine which of the two components had the greater effect on compliance behavior. Experiment 2 examined the components of Experiment 1's combination stressor.

6. Experiment 2

This experiment examined the individual effects of time pressure and social monitoring on warning compliance with a posted warning sign. It was expected that the presence of either or both variables would negatively affect compliance.

7. Method

7.1. Participants

Eighty undergraduates (42 males, 38 females) from North Carolina State University participated to fulfill an introductory psychology course requirement. Their age ranged from 17 to 22 years ($M = 18.7$, $SD = 0.93$).

7.2. Design

Participants were randomly assigned to one of the four conditions: (1) no time pressure and no social monitoring, (2) no time pressure and social monitoring, (3) time pressure and no social monitoring, or (4) time pressure and social monitoring. There were 20 participants in each condition.

7.3. Materials

In all four conditions, a black print on white background warning sign was posted on the wall above a table containing the chemistry materials. The wording of the warning was identical to the warning used in Experiment 1 except that it also included the instruction to wear goggles (in addition to the gloves and mask). The change was made in response to informal feedback from academic colleagues in chemistry and chemical engineering, as well as comments from previous research participants that chemistry courses frequently require students to wear goggles during chemical reaction demonstrations and research. The revised warning stated: "CAUTION: Skin and Lung Irritant. Improper mixing may result in a compound that can burn skin and lungs. Wear rubber gloves, mask, and goggles." All other materials were identical to those used in the earlier experiment with two exceptions: (1) a shorter version of the post-task questionnaire was used, and (2) the sheets for Experiment 1's within-instructions condition were not used.

7.4. Procedure

The procedure was the same as that used in the first experiment with a few exceptions which mainly concern the time stress and social monitoring factors. Time stress was manipulated by telling half of the participants that they had a limited amount of time to complete the task and that they needed to work at a rapid pace to finish it in the time allotted (5 min); the other half were told that they could take all

the time they needed to complete the task. Social monitoring was manipulated by having half the participants perform the task while the experimenter stood immediately adjacent to them while appearing to be measuring their performance; and the other half of the participants performed the task while the experimenter stood behind them at the far end of the room out of their view. The participants were stopped from working on the task after 5 min (regardless of whether they had finished) and taken to another location to complete the post-task questionnaire. Later, participants were debriefed and thanked.

8. Results

Compliance was defined as wearing all three items of PPE as specified in the warning. Participants who complied were given a score of '1' and failure to comply (i.e. not wearing all of the PPE) was given a score of '0'. Table 2 shows the proportion compliance means. A 2 (time stress: absence vs presence)×2 (social monitoring: absence vs presence) between-subjects ANOVA showed a significant main effect of time stress, $F(1, 76)=6.74$, $p<0.05$. Participants under no time stress ($M=0.53$) complied significantly more often than participants under time stress ($M=0.25$). There was no significant main effect of social monitoring or interaction ($p>0.05$). In fact, the means show a trend for greater compliance with more apparent social monitoring ($M=0.45$) than with its absence ($M=0.33$). Analyses using dependent variables that took into account partial compliance produced similar results.

ANOVAs were also performed using the data derived from the questionnaire. Significant main effects of the time stress manipulation were seen for some of the measures. Time stress produced lower ratings of carefulness in performing the task, $Ms=5.03$ vs 4.03, $F(1, 76)=5.63$, $p<0.05$, less frequent reports of reading the warning, $Ms=0.30$ vs. 0.55, $F(1, 76)=5.59$, $p<0.05$, and less frequent reports of seeing the PPE, $Ms=0.78$ vs 0.95, $F(1, 76)=6.38$, $p<0.05$. The social monitoring independent variable produced only one significant main effect. The presence of social monitoring produced less frequent reports of reading the warning compared with its absence, $Ms=0.30$ vs 0.55, $F(1, 76)=5.59$, $p<0.05$. No significant interactions were found for any of the questionnaire measures.

Table 2
Mean proportion compliance as a function of time pressure and social monitoring

Social monitoring	Time pressure		
	Low	High	Mean
Low	0.50	0.15	0.33
High	0.55	0.35	0.45
Mean	0.53	0.25	

9. Discussion

The composite stress condition that had been employed in Experiment 1 was separately manipulated in the present experiment as the absence vs presence of time stress and social monitoring. Analyses indicated that participants who were under time pressure complied less frequently with the warning than participants who were under no time pressure. This result supports other research (e.g. Wright, 1974; Janis, 1982; Keinan, 1987; Williams et al., 1990) which has shown that time stress decreases performance on a variety of tasks and confirms our a priori expectation.

However, this experiment failed to show a significant effect of social monitoring (as a main effect or in an interaction) on compliance. Contrary to our expectation, the condition that had the experimenter in close proximity to the participant and appearing to measure their performance produced somewhat greater compliance than the condition where the experimenter was more distant and less apparent. The difference between these two conditions was not significant, however. It is possible that two opposing effects are occurring in the social monitoring situation. That is, social monitoring may in fact cause stress and this stress may produce less than optimal performance, but it is counteracted by another effect inherent with social monitoring. The highly apparent performance evaluation might have led participants to be more careful to do everything correctly. That is, they were more likely to look around for cues on how to behave appropriately, to see the warning and PPE, and to be motivated to put on the PPE. This is analogous to close oversight or surveillance by a supervisor who spurs the employee to behave in a vigilant manner and where failure to perform correctly might result in reprimand (a cost of non-compliance). However, it is difficult to draw conclusions about the influence of social monitoring because the experimental manipulation mainly produced null effects. Subsequent investigations might use a stronger social monitoring manipulation such as having more than one observer.

Other analyses of the post-experiment questionnaire indicated that participants in the high time stress conditions more frequently reported not reading the warning, not noticing the PPE, and being less careful in the handling of the chemicals than participants in the low time stress condition. These reports provide a manipulation check for the time stress factor, and together with the compliance results indicate that the main stressor in both experiments was time pressure.

10. General discussion

The present research is the first set of experiments examining the influence of stress on behavioral compliance with warnings. The results of both experiments show that compliance is greater under lower stress than under higher stress. In Experiment 1, the stress manipulation was a composite of both time stress and social monitoring. In Experiment 2, these two components were separately manipulated. The results of the second experiment indicate that time stress, but not social monitoring, reduced warning compliance on the chemistry task. Indeed, Experiment 2 showed that social

monitoring produced a non-significant trend of better performance, a finding that was opposite to our original expectations. It is possible that social monitoring did in fact produce stress but it was of a moderate level. According to the classic inverted-U function of performance and arousal (Yerkes and Dodson, 1908), maximal performance occurs at moderate arousal levels. Thus, on the one hand, the enhancement of performance (compliance) by social monitoring could be due (although not necessarily optimally) to the production of moderate arousal. On the other hand, time stress decreased performance because the arousal was to the right of maximal-performance level on the Yerkes–Dodson curve.

It is also possible that social monitoring produces two effects working in opposition to each other. Social monitoring may actually be highly stressful, and possibly under different conditions than those used in the present research, it might reduce compliance. At the the same time, social monitoring might also promote greater rule-following behavior, as occurs when a supervisor is watching. This notion fits with other common behaviors such as drivers slowing down in the presence of a police cruiser. It also concurs with current theory on worker productivity under manager supervision. For example, the frequency with which a manager monitors a task at work serves as a cue to workers as to the importance of that task (Larson and Callahan, 1990). The issue of whether there are opposing forces involved in social monitoring (stress, carefulness) will require additional research. The implication, however, is that if one can reduce stress, supervision might enhance warning compliance.

Confirmation that participants felt some stress in the higher-stress conditions was provided not only by the significant compliance effects discussed above but also from the results of Experiment 1's post-experiment questionnaire. Participants in the higher stress conditions gave higher ratings of perceived stress, and of being bothered to a greater extent by the experimenter's presence. These participants also accrued higher scores on the worry subtest of the cognitive interference scale than participants in the lower stress conditions. The worry subtest is indicative of self-focus or preoccupation with one's performance, and it is positively related to test anxiety (Sarason et al., 1990) and negatively related to the number of correct answers on an information test (Sarason et al., 1986). This internal focus restricts or interferes with perceptual and cognitive processing and could, as a consequence, reduce compliance. In addition, the present study showed that under higher stress, reports of seeing the PPE were less frequent—an effect that would be expected if the stress was narrowing attentional focus.

Warning placement was also found to produce a main effect on behavioral compliance in Experiment 1, although the anticipated interaction with the stress condition was not significant. More participants complied with the within-instruction warning than the posted-sign warning. This location effect confirms the findings of several studies including Wogalter et al. (1994, 1995) which showed that placing the warning in a location where participants are known to look (in this case, the chemistry task instructions) produces higher compliance than placing it in a location that participants are less likely to look (in this case, a posted sign). We do not know if the effect is due to perceived relevance or the narrowing of attention and cognition. Research in this area would be advanced by measuring what participants actually

look at. Objective measurement of eye movement and looking behavior would help clarify this issue.

Only one type of task (the mixing of chemicals in a laboratory setting) was used in the present study. Additional research using other tasks, participant samples, and situations would provide information on the present results' general application. However, other research using the chemistry paradigm have successfully confirmed effects found in diverse warning situations (e.g. Wogalter et al., 1989; Wogalter and Young, 1991).

The results have policy implications for companies and organizations that employ workers performing tasks under time pressure. Under fast-paced conditions and high cognitive load, workers might not see or comply with available safety information. Training workers on tasks that may need to be performed under time-constrained conditions might reduce the stress itself or its effects when such conditions occur.

The results also have implications for industrial equipment and consumer products that can be expected to be used under time-stress conditions. Some examples include fire extinguishers, electric generators, pharmaceuticals (in cases of acute illness, injury or overdose), and medical devices. During emergency situations where time is critical, people may only briefly scan the labels of these products so it is essential that important information on the label be acquired quickly and accurately. The warning information should be designed so that it is salient (conspicuous), located where people will be looking, legible, and comprehensible. It is also important to test the adequacy of these warnings on representative samples of users, and to redesign inadequate ones.

In designing warnings, it is important to consider the environment, the individuals who will be in that environment, and the levels of stress experienced by them in that situation. Stress levels are affected by other aspects of people's lives which vary from person to person and across time. In situations where certain environmental stressors are unavoidable or expected, strategies such as training people on relevant tasks, enhancing their coping skills, and using well-designed warnings may help to reduce accidents and injury.

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