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Kyungwon Kang[a]; Shezeen Oah[b]; Alyce M. Dickinson[c]
[a] Chung-Ang University, Seoul, Korea [b] Department of Psychology, Chung-Ang University, Seoul, Korea [c] Department of Psychology, Western Michigan University, USA

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The Relative Effects of Different Frequencies of Feedback on Work Performance: A Simulation

Kyungwon Kang
Shezeen Oah
Alyce M. Dickinson

ABSTRACT. This laboratory simulation examined the relative effects of two frequencies of feedback on work performance under hourly pay and incentive pay. The study had four experimental conditions: feedback delivered after every session under hourly pay and under incentive pay, and feedback delivered after every fourth session under hourly pay and under incentive pay. Thirty-five college students were randomly assigned to one of the four conditions. Each participant attended 24 thirty-minute sessions. Participants performed a simulated work task on the computer that consisted of computer-related activities such as dragging, clicking, and typing. The dependent variable was the number of correctly completed units of work. An analysis of covariance was con-

Kyungwon Kang, MA, was affiliated with Chung-Ang University, Seoul, Korea, during the conduct of this study. He is deceased.

Shezeen Oah, PhD, is affiliated with the Department of Psychology, Chung-Ang University, Seoul, Korea.

Alyce M. Dickinson, PhD, is affiliated with the Department of Psychology, Western Michigan University.

Address correspondence to: Alyce M. Dickinson, PhD, Department of Psychology, Western Michigan University, 1903 W. Michigan Avenue, Kalamazoo, MI 49008- 5439 (E-mail: alyce.dickinson@wmich.edu).

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ducted to analyze the data using pretest scores as a covariate. Participants who received feedback every session completed significantly more work units than participants who received feedback every fourth session. In addition, an interaction between feedback frequency and pay systems was found: Feedback delivered every session was more effective than feedback delivered every fourth session under the incentive pay system, but not under the hourly pay system. The results suggest that the relative effects of feedback frequency may depend upon the extent to which feedback is correlated with differential consequences for performance.

KEYWORDS. Feedback, monetary incentives

Feedback, alone or in combination with other independent variables, has been widely used to improve a variety of organizational performances such as customer service (e.g., Johnson & Fawcett, 1994), sales (e.g., Feeney, Staelin, O'Brien, & Dickinson, 1982), safety (e.g., Fox, Hopkins, & Anger, 1987; Sulzer-Azaroff, Loafman, Merante, & Hlavacek, 1990), tardiness and absenteeism (e.g., Boudreau, Christian, & Thibadeau, 1993), and managerial and staff performance in human service settings (e.g., Methot, Williams, Cummings, & Bradshaw, 1996). In a review of studies published in the *Journal of Organizational Behavior Management* between 1977 and 1986, the first ten years of the *Journal's* publication, Balcazar, Shupert, Daniels, Mawhinney, and Hopkins (1989) reported that approximately 65% of the articles used feedback as the independent variable or as a component of the independent variable. A more recent review (Nolan, Jarema, & Austin, 1999) that analyzed the *Journal's* second decade of publications found that percentage to be 71%. The popularity of feedback can probably be attributed to several features such as simplicity, low cost, and flexibility (Prue & Fairbank, 1981).

Despite its extensive use and success, some authors have advised caution when implementing feedback. In their classic paper, Balcazar, Hopkins, and Suarez (1985-86) reviewed studies that had been published in four major journals (the *Academy of Management Journal*, the *Journal of Applied Behavior Analysis*, the *Journal of Applied Psychology*, and the *Journal of Organizational Behavior Management*) in the previous ten

years and categorized the feedback interventions according to several dimensions that might be related to its effectiveness. The dimensions included whether feedback was used alone or in combination with behavioral consequences and/or goal-setting, and the characteristics of feedback such as (a) the source of the feedback (i.e., supervisors, peers or self), (b) the privacy of the feedback, (c) the feedback participants (i.e., individual, group, or individuals and groups), (d) the medium[1] of feedback (i.e., verbal, written, or graphic), and (e) the frequency of feedback. They then determined the percentage of studies in each category that resulted in consistent, mixed, no, or unknown effects. Based on this analysis, Balcazar et al. maintained that feedback did not improve performance as consistently or as uniformly as many believed (e.g., Fairbank & Prue, 1982; Kopelman, 1982). For example, they reported that when feedback was used alone, it produced consistent improvements in performance in only 28% of the studies. In addition, the authors arrived at two major conclusions. First, "If no system of functional, differential consequences exist, there is probably no point in establishing a feedback system" (Balcazar et al., 1985-86, p. 84). Second:

> If a feedback system is going to be established independently of careful consideration of the existence of functional, differential consequences, and that appears to be the case for the conditions that existed as baselines for most of the literature presently reviewed, the evidence suggests that the best bets are to combine feedback that is graphically presented at least once a week with tangible rewards. Eighty percent of the studies with known effects that applied these characteristics were consistently effective regardless of whether goal setting procedures were additionally used. (Balcazar et al., 1985-86, p. 84)

Alvero, Bucklin, and Austin (2001) updated Balcazar et al.'s (1985-86) review, analyzing studies that were published in the same four journals between 1985 and 1998. Although Alvero et al. modeled their procedures after Balcazar et al.'s, differences between the classifications used in the two studies and the small number of feedback applications in the Alvero et al. study (43 studies with 68 feedback applications) made comparisons of the results problematic. Nonetheless, the authors stated:

> Overall, our findings corroborate those of Balcazar et al. (1985), although specific dimensions depict more or less agreement. For instance, the most consistent effects continue to occur when feed-

> back is used in combination with other procedures. However, our review found feedback and antecedents to be most consistently effective, whereas Balcazar et al. (1985) found feedback and consequences to be the most consistently effective. It is important to note, again, that caution should be taken when analyzing this latter finding due to the low number of applications (four) that implemented a combination of feedback and antecedents. (Alvero et al., 2001, pp. 23-24)

Both reviews have limitations. First, as noted by Alvero et al. (2001), their database was relatively small (68 feedback applications). Balcazar et al.'s (1985-86) review was based on 69 articles with 126 feedback applications, which could also be considered limited. As a result, in both reviews, many of the feedback categories contained fewer than five articles, and the number of articles differed considerably across categories. Additionally, conclusions were based on across-study comparisons rather than on studies that directly compared the effects of variations in the feedback dimensions. While these reviews provide relevant and valuable summative comparisons, studies that directly compare the effects of variations in the feedback dimensions on performance are needed.

A few studies have directly examined the relative effects of feedback when some of its dimensions have been manipulated. For example, Emmert (1978), Newby and Robinson (1983), and Stone (1971) compared the relative effectiveness of individual versus group feedback and found individual feedback to be more effective than group feedback. Also, the relative effects of methods of feedback delivery have been investigated. For example, Wilk and Redmon (1998) found that performance levels improved when the graphic display of performance was added to vocal feedback, a finding that is consistent with those from Balcazar et al. (1985-86) and Alvero et al. (2001).

Similarly, only a small number of studies have examined the relative effectiveness of feedback frequency on organizational performance, perhaps, as suggested by Leivo (2001), because it is commonly believed that more frequent feedback results in higher levels of performance. Thus, in organizational studies, while feedback has typically been provided as frequently as possible, usually daily or weekly (Alvero et al., 2001; Balcazar et al., 1985-86; Leivo, 2001), few direct comparisons have been made. The results of those comparisons have been mixed, possibly due to the fact that the interventions were quite different. For example, Chhokar and Wallin (1984) found that after an initial acquisition period consisting of a 6-week training and goal-setting phase, safety behaviors were maintained

as well when feedback was provided every two weeks as when feedback was provided every week. And, although the data are equivocal, after an initial task clarification, training and supervisory vocal feedback phase for housekeeping behaviors (tools placed in the correct places, walkways clear, etc.), Leivo (2001) reported that the behaviors were maintained equally well when publicly posted graphic feedback was provided as rarely as once every three months as when it was provided once a month. In contrast, Alavosius and Sulzer-Azaroff (1990) and Mason and Redmon (1992) examined feedback that was provided more frequently than once a week for novel repertoires and found that more frequent feedback enhanced acquisition (Alavosius & Sulzer-Azaroff, 1990) and performance (Mason & Redmon, 1992).

Mason and Redmon (1992) compared the effects of delayed and immediate feedback on quality control behavior in a simulated work situation. Under the immediate feedback condition, the cumulative percentage of correct responses was displayed on the computer screen immediately following each of 200 quality control responses. Under the delayed feedback condition, the percentage of correct responses was displayed after the end of the session, which was approximately 15 minutes. Not only was immediacy altered in this procedure, but so too was the frequency of feedback. The accuracy of quality control responses was higher under the immediate, more frequent feedback conditions than under the delayed, less frequent feedback conditions.

Alavosius and Sulzer-Azaroff (1990) examined the relative effects of no feedback, continuous feedback and intermittent feedback on the acquisition of safety behavior in a human service setting. In the continuous, or "dense" feedback condition, feedback was provided "many times a day," following approximately one or two performances. In the intermittent feedback condition, the experimenter observed the participant's performance once a week, viewed and scored three consecutive performances of the designated task, and then immediately reviewed the information with the participant. To assess whether the two feedback schedules would differentially affect maintenance, feedback was withdrawn during the final phase of the study and follow-up measures were taken over a seven-month period. Substantial improvements were produced when feedback was introduced. In addition, the dense feedback schedule resulted in much more rapid acquisition of behavior than the weekly, intermittent feedback schedule. Both types of feedback, however, effectively maintained behavior once mastery had been achieved. Moreover, during the seven-month follow-up period, performance levels were similar, regardless of the initial feedback schedule.

Thus, in this study, more frequent feedback affected the acquisition, but not the maintenance of behavior.

Both Balcazar et al. (1985-86) and Alvero et al. (2001) found that the majority of studies they reviewed, 63% and 71%, respectively, used feedback in combination with other procedures rather than alone. Moreover, both reviews concluded that feedback combined with other procedures produced much higher levels of consistent effects than feedback alone, although Balcazar et al. found that the effects of feedback were most consistent when feedback was combined with behavioral consequences while Alvero et al. found that its effects were most consistent when it was combined with antecedents.

Based on the results of their review, Balcazar et al. (1985-86, p. 84) argued that:

> . . . most of what we might want to know about feedback systems will likely be circumscribed by the knowledge we have about how to reinforce good work because the effects of feedback will probably be determined by such reinforcement. What we would, then, seem to need to know about feedback systems would be how to construct them, *given particular reinforcement systems* [italics added], so that they will augment the reinforcement.

As implied by Balcazar et al. (1985-86), the relative effects of different dimensions of feedback, including feedback frequency, could well depend upon the other contingencies of reinforcement that are present. Therefore, the effects of these different dimensions need to be investigated under different contingencies of reinforcement rather than under a single contingency. Although previous investigators (Alavosius & Sulzer-Azaroff, 1990; Chhokar & Wallin, 1984; Leivo, 2001; Mason & Redmon, 1992) have examined the relative effects of different frequencies of feedback, they did not examine its effects under different pay or reinforcement conditions. Thus, the main purpose of the current study was to examine the relative effects of different frequencies of feedback when different contingencies of reinforcement were present for work performance; specifically, to examine the effects of feedback frequency under two different pay systems, hourly pay and individual incentive pay.

Individual incentive pay provides explicit differential consequences for work performance, and hence is likely to increase the effectiveness of feedback in comparison to hourly pay. Several authors (e.g., Balcazar et al., 1985-86; Bucklin, McGee, & Dickinson, 2002; Duncan & Bruwelheide,

1985-86; Prue & Fairbank, 1981) have discussed the possible behavioral mechanisms that may cause feedback to affect performance, and each is related to its correlation with functional, differential behavioral consequences. First, feedback might function as a discriminative stimulus. However, in order for this to occur, consequences must be differentially delivered after the relevant work behaviors. According to Balcazar et al., the consequences must be in addition to the feedback: "Feedback will function to prompt . . . improved performance if and only if it is related to some more primary consequence" (p. 76). Because of its presentation with other reinforcers, feedback may also become a conditioned reinforcer. Balcazar et al. specifically addressed the relationship between feedback and monetary incentives, stating that when monetary incentives are implemented, feedback may prompt higher levels of performance because similar kinds of feedback have been correlated with reinforcement or punishment in the past. The higher levels of performance are then reinforced and maintained by the additional pay, which, in turn, maintains the feedback as a discriminative stimulus and probably as a conditioned reinforcer as well. Feedback, alone or in combination with monetary incentives, could also serve as an establishing operation (Michael, 1982), increasing the reinforcing value of the worker's accomplishment and evoking work performance that produces that accomplishment (Bucklin et al., 2002). Once again, it is likely that the incentives would enhance any effect that feedback alone would have as an establishing operation. Findings from Balcazar et al. and Alvero et al. (2001) are also consistent with the preceding analyses in that they found that feedback combined with consequences produced more consistent effects than feedback alone.

As pointed out by Bucklin et al. (2002), several authors (e.g., Agnew & Redmon, 1992; Peterson, 1982) have maintained that performance feedback often violates the definitions of discriminative and reinforcing stimuli, due to the temporal delay between the feedback and the response or between the response and the feedback. In such situations, feedback may influence performance primarily through rule control. Regardless, the rules that govern behavior are likely to be more effective if feedback is correlated with differential consequences. The behavioral mechanisms that cause feedback to be effective are usually unknown, and no doubt differ depending upon the situation and performer's history (Bucklin et al.). Nevertheless, the preceding analyses suggest that feedback is likely to be more effective when it is correlated with functional, differential consequences.

Because monetary incentive pay provides explicit differential consequences for performance, feedback may be more effective when it is

combined with monetary incentive pay than with hourly pay. Case studies reported by Dierks and McNally (1987) and Gaetani, Hoxeng, and Austin (1985) support this analysis. In those studies, performance improved when feedback was added to hourly pay, and improved even more when monetary incentive pay was implemented along with the feedback. It is not possible, however, to determine whether the elevated performance levels resulted solely from the monetary incentives, or from the monetary incentives and the concomitant enhanced effectiveness of the feedback.

Feedback alone and in combination with hourly pay has been shown to improve performance, albeit not as much as when it has been combined with behavioral consequences. Nonetheless, these data appear to contradict the argument that feedback acquires its effectiveness due to its correlation with differential consequences. There are, however, several reasons why feedback may enhance performance in the absence of obvious consequences. First, as suggested by Balcazar et al. (1985-86) and Prue and Fairbank (1981), feedback may initially enhance performance because similar kinds of feedback have been historically correlated with reinforcement or punishment. If the feedback was not correlated with reinforcement or punishment in the current context, however, its effects would be expected to be temporary. Second, a system of differential consequences may already exist in the current setting and may not, therefore, need to be explicitly programmed. Finally, a system of differential consequences may be initiated when the feedback is implemented, even though, once again, it has not been explicitly programmed. For example, a supervisor may begin to differentially consequate performance based on the feedback. Moreover, the supervisory consequences may be related to other organizational rewards. Changes in the behavior may also result in automatic or natural reinforcers. Alavosius and Sulzer-Azaroff (1990) discussed this possibility in their safety study, noting that the newly acquired safe behaviors resulted in several new reinforcers such as less effort, less time and less resistance from patients: "Thus, the new responses occasioned and shaped by the feedback, were probably reinforced intermittently by natural contingencies" (p. 160). The extent to which feedback becomes correlated with behavioral consequences no doubt varies from setting to setting, and may account for its inconsistent effects.

If, in fact, feedback controls behavior more effectively when it is correlated with functional, differential consequences, then differences in its frequency might be more important under incentive pay than under hourly pay. In other words, performance differences caused by differ-

ences in feedback frequency might be greater with incentive pay than with hourly pay. We could not locate any studies that have examined this issue. Given the difficulty of controlling the extent to which feedback becomes correlated with differential consequences in actual settings, which may eliminate or reduce performance differences when it is combined with hourly pay and incentive pay, laboratory studies that eliminate, or at least reduce, this confound appear to be particularly appropriate, at least initially. Therefore, the main purpose of the current study was to examine the relative effects of two different frequencies of feedback under two different pay conditions, incentive pay and hourly pay, in a controlled laboratory setting.

METHOD

Participants

Forty-eight volunteer college students (23 males and 25 females) from a mid-sized university in South Korea participated in this study. However, 13 withdrew and their data were excluded from analysis. Therefore, there were 35 participants (17 males and 18 females).

Setting and Apparatus

The experimental setting consisted of a university laboratory that contained six personal computers and an adjacent, separate room. The computers in the laboratory were PC computers with Windows 95 operating systems. The computerized simulated work task was developed specifically for this study and is described in a later section. The instructions for the work task were written and presented in Korean, but have been translated into English for the purposes of this paper. Up to six participants from the four experimental groups worked in the laboratory at the same time, however, they did not start or end a session at the same time. The experimenter greeted individual participants in the room next to the computer laboratory and then escorted them to the laboratory. When a participant completed a session, the experimenter escorted him or her back to the adjacent room. The end-of-session feedback and pay procedures differed across the four experimental groups as described in the *Procedures* section, however, all feedback and pay were given to participants individually and privately in the room next to the computer laboratory.

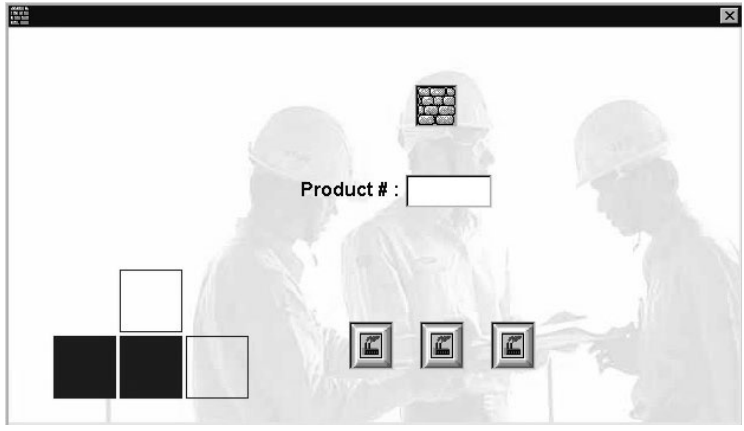
Experimental Design

A 2 × 2 factorial design was used. The participants were randomly assigned to one of four conditions: (1) feedback delivered every session under hourly pay, (2) feedback delivered every fourth session under hourly pay, (3) feedback delivered every session under incentive pay, or (4) feedback delivered every fourth session under incentive pay. Each participant completed 24 thirty-minute sessions and attended one session per day, three or four days a week.

Work Task and Dependent Variable

The computerized work task consisted of three steps. In the first step, a square block was presented in the upper middle portion of the computer screen. Four empty squares were located in the lower left corner of the computer screen (see Figure 1). Participants dragged the block to one of the empty squares using the computer mouse. After one block had been placed in one of the squares, another block appeared on the computer screen, until all four squares were filled. The squares had to be filled in the following order: bottom left, bottom middle, bottom right, top middle. When participants correctly dragged the box to one of the squares, the square turned blue. If participants did not place the block in the correct square or did not place it precisely within the boundary of the square, the square did not turn blue, and the message "TRY AGAIN"

FIGURE 1. The First Step of the Work Task



appeared on the screen. Participants had to click the "OK" button before they could move the box again. After participants had correctly placed the blocks in the four squares, the second step started automatically.

In the second step, a box labeled "Product Number" appeared on the screen (see Figure 2). A nonsense syllable, consisting of four letters and three numbers, was contained in the box, and the following instruction was displayed: "Please type the product number in the blank box below." The software program randomly created the nonsense syllables that were presented to the participants. If participants did not type the syllable correctly, the message "TRY AGAIN" appeared on the screen and participants had to click the "OK" button before they could retype the syllable. After the participants typed the syllable correctly, the third step of the work task started automatically.

In the third step, three "chimney" icons appeared in the lower middle portion of the screen (see Figure 3). The following instruction was displayed below the icons: "Double click each chimney icon in sequence, from left to right." When participants double clicked the icon, it disappeared. If participants did not double click the icons in the correct order, the icons did not disappear. After participants had double clicked each icon in the correct sequence and the icons were no longer visible, the third step was completed.

When the third step was completed, the computer automatically recorded it as one completed "work task" and restarted the first step. The dependent variable was the number of correctly completed work tasks.

FIGURE 2. The Second Step of the Work Task

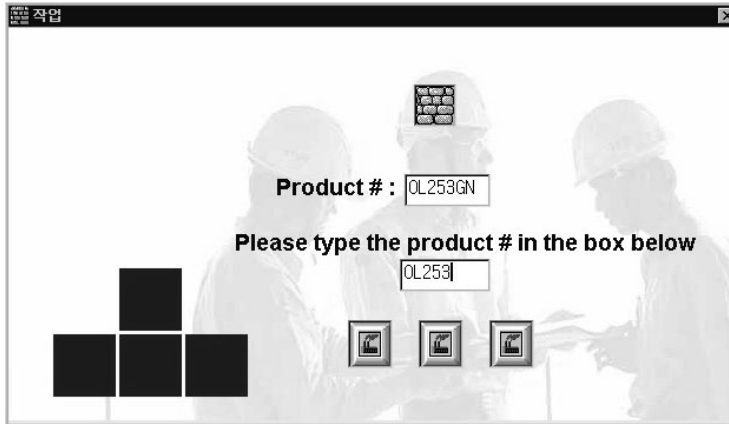
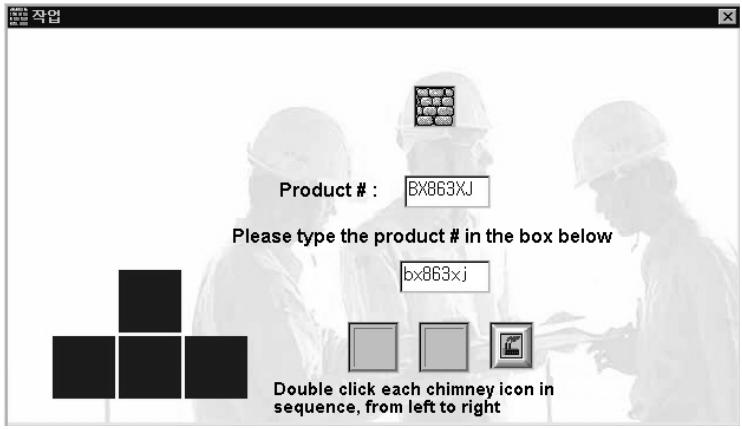


FIGURE 3. The Third Step of the Work Task



Independent Variables

There were two independent variables: feedback frequency and pay system. Feedback was provided to participants after every 30-minute session or after every fourth session. At the end of every session or at the end of every fourth session, the experimenter told the participants how many work tasks they had completed during that session or during the preceding four sessions, plotted the data on a graph, and compared the data to that of the previous session or to that of the four sessions that preceded the most recent four sessions. Because participants attended 24 sessions, those in the "every session" feedback condition received feedback twenty-four times and those in the "every fourth session" feedback condition received feedback six times.

The other independent variable was the type of pay system: hourly pay or individual incentive pay. In the hourly pay condition, participants received 1,000 won (slightly less than $1.00) for each 30-minute session, regardless of the number of work tasks they completed. In the individual incentive pay condition, participants received a base pay of 1,000 won and could earn an additional 10 won for each work task they completed. At the time this study was conducted, the minimum wage for part-time jobs in Korea was approximately 2,000 won per hour.

Participants in the incentive pay condition could earn more money than participants in the hourly pay condition. The pay systems were designed in this manner for two reasons. First, in prior monetary incentive

studies, performance has not been affected by (a) the total amount of money earned in hourly pay versus the total amount earned in hourly pay and incentive pay, (b) the total amount of money earned only in incentive pay, or (c) the amount of the per piece incentive (Bucklin & Dickinson, 2001). Thus, it was not deemed necessary to control for the amount earned. Second, when incentive systems are implemented in applied settings, workers typically are able to earn more money than when they are paid hourly; hence the pay systems more accurately simulated conditions that exist in actual employment settings than they would have if the amount of money earned had been held constant across pay conditions.

Procedures

As indicated earlier, participants met the experimenter in a room that was next to the computer laboratory before the experimental session. The experimenter instructed participants privately before escorting them to the computer laboratory. When the session was over, the experimenter escorted the participants back to the room, where all interactions (provision of feedback and payment) were conducted privately with each participant.

Before the first experimental session, all participants attended a preliminary session. In the first part of this session, the experimenter demonstrated the work task individually to each participant, and participants were given the opportunity to practice the task for five minutes. Immediately after this, participants performed the task for thirty minutes and the computer recorded their performance. This pre-measure of work performance was used as a covariate score when the data were analyzed using an analysis of covariance. After the pre-measure was obtained, the experimenter escorted the participants back to the room next to the computer laboratory and explained the pay system and pay procedures to participants privately. The feedback procedure was not described to the participants. Then, before each session, when the experimenter greeted participants in the room next to the computer laboratory, the experimenter reminded them of how they would be paid (hourly or base pay plus incentives). The experimenter also told participants that they could take work breaks whenever they wanted.

All participants were paid in cash after every fourth session regardless of the feedback condition and pay condition to which they were assigned. This pay procedure was implemented to control for the frequency of pay. Pay was not provided after every session because in-

centives themselves are a form of feedback and if pay had been provided after every session, participants assigned to the "every 4th session/incentive pay" condition would actually have received feedback after every session. Pay was not provided only at the end of the study because it was necessary that the participants come into contact with the actual pay contingencies during the study.

Even though participants in the "every session/incentive pay" condition were paid only after every fourth session, the experimenter told them how many work tasks were completed and how much money they had earned in incentives after each session. After every fourth session, they were told how much total money they had earned and then paid. Participants in the every 4th session/incentive pay condition were told how many work tasks they had completed and how much money they had earned in incentives during each of the last four sessions after every fourth session. They were also told the total amount of money they had earned during the last four sessions, and then paid. Participants in the every session/hourly pay and every 4th session/hourly pay conditions were told after the fourth session how much total money they had earned, and then paid. Participants in the every session/hourly pay condition were not told how much money they earned after each session because the experimenter reminded these participants of the hourly payment before each session.

Once the experimenter had escorted the participants to the computer laboratory, they started each session by clicking the "START" button on the computer screen. The computer automatically stopped the session after thirty minutes and recorded the number of completed work tasks. The experimenter then escorted the participants to the room that was next to the computer laboratory.

As indicated previously, if participants were assigned to one of the every session feedback conditions, at the end of the session, the experimenter told them how many work tasks they had completed, plotted the data on a graph and compared it to the data from the preceding session. Participants in the incentive pay condition (in contrast to the hourly pay condition) were also told how much money they had earned in incentives during the session. After every fourth session, participants in both pay conditions were told how much total money they had earned during the preceding four sessions and then paid in cash.

After every fourth session, the experimenter told participants assigned to the every 4th session feedback conditions how many work tasks they had completed during each of the preceding four sessions, plotted each session's data on a graph and compared the data to the data

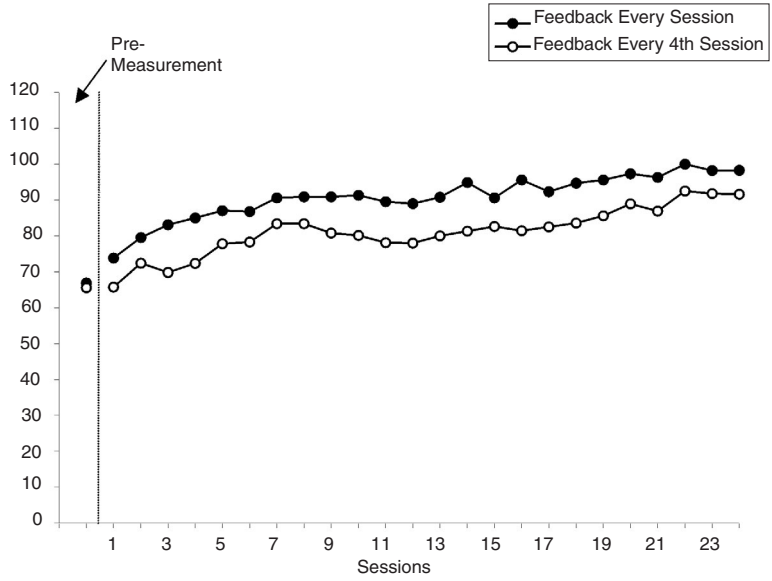
for the four sessions that preceded the most recent four. Participants in the incentive pay condition were told how much money they had earned in incentive pay for each of the last four sessions and the total amount they had earned and then paid. Participants in the hourly pay condition were told how much total money they had earned during all four sessions and then paid.

RESULTS

The number of work tasks completed by each participant per session in each of the four experimental conditions are displayed in Appendices A, B, C, and D. Appendix E contains the average amount of incentive pay and total pay (in won) earned per session by participants in the two incentive pay conditions. Participants in the two hourly pay conditions earned 1,000 won per session, thus these data are not included in an appendix.

Figure 4 displays the mean number of work tasks completed by session by participants in the every session and every 4th session feedback conditions under the incentive pay system. As can be seen, participants

FIGURE 4. The Effects of the Two Frequencies of Feedback Under the Incentive Pay System



who received feedback after every session performed consistently higher across all 24 sessions than participants who received feedback after every fourth session.

Figure 5 displays the mean number of work tasks completed by session by participants in the every session and every 4th session feedback conditions under the hourly pay system. Participants who received feedback after every session performed similarly to participants who received feedback every fourth session for the first 15 sessions, then performed higher during the last nine sessions.

As can seen in Figures 4 and 5, practice effects were evident for all four conditions. To determine whether the practice effects were constant across conditions, a repeated measures ANOVA was conducted. The three-way interaction effect among Session, Feedback Frequency, and Pay System was not statistically significant at the .05 level (see Table 1). In other words, the trends across the four groups were not statistically significantly different at the .05 level of significance.

Because of the separation in performance that emerged during the last nine sessions for participants in the two feedback frequency conditions under hourly pay, analyses were conducted on the complete data set and also on the data for only the last nine sessions. Tables 2 and 3 display the

FIGURE 5. The Effects of the Two Frequencies of Feedback Under the Hourly Pay System

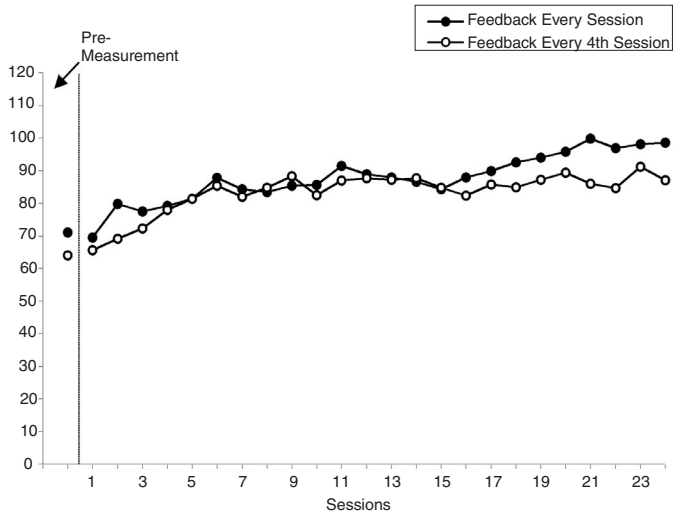


TABLE 1. Multivariate Tests of Significance for the Three-Way Interaction Among Session, Feedback Frequency, and Pay System

Test Name	Value	F	Hypothesis df	Error df	*p*
Pillai's Trace	.736	.968	23	8	.560
Wilks' Lambda	.264	.968	23	8	.560
Hotelling's Trace	2.782	.968	23	8	.560
Roy's Largest Root	2.782	.968	23	8	.560

TABLE 2. Means and Standard Deviations for Each Experimental Condition for All 24 Sessions

	Feedback Frequency			
	Every Session		Every 4th Session	
Pay System	Mean	SD	Mean	SD
Incentive	90.92	14.63	81.27	8.21
Hourly	87.72	10.43	83.35	16.70

TABLE 3. Means and Standard Deviations for Each Experimental Condition for the Last 9 Sessions

	Feedback Frequency			
	Every Session		Every 4th Session	
Pay System	Mean	SD	Mean	SD
Incentive	96.49	12.32	87.19	8.48
Hourly	94.79	9.61	86.43	16.84

performance means and standard deviations for participants in each of four experimental conditions for the full data set and for the last nine sessions, respectively. For the full data set, the mean number of work units completed for participants in the every session/incentive pay condition was 90.92 with a standard deviation of 14.63, the mean for participants in the every 4th session/incentive pay condition was 81.27 with a standard deviation of 8.21, the mean for participants in the every session/hourly pay condition was 87.72 with a standard deviation of 10.43, and the mean for participants in the every 4th session/hourly pay condition was 83.35 with a standard deviation of 16.70.

For the last nine sessions, the mean for participants in the every session/incentive pay condition was 96.49 with a standard deviation of 12.32, the mean for participants in the every 4th session/incentive pay condition was 87.19 with a standard deviation of 8.48, the mean for participants in the every session/hourly pay condition was 94.79 with a standard deviation of 9.61, and the mean for participants in the every 4th session/hourly pay condition was 86.43 with a standard deviation of 16.84.

In order to determine whether performance was differentially affected by the two different feedback frequencies under the two pay systems, an analysis of covariance (ANCOVA) was conducted. The pre-measure of work performance was used as the covariate. To determine whether the covariate was a reliable measure of pre-intervention ability, the pretest scores were correlated with the mean post-test scores for all 24 sessions for all participants. The resulting correlation was .85 ($p < .001$).

Tables 4 and 5 display the adjusted means for participants in each of four experimental conditions for all 24 sessions and for the last nine sessions, respectively.

Table 6 shows the source table for results of the ANCOVA for all 24 sessions and the Partial Eta squared, a measure of the effect size (Cohen, 1988; Myers & Wells, 2003). The main effect of feedback frequency was statistically significant at the .05 level (F = 4.28, $p = .05$), with an effect size of .13. However, the main effect of pay system was not statistically

TABLE 4. Adjusted Means for Each Experimental Condition for All 24 Sessions

	Feedback Frequency	
Pay System	Every Session	Every 4th Session
Incentive	90.95	82.10
Hourly	85.27	85.16

TABLE 5. Adjusted Means for Each Experimental Condition for the Last 9 Sessions

	Feedback Frequency	
Pay System	Every Session	Every 4th Session
Incentive	96.52	87.86
Hourly	92.79	87.90

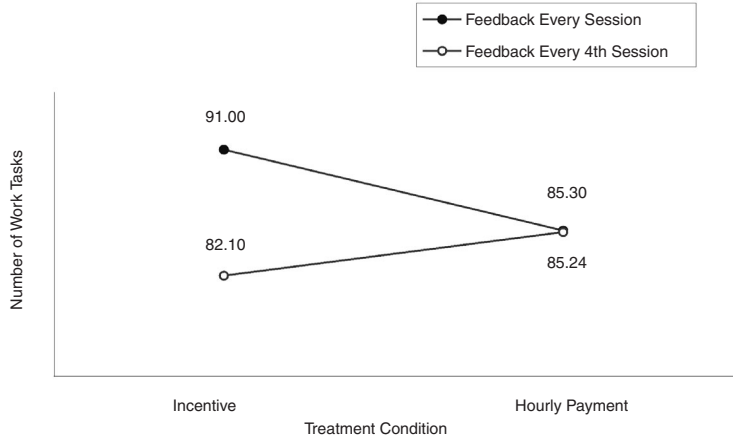
significant (F = .37, p = .55). As also can be seen from Table 6, the interaction effect between feedback frequency and pay system was statistically significant at the .05 level (F = 4.11, p = .05). Figure 6 displays the pattern of the interaction effect between feedback frequency and pay system.

Because the interaction effect between feedback frequency and pay system was statistically significant, ANCOVAs were conducted to determine whether the simple main effects of feedback frequency under each pay system were statistically significant. To maintain the family-wise error rate (FWE) at .05, the Dunn-Bonferroni method was used (Dunn, 1961; Myers & Well, 2003), whereby p is compared with .05 divided by the number of comparisons. Thus, in this case, because there

TABLE 6. Source Table for the Analysis of Covariance for All 24 Sessions

Source	df	SS	MS	F	p	Partial Eta^2
Covariate	1	4091.08	4091.08	104.97	.00	.78
Feedback Frequency (A)	1	166.77	166.77	4.28	.05	.13
Pay System (B)	1	14.24	14.24	.37	.55	.01
A X B	1	160.07	160.07	4.11	.05	.12
Error	30	1169.18	38.97			
Total	34	5794.89				

FIGURE 6. The Interaction Effect Between Feedback Frequency and Pay System



were two comparisons, p was compared to .025. As can be seen from the source table in Table 7, under the incentive system, the two different feedback frequencies produced a statistically significant difference in performance at the .05 level ($F = 9.74$, $p < .01$), but they did not produce a statistically significant difference in performance under the hourly pay system at the .05 level ($F = .00$, $p = .96$). The effect size for the two different frequencies of feedback under the incentive pay system was .41, which is a moderate effect size.

Although it was not the purpose of the study to compare the effects of the pay systems under each feedback frequency, the results of the ANCOVAs for these simple main effects are also presented in Table 7. Again using the Dunn-Bonferroni method (Dunn, 1961; Myers & Well, 2003), where p is compared to .025 to maintain the FWE at .05, the two pay systems did not produce a statistically significant difference in performance under either of the two feedback frequencies.

Table 8 shows the results of the ANCOVA and the Partial Eta Squared for the last nine sessions. As with the results of the ANCOVA for all 24 sessions, the main effect of feedback frequency was statistically significant at the .05 level ($F = 6.30$, $p = .02$). The effect size was .17. Also similar to the results of the ANCOVA for all 24 sessions, the main effect of pay system was not statistically significant ($F = .47$, $p = .50$). Differing from the ANCOVA results for the complete data set, the interaction effect between feedback frequency and pay system was not statistically significant at the .05 level ($F = .49$, $p = .49$).

Even though the interaction effect between feedback frequency and pay system was not statistically significant, in order to compare the results with the results of the ANCOVAs conducted for all 24 sessions,

TABLE 7. Source Table for the Analysis of Covariance for Simple Main Effects for All 24 Sessions

Source	df	SS	MS	F	p	Partial Eta^2
Feedback Frequency						
Hourly Pay System	1	.118	.118	.00	.96	.00
Incentive Pay System	1	379.60	379.60	9.74	.00	.41
Pay System						
Every Session	1	151.87	151.87	3.90	.06	.21
Every 4th Session	1	35.64	35.64	.92	.35	.06
Error	30	1169.18	38.97			

TABLE 8. Source Table for the Analysis of Covariance for the Last 9 Sessions

Source	df	SS	MS	F	*p*	Partial Eta^2
Covariate	1	2710.76	2710.76	44.91	.00	.60
Feedback Frequency (A)	1	380.31	380.31	6.30	.02	.17
Pay System (B)	1	28.48	28.48	.47	.50	.02
A X B	1	29.59	29.59	.49	.49	.02
Error	30	1810.85	60.36			
Total	34	5227.95				

ANCOVAs were conducted to determine whether the simple main effects of feedback frequency under each pay system were statistically significant. As described earlier, in keeping with the Dunn-Bonferroni method (Dunn, 1961; Myers & Well, 2003) of maintaining the FWE at .05, *p* was compared to .025. As can be seen from the source table in Table 9, as with the results for the ANCOVA for the simple main effects for all 24 sessions, the two different feedback frequencies produced a statistically significant difference in performance under the incentive pay system at the .05 level ($F = 6.00$, $p = .02$), but they did not produce a statistically significant difference in performance under the hourly pay system ($F = 1.24$, $p = .30$). The effect size for the two different frequencies of feedback under the incentive pay system was .33, slightly lower than the effect size for all 24 sessions.

Although the performance means for participants in the every session/hourly pay condition and the every 4th session/hourly pay condition appear different during the last nine sessions, they do not differ according to statistical conventions. This is probably due, at least in part, to the high variability displayed by participants in the every 4th session/hourly pay condition (see Table 3 that displays the performance means and standard deviations for all four groups).

Once again, as with the results of the ANCOVA for the simple main effects for all 24 sessions, the two pay systems did not produce a statistically significant difference in performance under either of the two feedback frequencies (see Table 9).

DISCUSSION

In the present study, the effects of feedback frequency were dependent upon the type of pay system. The data patterns shown in Figures 4 and 5 are noteworthy. Under the individual incentive pay

TABLE 9. Source Table for the Analysis of Covariance for Simple Main Effects for the Last 9 Sessions

Source	df	SS	MS	F	*p*	Partial Eta^2
Feedback Frequency						
Hourly Pay System	1	74.66	74.66	1.24	.30	.07
Incentive Pay System	1	362.40	362.40	6.00	.02	.33
Pay System						
Every Session	1	60.61	60.61	1.00	.32	.07
Every 4th Session	1	.08	.08	.00	.98	.00
Error	30	1810.85	60.36			

system, participants who received feedback after every session performed consistently higher across all 24 sessions than participants who received feedback after every fourth session. The difference between the mean performances was practically as well as statistically significant, as participants who received feedback after every session completed an average of about 10 additional work tasks during the 30-minute session. In contrast, under the hourly pay system, participants who received feedback after every session performed the same as participants who received feedback after every fourth session for the first 15 sessions, although they performed higher during the last nine sessions. Nonetheless, across the nine sessions as across all 24 sessions, the difference between the mean performances was not statistically significant. These results are important in that they are, to our knowledge, the first to demonstrate that the differential effects produced by differences in feedback frequency depended upon the contingencies of reinforcement that existed. More specifically, more frequent feedback controlled behavior more effectively only when it was correlated with differential consequences for performance.

Both Mason and Redmon (1992) and Alavosius and Sulzer-Azaroff (1990) found that very frequent feedback (after every behavior or after one or two behaviors) resulted in higher levels of performance than less frequent feedback in the absence of explicitly programmed differential consequences. As in the present study, the feedback in these studies was provided for relatively new behaviors; that is, prior to other interventions as in Chhokar and Wallin (1984) and Leivo (2001). However, our results also indicate that more frequent feedback may not always result

in higher levels of performance, and that its effects may depend upon the extent to which the feedback is correlated with differential consequences. Given these findings, statements about the generality of results of studies that have compared the relative effects of different frequencies of feedback should be made cautiously.

The existing literature also suggests such caution. For example, Alavosius and Sulzer-Azaroff (1990), Chhokar and Wallin (1984) and Leivo (2001) all found that different frequencies of feedback maintained behaviors equally well once the behaviors had been acquired and mastered. And, while these results are consistent with statements that frequent feedback is less important for the maintenance, as opposed to the acquisition, of behaviors (e.g., Alavosius & Sulzer-Azaroff, 1990; Fairbank & Prue, 1982), it is not known whether results would differ if differential consequences were provided for such well-learned behaviors.

Findings from both Balcazar et al. (1985-86) and Alvero et al. (2001) also contradict the general belief that more frequent feedback results in higher levels of performance. Balcazar et al. found that the percentages of interventions that produced consistent effects were similar for daily and weekly feedback (42% and 41%, respectively). They did find, however, that both daily and weekly feedback produced more consistent effects than monthly feedback. Alvero et al. reported different results. They found that the percentage of interventions that produced consistent effects was higher for daily feedback than for weekly feedback (71% and 52%, respectively), but also found that percentage to be higher for monthly feedback (80%). Because these results are based on across-study comparisons, the inconsistencies could be due to other dimensions of the feedback interventions (i.e., source, content, participants, medium), differences in task complexity (Fairbank & Prue, 1982; Ilgen, Fisher, & Taylor, 1979; Leivo, 2001), and/or differences in the mastery level of the targeted behaviors (Alavosius & Sulzer-Azaroff, 1990; Fairbank & Prue, 1982; Ilgen et al., 1979; Leivo, 2001), but they could also be due to different reinforcement contingencies that existed in the settings in which the studies were conducted. Therefore, not only should future researchers directly compare the relative effects of particular dimensions of feedback while holding the other variables constant, but they should compare their relative effects under different reinforcement contingencies.

The experimental task in the current study provided considerable task-produced feedback, and participants could not proceed from one step to the next until the previous step had been completed correctly. The experimenter-provided performance feedback was overlaid on this task-produced feedback. While the task-produced feedback was con-

stant across all four experimental conditions, controlling for internal validity, it constrains the generality of the results to those circumstances in which task execution generates such salient feedback. It is possible that the optimal frequency for feedback that is external to the task, such as supervisory feedback, may differ for tasks whose execution creates such salient feedback versus those which do not.

Thirteen of the original 48 participants withdrew before the end of the study. Four dropped out from the feedback every session/hourly pay condition, five from the feedback every 4th session/hourly pay condition, and four from the feedback every 4th session/incentive pay condition. No participant dropped out from the feedback every session/incentive pay condition. It should first be recognized that the results of the study may have been affected by the high withdrawal rate. Nonetheless, it is interesting to note that none of the participants withdrew from the feedback every session/incentive pay condition. Thus, the combination of frequent feedback and incentive pay may have increased retention.

As indicated earlier, in this study, under hourly pay, participants who received feedback after every session performed similarly to those who received feedback after every fourth session for the first 15 sessions, but performed higher during the last nine sessions. While this trend was visually noticeable (see Figure 5), the difference between the means was not statistically significant. As also mentioned previously, given that frequent feedback is considered to be more important when behavior is being acquired than when it has achieved a steady state (e.g., Alavosius & Sulzer-Azaroff, 1990; Fairbank & Prue, 1982), if these results had been statistically significant, they would have been difficult to explain. Nevertheless, it would have been better if we had been able to continue the study to determine whether these performance trends would have continued and the differences stabilized. Unfortunately, the current study had to be terminated due to financial constraints.

Participants who received incentive pay did not perform statistically significantly better than participants who received hourly pay. Thus, in the current study, while the feedback was correlated with differential consequences in the incentive pay conditions, it was not correlated with *functional*, differential consequences. The current results are not consistent with the results of most prior studies (for reviews see Bucklin & Dickinson, 2001, and Jenkins, Gupta, Mitra, & Shaw, 1998) and, therefore, may be an anomaly. On the other hand, it may be that the amount of the incentive was not sufficient to control performance. Participants

in the two incentive pay conditions earned an average of 860.59 won per 30-minute session. While this represents 46% of their total wages earned in incentive pay per session, the amount is less than $1.00 in American dollars (1,000 won is slightly less than $1.00). Although small amounts of incentive, as low as $.11 per 45-minute session (Frisch & Dickinson, 1990), have been shown to influence behavior substantially, the amount offered in the current study may have been too insignificant to affect performance. The lack of statistical significance notwithstanding, the mean performance of participants who received feedback every session under incentive pay was consistently higher than the mean performance of participants who received feedback every session under hourly pay, while the mean performance of participants who received feedback after every 4th session under incentive pay was not consistently higher than the mean performance of participants who received feedback after every 4th session under hourly pay (see Tables 4 and 5). These differences raise the possibility that the effects of monetary incentives may be dependent upon the frequency of feedback. This possibility is supported by the results of two studies (Bucklin et al., 2002; Thurkow & Hopkins, 1994). Both found that frequent feedback enhanced the effectiveness of individual monetary incentive systems. Unfortunately, as with the current study, the results of neither were definitive. Thus, future studies should examine this possibility.

As with all laboratory simulation studies, caution should be used when attempting to extend the results of the current study to actual work situations. Differences in tasks, participants, the length of the work periods, the amount of base pay, the amount of the monetary incentives, and the timing of feedback could generate very different findings. Kopelman (1986), in a review designed to assess the extent to which the results of feedback studies conducted in laboratory settings could be generalized to work settings, concluded that laboratory experiments often underestimate, rather than overestimate, the effects of feedback interventions in field settings. Nevertheless, it does not follow that the results of this particular study, nor any other, will generalize to actual settings.

The results of this study suggest several opportunities for future research. First, given that this was the first study to find that the relative effects of feedback frequency depended upon the extent to which the feedback was correlated with differential consequences, direct and systematic replications are needed to determine whether the results are reproducible. Second, in this study as in the two prior studies where more frequent feedback improved performance (Alavosius & Sulzer-Azaroff, 1990; Mason & Redmon, 1992), the feedback was delivered soon after

the behaviors occurred (after every one or two behaviors, after every behavior, or after a 30-minute session). Thus, different frequencies of feedback should be examined under different contingencies of reinforcement, particularly less frequent feedback (daily versus weekly, weekly versus every other week, etc.). Third, although the current study was conducted in the laboratory to control for the extent to which feedback becomes correlated with differential consequences in actual work settings, replications in work settings are needed. Fourth, different frequencies of feedback should be examined under different contingencies of reinforcement with well-learned behaviors as opposed to relatively new behaviors. And fifth, studies should investigate the effects of variations in other feedback dimensions under various pay systems and reinforcement contingencies as well, in order to determine "how to construct them [feedback systems] given particular reinforcement systems, so that they will augment the reinforcement" (Balcazar et al., 1985-86, p. 84).

NOTE

1. Balcazar et al. (1985-86) used the term "mechanism" to refer to the method by which feedback was presented (e.g., vocal, written, graphic, etc.). Like Alvero et al. (2001), we adopted the term "medium" because "mechanism" has come to refer to the behavioral function of a stimulus.

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APPENDIX A

Number of Work Tasks Completed by Each Participant per Session: Feedback Every Session/Hourly Pay Condition

	Participant							
Session	1	2	3	4	5	6	7	8
Pre-Measure	63	76	87	95	77	60	49	61
1	73	82	78	84	71	41	62	65
2	83	91	85	96	84	58	69	72
3	87	91	83	94	76	61	64	64
4	68	86	98	85	78	79	64	75
5	90	101	83	93	75	68	69	71
6	87	105	114	88	88	85	58	77
7	77	112	89	106	85	69	67	69
8	86	95	96	111	82	66	67	64
9	74	99	108	96	81	83	68	73
10	76	94	100	97	89	84	65	80
11	80	102	116	105	79	88	73	88
12	75	102	90	109	89	79	78	88
13	71	91	107	104	85	81	75	89
14	74	94	90	105	74	94	69	93
15	76	99	88	102	80	69	72	88
16	84	99	94	108	79	81	65	93
17	89	103	95	97	68	89	82	95
18	76	113	98	107	86	84	80	96
19	80	111	94	109	86	93	86	92
20	93	111	100	104	76	96	93	93
21	89	113	108	110	96	91	95	96
22	95	109	104	104	84	90	88	101
23	97	108	110	110	82	90	91	97
24	97	101	111	111	85	86	96	102

APPENDIX B

Number of Work Tasks Completed by Each Participant per Session: Feedback Every 4th Session/Hourly Pay Condition

	Participant						
Session	1	2	3	4	5	6	7
Pre-Measure	49	47	42	99	61	65	85
1	51	44	54	97	64	73	76
2	50	51	44	99	70	75	95
3	57	43	54	116	60	87	89
4	73	64	62	113	68	78	87
5	77	71	66	124	64	91	76
6	84	77	64	123	69	97	83
7	82	68	70	123	66	85	79
8	79	73	79	108	73	99	82
9	73	77	87	126	64	104	87
10	76	74	66	107	78	95	81
11	62	78	77	120	81	97	93
12	76	84	62	126	79	95	91
13	77	84	84	113	81	83	88
14	84	80	76	129	78	87	79
15	71	66	76	111	82	103	84
16	65	76	76	104	75	102	78
17	62	71	76	119	83	99	90
18	65	70	75	111	84	105	84
19	65	72	76	113	84	106	94
20	70	71	85	122	80	100	97
21	65	80	73	115	84	101	83
22	61	83	79	109	82	93	85
23	60	87	95	123	86	103	84
24	59	79	82	113	79	107	90

APPENDIX C

Number of Work Tasks Completed by Each Participant per Session: Feedback Every Session/Incentive Pay Condition

	Participant											
Session	1	2	3	4	5	6	7	8	9	10	11	12
Pre-Measure	46	52	79	40	90	111	53	95	50	61	66	60
1	49	68	87	41	92	111	55	110	63	69	72	69
2	70	37	88	69	95	108	75	123	64	77	75	73
3	64	68	99	74	95	109	62	117	76	79	71	83
4	59	80	102	71	84	112	79	127	76	81	66	83
5	63	77	98	77	93	127	76	113	80	92	73	75
6	71	79	81	70	91	115	83	116	91	89	75	80
7	79	90	105	78	98	108	91	117	78	79	76	88
8	73	73	92	82	94	113	79	122	98	94	81	90
9	75	79	92	74	100	128	73	130	79	95	79	87
10	82	86	82	74	105	137	72	121	84	81	78	93
11	73	82	90	85	110	114	82	117	88	68	81	84
12	68	72	91	73	108	107	82	122	90	91	82	82
13	72	76	107	61	118	108	81	117	94	90	84	81
14	71	84	96	76	109	130	78	126	96	98	86	89
15	78	89	101	89	102	101	79	117	92	81	69	89
16	84	92	97	81	106	112	79	128	93	101	83	91
17	85	87	97	86	108	103	78	120	93	85	84	82
18	87	88	100	83	107	111	79	124	92	96	81	88
19	85	95	102	81	106	113	79	122	95	96	87	86
20	95	92	96	80	114	114	89	122	97	96	90	83
21	93	91	94	84	112	119	81	115	97	93	91	86
22	95	94	104	85	113	118	88	131	100	94	90	89
23	94	96	103	84	105	113	87	117	107	91	97	84
24	95	95	102	82	104	106	88	125	104	95	99	85

APPENDIX D

Number of Work Tasks Completed by Each Participant per Session: Feedback Every 4th Session/Incentive Pay Condition

	Participant							
Session	1	2	3	4	5	6	7	8
Pre-Measure	50	58	58	54	69	68	76	92
1	48	62	66	71	55	78	66	80
2	57	71	67	78	70	69	81	86
3	63	66	60	78	58	73	75	85
4	50	72	71	66	67	77	77	98
5	61	72	70	80	76	86	81	96
6	63	78	79	83	71	92	71	89
7	64	83	76	90	85	98	78	93
8	67	85	91	89	85	82	81	87
9	79	74	78	74	79	83	86	93
10	72	76	75	74	85	83	82	94
11	63	83	81	69	76	77	75	101
12	69	73	82	75	64	84	80	97
13	69	79	89	79	65	75	86	98
14	72	71	88	80	70	86	81	102
15	70	70	89	85	75	86	86	100
16	71	74	89	80	76	83	75	103
17	65	78	88	84	82	82	86	95
18	68	85	85	86	78	90	73	104
19	65	76	97	87	87	81	92	100
20	78	81	96	92	82	90	95	97
21	59	80	90	87	86	100	89	104
22	76	88	97	95	91	98	89	106
23	78	90	99	94	92	93	90	98
24	80	91	98	93	93	96	87	95

APPENDIX E

The Average Amount of Pay (Won) Earned per Session in the Incentive Groups

	Group			
	Feedback Every Session		Feedback Every 4th Session	
Session	Incentive	Total	Incentive	Total
1	738.3	1,738.3	657.5	1,657.5
2	795.0	1,795.0	723.8	1,723.8
3	830.8	1,830.8	697.5	1,697.5
4	850.0	1,850.0	722.5	1,722.5
5	870.0	1,870.0	777.5	1,777.5
6	867.5	1,867.5	782.5	1,782.5
7	905.8	1,905.8	833.8	1,833.8
8	909.2	1,909.2	833.8	1,833.8
9	909.2	1,909.2	807.5	1,807.5
10	912.5	1,912.5	801.3	1,801.3
11	895.0	1,895.0	781.3	1,781.3
12	890.0	1,890.0	780.0	1,780.0
13	907.5	1,907.5	800.0	1,800.0
14	949.2	1,949.2	812.5	1,812.5
15	905.8	1,905.8	826.3	1,826.3
16	955.8	1,955.8	813.8	1,813.8
17	923.3	1,923.3	825.0	1,825.0
18	946.7	1,946.7	836.3	1,836.3
19	955.8	1,955.8	856.3	1,856.3
20	973.3	1,973.3	888.8	1,888.8
21	963.3	1,963.3	868.8	1,868.8
22	1,000.8	2,000.8	925.0	1,925.0
23	981.7	1,981.7	917.5	1,917.5
24	983.3	1,983.3	916.3	1,916.3
Total	21,820.0	45,820.0	19,485.0	43,485.0
Average	909.2	1,909.2	811.9	1,811.9