A Comparison of the Effects of Positive and Negative Reinforcement Contingencies on Safety Rule Following Behavior

Jaehee Lee and Shezeen Oah

Chung-Ang University

Author Note

Jaehee Lee, Department of Psychology, Chung-Ang University, Seoul, Korea; Shezeen Oah, Department of Psychology, Chung-Ang University, Seoul, Korea

Correspondence concerning this article should be addressed to Shezeen Oah, Department of Psychology, Chung-Ang University, Seoul, Korea, 221 Huksuk-dong, Dongjak-gu, Seoul, Korea, 156-756 (E-mail: geneoah0211@yahoo.com)

Abstract

This study compared the effects of positive and negative reinforcement on safety rule following behavior. Fifty-eight participants were randomly assigned to one of two experimental conditions: positive and negative reinforcement contingencies. Participants had to work on a computerized work task and follow safety rules while working on the task. Participants in the positive reinforcement group earned a base pay of 5,000 won (slight less than $5.00) at the beginning of the experiment and could *earn* additional 50 won for completing each task if they followed all the safety rules given. Participants in the negative reinforcement contingency earned 10,000 won at the beginning of the experiment and could *lose* 50 won for completing each task if they did not follow any of the safety rules. The results showed that the positive and negative reinforcement did not have differential impacts on rule following behavior. Future research should replicate the present findings and needs to deal with other relevant variables such as schedules of reinforcement and emotional responses of participants.

Keywords: positive reinforcement, negative reinforcement, safety behavior, rule following behavior

A Comparison of the Effects of Positive and Negative Reinforcement Contingencies on Safety Rule Following Behavior

Behavioral approach to promote safety has been successful in a wide variety of work settings, including manufacturing (e.g., Hermann, Ibarra, & Hopkins, 2010; Laitinen, Saari, Kivistö, & Rasa, 1998), mining (e.g., Fox, Hopkins, & Anger, 1987), transportation (e.g., Haynes, Pine, & Fitch, 1982; Olson & Austin, 2001), construction (e.g., Laitinen & Ruohomaki, 1996; Lingard & Rowlinson, 1998) and the medical setting (e.g., Sasson & Austin, 2005). While behavioral safety studies used both consequent and antecedent interventions, it has been found that consequent interventions have been more effective in improving safety (Grindle, Dickinson, & Boettcher, 2000). Within the consequent interventions, those procedures classified as positive reinforcement compared to those classified as aversive (i.e., negative reinforcement and punishment) have dominantly been used. In fact, only a limited number of published studies (Larson et al., 1980; Leslie & Adams, 1973; Rubinsky & Smith, 1973) in safety area have implemented aversive procedures.

Although several reasons for this trend may exist, one probable cause is that the use of aversive control has negative side effects such as negative emotional responses and aggressive behaviors. For this and other reasons, using aversive procedures has not been preferred and has almost been rejected in the field of Organizational Behavior Management and safety area is no exception. However, it has been proposed that aversive control may be necessary or even advantageous for the individuals under some circumstances. For example, Perone (2003) describes the long-term advantages of aversive control: “When a punishment contingency is effective, undesirable behavior is decreased and the aversive stimulus is almost never contacted. When an avoidance contingency is effective, desirable behavior is increased, and again there is minimal contact with the aversive stimulus" (p. 13). Thus, it can be considered that aversive control of safety-related behavior in work settings might be acceptable or even desirable because it may foster behavior that contributes to the *long-term* interest of the individual. Specifically, aversive control of safety related behavior may prevent workers from engaging in at-risk behaviors and eventually reduces injuries or death, despite some plausible negative side effects at the time when the aversive control is applied.

Another reason for the general reluctance to use aversive control may stem from the notion that the strengthening effects of the positive reinforcement and negative reinforcement may differ. Daniels and Daniels (2004), for example, asserted that positive reinforcement is more effective than negative reinforcement: "it [i.e., positive reinforcement] will cause performance to continue to increase to its physical asymptote. On the other hand, with negative reinforcement, improvement is limited to the amount of behavior that will terminate or avoid a punisher" (p. 103). Despite the long existing conceptual distinction between positive and negative reinforcement, however, some behavior analysts (e.g., Baron & Galizio, 2005, 2006; Michael, 1975; Peron, 2003) have raised issues related to the ambiguity of this distinction. For example, Michael suggested that the distinction be abandoned altogether, asserting that there is no good basis that indicates the differing effects of positive and negative reinforcement. Consistent with Michael's assertion, Baron's (1991) review of the literature on aversive control also indicated that similarities between positive and negative reinforcement are more apparent than their differences. Thus, it seems that the notion of the superior effects of positive reinforcement on behavior is not in fact empirically well founded. As a matter of fact, some empirical studies (e.g., Costantini & Hoving, 1973; Meyer & Offenbach, 1962; Penney, 1967; Penney & Lupton, 1961) even contradict the notion. For example, Penney found that punishing errors rather than reinforcing correct responses was more effective in promoting children's discrimination learning. Costantini and Hoving also found that response inhibition was better promoted by removing tokens for fast performance than by providing tokens for slow performance.

In short, aversive procedures have seldom been used in safety area, due to an empirically unsupported presumption that their effects on safety-related behavior are less effective than those of positive procedures. Therefore, the current study was conducted to empirically examine the relative effects of positive and negative reinforcement on safety rule following behavior in a laboratory setting.

Method

Participants

Sixty volunteer undergraduate students (26 males and 34 females) from a university in South Korea participated in this study. They were recruited via advertisements on bulletin boards across the campus. It was stated in the advertisement that participants would be paid for their participation. Two participants withdrew during the experimental session and their data were thus excluded from analysis. Therefore, there were 58 participants included in the final analysis (25 males and 33 females). Their mean age was 22.3 (SD = 2.39).

Setting and Apparatus

The experimental setting consisted of a university computer laboratory that contained 40 personal computers. The computers in the laboratory were PCs using the Windows XP operating systems. A computerized simulated work task was developed for this study, which is described in a later section. Although up to 40 participants could work in the laboratory at the same time, they did not start the preliminary session (described in a later section) and experimental sessions at the same time. Participants instead came to the laboratory at their scheduled time and started the sessions individually.

Work Task and Dependent Variables

The computerized work task developed for this study simulated the task of welding. Participants had to complete two steps of the work task: (1) moving iron plates to the working area and (2) welding the iron plates together. A stack of iron plates was presented in the upper right portion of the computer screen (see Figure 1). Four empty rectangles were located in the middle portion of the screen. Participants had to drag the iron plate to one of the four empty rectangles using the computer mouse and repeated until all rectangles were filled. No specific sequence of filling the rectangles was required.

In the next step, participants dragged the “welder” icon presented in the upper left portion of the screen using the right mouse button and welded the iron plates. Welding of the iron plates was simulated by holding down the left mouse button while dragging the welder with right mouse button. The welded portion was indicated by the gray blotting in the gaps between the iron plates. Participants had to click the “complete” button presented in the lower right corner of the screen after finishing the welding. When this step was completed, the computer automatically recorded it as one completed “work task” and restarted the first step. The cumulative number of work tasks participants had completed was presented, in real time, in the box labeled “Number of Work Tasks Completed”, which appeared on the right upper portion of the screen. The time that had elapsed since the start of the experimental session was also shown in the box labeled “Elapsed Time”.

Insert Figure 1 About Here

In performing the work task, participants were asked to follow seven safety rules. Before moving the iron plates to the four rectangles, participants were asked to follow safety rules 1 and 2 as follows:

Rule 1. “Wear the protective gloves”: simulated by clicking the “gloves” icon presented in the upper left portion of the screen.

Rule 2. “Wear the arm protectors”: simulated by clicking the “arm protectors” icon presented in the upper left portion of the screen.

After the iron plates had been placed in the four rectangles, participants were asked to follow rules 3 and 4 as follows:

Rule 3. “Clean the iron plates using the brush”: simulated by dragging the “brush” icon, presented in the lower left portion of the screen, around the plates so that all four iron plates were eventually touched by the brush.

Rule 4. “Wear the protective mask”: simulated by clicking the “mask” icon presented in the upper left portion of the screen.

When welding, participants were asked to follow Rules 5 and 6 as follows:

Rule 5. “Hold the *bottom* part of the welder”: simulated by positioning the cursor at the bottom part of the welder when dragging it.

Rule 6. “Completely cover the gaps between the iron plates”: simulated by blotting the gray completely in the gaps between the iron plates.

After the completion of the welding element of the task, participants were asked to follow Rule 7 as follows:

Rule 7. “Clean away residues by sweeping the brush”: Red circles were produced irregularly around the welded joints to simulate residues. Dragging the “brush” icon to the welded area and moving the icon around the area simulated cleaning, which made the red circles disappear.

If participants followed all seven rules, the computer recorded it as one correctly completed work task. The main dependent variable in the present study was the number of correctly completed work task. If participants did not follow any of the seven rules, it was considered as an incorrectly completed work tasks.

An additional dependent variable in the present study was the amount of time participants spent on each correctly completed work task, which was obtained by the following formula: the amount of time for completing 100 welding tasks divided by the number of correctly completed work tasks.

Independent Variable and Experimental Design

The independent variable was contingency type: positive and negative reinforcement contingencies. A between-group design was used. Sixty participants were randomly assigned to one of two groups: (1) the positive reinforcement group and (2) the negative reinforcement group. However, one participant from each group withdrew without finishing the experimental sessions. Therefore, the number of participants in both groups was 29. Each participant was asked to complete 100 work tasks in one session, with no time limit.

In the positive reinforcement group, participants received a base pay of 5,000 won (slightly less than $5.00) at the beginning of the experimental session and could earn additional 50 won for each correctly completed work task. The base pay (i.e., 5,000 won) was presented in a box labeled “Pay Amount” which was found in the upper right portion of the screen at the beginning of the session. Each time participants correctly completed a work task, 50 won was added to the base pay and their new pay amount was presented in the box. When participants incorrectly completed a work task, the pay amount remained unchanged.

In the negative reinforcement group, by contrast, participants received a base pay of 10,000 won at the beginning and lost 50 won for each incorrectly completed work task. Each time participants incorrectly completed a work task, 50 won was deducted from their base pay and the new pay amount was shown. When participants correctly completed a work task, the pay amount remained unchanged.

Procedure

Before the experiment, all participants attended a preliminary session. For this preliminary session, participants met the experimenter in a room that was next to the computer laboratory. In this session, the experimenter demonstrated how to perform the work task and showed how to follow the seven safety rules individually to each participant. More specifically, the experimenter demonstrated examples of both correctly and incorrectly completed work tasks for each of the seven safety rules. Then, participants had opportunity to practice performing the work task while following the rules until they could correctly complete five work tasks in a row.

Immediately after this preliminary session, the experimenter escorted the participants to the adjacent computer laboratory. Participants were told that they should complete 100 work tasks with no time limit. The experimenter also reminded them that they would be paid after the completion of the session. Then, the experimenter launched the work task program and the experimental session started. When participants completed 100 work tasks, the program automatically ended. All participants were paid in cash after the completion of their session.

Results

To determine whether the number of correctly completed work task was differentially affected by the two different experimental conditions, we conducted an independent *t*-test. Table 1 displays the means and standard deviations for participants of the two experimental conditions, the results of the *t* test, effect size, and 95% confidence intervals (CIs). As can be seen in the table, the means for the participants in the positive and negative reinforcement groups were 66.07 (*SD* = 11.46) and 70.93 (*SD* = 12.59), respectively. The *t*-test indicated that the mean difference between the two groups was not statistically significant, $t(56)$, $p > 0.05$.

Insert Table 1 About Here

Table 2 shows the results of the analysis on the amount of time spent on each correctly completed work task. The means for the participants in the positive and negative reinforcement groups were 71.45 (*SD* = 15.40) and 73.77 (*SD* = 17.84), respectively. The mean difference between the two groups was also not statistically significant, $t(56)$, $p > 0.05$.

Insert Table 2 About Here

Discussion

The main purpose of the present study was to empirically examine whether positive and negative reinforcement contingencies have differential impacts on safety rule following behavior. It was found that the two dependent variables in the present study, the number of correctly completed work tasks and the amount of time spent per correctly completed work task, were not differentially affected by the two different reinforcement contingencies.

These findings contradict the widely believed notion in the field of OBM that negative reinforcement is less effective than positive reinforcement. Furthermore, the present findings also contradict previous studies that showed negative reinforcement was more effective than positive reinforcement (e.g., Costantini & Hoving, 1973; Meyer & Offenbach, 1962; Penney, 1967; Spence, 1966; Tindal & Ratliff, 1974). Further research is definitely needed to address the inconsistent results of theses studies and our own. In the future research, however, it should be ensured that qualitatively and quantitatively equivalent consequences are used for both positive and negative reinforcement contingencies (Magoon & Critchfield, 2008). Previous studies had a methodological problem associated with this issue, in that qualitatively dissimilar events were used as the basis for reinforcement and punishment (e.g., food for reinforcement and a loud noise for punishment), making a proper comparison difficult. The present study avoided this methodological pitfall because money was used as the basis for consequences in both positive and negative reinforcement contingencies and the same amount of money was either added to or deducted from the base pay depending on the contingencies. This feature may in part account for the results being different to those of the previous studies.

Another important variable that should be considered in any future research is the schedule of reinforcement. In the present study, a consequence was delivered for every instance of a correctly or incorrectly completed work task. However, this will not be the case in real work settings where many of both safe and at-risk behaviors could go unnoticed. In such a situation, natural reinforcers (e.g., convenience or time saved) will be delivered for at-risk behaviors, but no consequences will be delivered for safe behaviors. This means that although safety performance would decrease in both positive and negative reinforcement contingencies, the degree to which safety performance decreases in the two condition could differ because of the different consequences delivered for safe and at-risk behaviors unnoticed. Therefore, the effects of varying reinforcement schedules on safety performance in both reinforcement contingencies will need to be examined.

Although not measured in the present study, the negative emotional responses that could be caused by negative reinforcement are an important issue and have extensively been discussed (e.g., Daniels, 1994; Daniels & Daniels, 2004; Sidman, 1989). Daniels, for example, is strongly against the use of negative reinforcement in the organizational setting in part because of its negative emotional side effects: "Even though … it may be difficult to see real difference in either rate or duration of responding under two consequences, negative reinforcement almost always produces negative reports from employees…" (p. 63). However, it is interesting to recognize that even positive reinforcement cannot be entirely free from negative emotional responses. Perone (2003) points out: "Aversive control is inevitable because every positive contingency can be construed in negative terms… I cannot help but be impressed with the propensity of people to respond to the negative side of positive contingencies" (p. 7). In other words, whenever a reinforcer is delivered contingent on a behavior, it must be withdrawn in the absence of that behavior. Consider, for example, the participants in the positive reinforcement group in the present study. When the participants correctly completed a work task, they earned an extra 50 won. This, of course, is a positive reinforcement contingency. However, it is also possible that they construed this as a negative contingency: without correctly completing work task, they were *denied* to earn the extra 50 won that they could have earned. Considering this, it does not seem to be reasonable to argue that using positive reinforcement rather than negative reinforcement is more desirable because it is free of negative emotional side effects. That said, it seems to be an *empirical* question whether a negative reinforcement contingency produces more negative emotional responses than a positive reinforcement contingency. Future research must attempt to empirically answer this question.

In conclusion, the findings from the present study contradict the widespread notion that negative reinforcement is less effective than positive reinforcement. However, more empirical evidence is required before this result can be generalized. The present study should be replicated in various settings with other work tasks and larger number of participants. In addition, other relevant variables such as reinforcement schedules and emotional responses should be dealt with together in replication studies.

References

Baron, A. (1991). Avoidance and punishment. In I. H. Iversen & K. A. Lattal (Eds.), *Techniques in the behavioral and neural sciences: Vol. 6. Experimental analysis of behavior* (Part 1, pp. 173-217). Amsterdam: Elsevier.

Baron, A., & Galizio, M. (2005). Positive and negative reinforcement: should the distinction be preserved? *The Behavior Analyst, 28*(2), 85-98.

Baron, A., & Galizio, M. (2006). The distinction between positive and negative reinforcement: Use with care. *The Behavior Analyst, 29*(1), 141-151.

Costantini, A. F., & Hoving, K. L. (1973). The effectiveness of reward and punishment contingencies on response inhibition. *Journal of Experimental child Psychology*, *16*(3), 484-494.

Daniels, A. C. (1994). *Bringing out the best in people*. New York: McGraw-Hill.

Daniels, A. C., & Daniels, J. E. (2004). *Performance management: Changing behavior that drives organizational effectiveness*. Atlanta: Aubrey Daniels International.

Fox, D. K., Hopkins, B. L., & Anger, W. K. (1987). The long-term effects of a token economy on safety performance in open-pit mining. *Journal of Applied Behavior Analysis*, *20*(3), 215-224.

Grindle, A. C., Dickinson, A. M., & Boettcher, W. (2000). Behavioral safety research in manufacturing setting: A review of the literature. Journal of Organizational Behavior Management, 20(1), 29-68.

Haynes, R. S., Pine, R. C., & Fitch H. G. (1982). Reducing accident rates with organizational behavior modification. *Academy of Management Journal*, *25*(2), 407-416.

Hermann, J. A., Ibarra, G. V., & Hopkins, B. L. (2010). A safety program that integrated behavior-based safety and traditional safety methods and its effects on injury rates of manufacturing workers. *Journal of Organizational Behavior Management, 30*(1), 6-25.

Laitinen, H., Saari, J., Kivistö, M., Rasa, P. L. (1998). Improving physical and psychosocial working conditions through a participatory ergonomic process: A before-after study at an engineering workshop. *International Journal of Industrial Ergonomics, 21*(1), 35-45.

Laitinen, H., & Ruohomaki, I. (1996). The effects of feedback and goal setting on safety performance at two construction sites. *Safety Science, 24*(1), 61-73.

Larson, L. D., Schnelle, J. F., Kirchner, R., Carr, A. F., Domash, M., & Risley, T. R. (1980). Reduction of police vehicle accidents through mechanically aided supervision. *Journal of Applied Behavior Analysis, 13*(4), 571-581.

Leslie, J. H., & Adams, S. K (1973). Programmed safety through programmed learning. *Human Factors, 15*(3), 223-236.

Lingard, H., & Rowlinson, S. (1998). Behavior-based safety management in Hong Kong's construction industry. *Journal of Safety Research, 28*(4), 243-256.

Magoon, M. A. & Critchfield, T. S. (2008). Concurrent schedules of positive and negative reinforcement: differential-impact and differential-outcomes hypotheses. *Journal of the Experimental Analysis of Behavior, 90*(1), 1-22.

Meyer, W. J., & Offenbach, S. (1962). Effectiveness of reward and punishment as a function of task complexity. *Journal of Comparative and Physiological Psychology, 55*(4), 532-534.

Michael, J. (1975). Positive and negative reinforcement: A distinction that is no longer necessary; or a better way to talk about bad things. *Behaviorism, 3*(1), 33-44.

Olson, R., & Austin, J. (2001). Behavior-based safety and working alone: The effects of a self-monitoring package on the safe performance of bus operators. *Journal of Organizational Behavior Management, 21*(3), 5-44.

Penney, R. K. (1967). Effects of reward and punishment on children's orientation and discrimination learning. *Journal of Experimental Psychology, 75*(1), 140-142.

Penney, R. K., & Lupton, A. A. (1961). Children's discrimination learning as a function of reward and punishment. *Journal of Comparative and Physiological Psychology, 54*(4), 449-451.

Perone, M. (2003). Negative effects of positive reinforcement. *The Behavior Analyst, 26*(1), 1-14.

Rubinsky, S., & Smith, N. (1973). Safety training by accident simulation. *Journal of Applied Psychology, 57*(1), 68-73.

Sasson, J. R., & Austin, J. (2005). The effects of training, feedback, and participant involvement in behavioral safety observations on office ergonomic behavior. *Journal of Organizational Behavior Management, 24*(4), 1-30.

Sidman, M. (1989). *Coercion and its fallout*. Boston: Authors Cooperative.

Spence, J. T. (1966). Verbal discrimination performance as a function of instruction and verbal reinforcement combination in normal and retarded children. *Child Development, 37*(2), 269-281.

Tindall, R. C., & Ratliff, R. G. (1974). Interaction of reinforcement conditions and developmental level in two-choice discrimination task with children. *Journal of Experimental Child Psychology, 18*(2), 183-189.

Table 1

Means and Standard Deviations for the Number of Correctly Completed Work Task, the Results of t-test, Effect Size, and 95% CIs

Group	*n*	*M* (*SD*)	*t*	*df*	*p*	*d*	95% CI
Positive	29	66.07 (11.46)	-1.54	56	0.13	-0.41	[61.71, 70.43]
Negative	29	70.93 (12.59)					[66.14, 75.72]

Note. CI = confidence interval.

Table 2

Means and Standard Deviations for the Amount of Time Spent per Correctly Completed Work Task, the Results of t-test, Effect Size, and 95% CIs

Group	*n*	*M* (*SD*)	*t*	*df*	*p*	*d*	95% CI
Positive	29	71.45 (15.40)	0.53	56	0.60	-0.14	[65.59, 77.31]
Negative	29	73.77 (17.84)					[66.98, 80.56]

Note. Unit of measurement: sec.

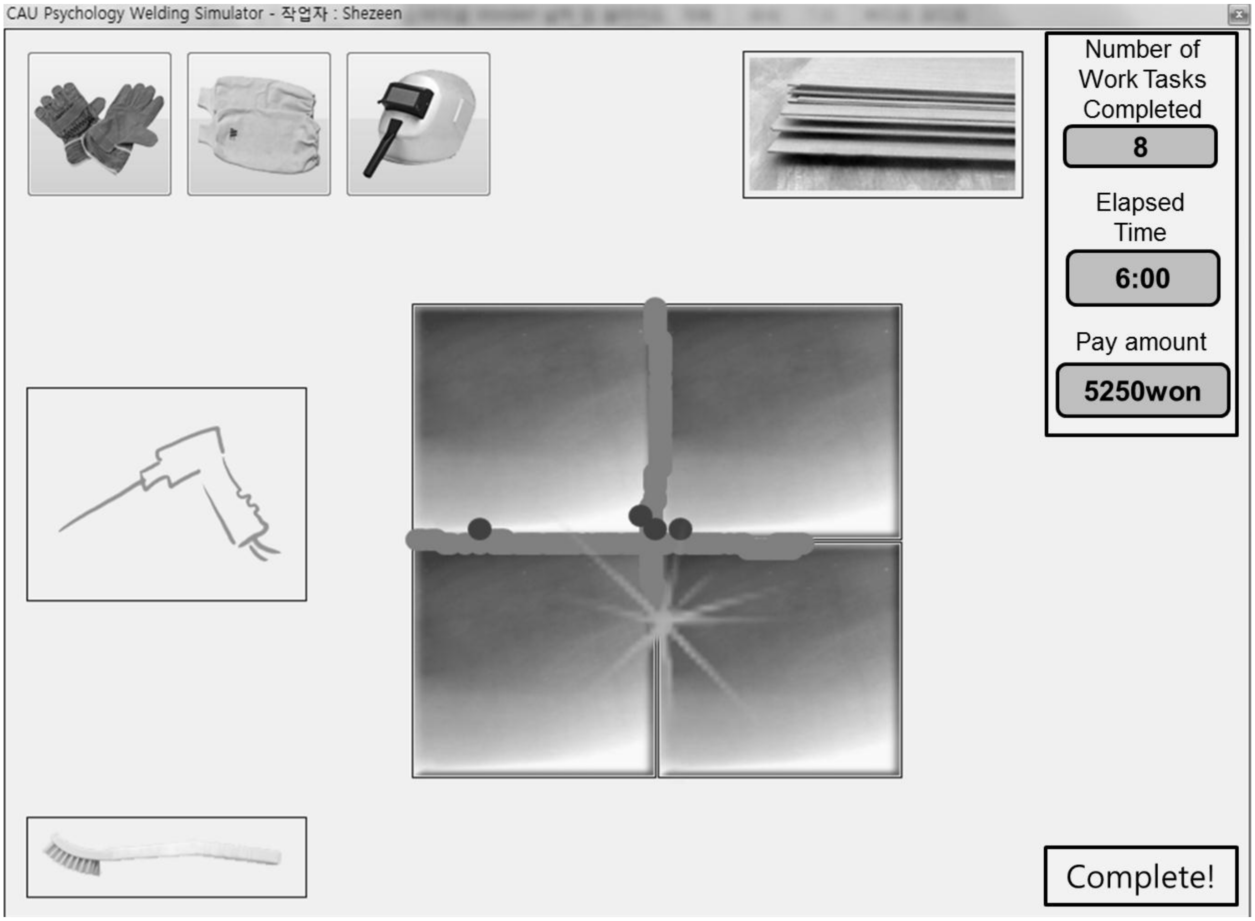

Figure 1. The simulated work task.