

An experiment was conducted to investigate how arithmetic problem solving performance of second-graders would be affected by two types of reinforcement schedules and three types of reinforcers. The data includes 60 arithmetic problem solving test scores (Score), as well three additional variables: a factor with two levels; random and spaced, differentiating different reinforcement schedules (Schedule), a factor with three levels; token, money, and food (Reinforc), and gender (Sex).

Prior to analysis, Levene's test of equality of error variances was conducted to ensure normality. The data does not significantly depart from normal, $F(11,48) = 1.271$, $p < .270$. Using Score as the dependent variable, a 3-way ANOVA was conducted. The 3-way interaction of Sex by Schedule by Reinforc was significant, $F(2,48) = 8.065$, $p < .001$, $\eta^2 = .252$, as shown in Figures 1 & 2.

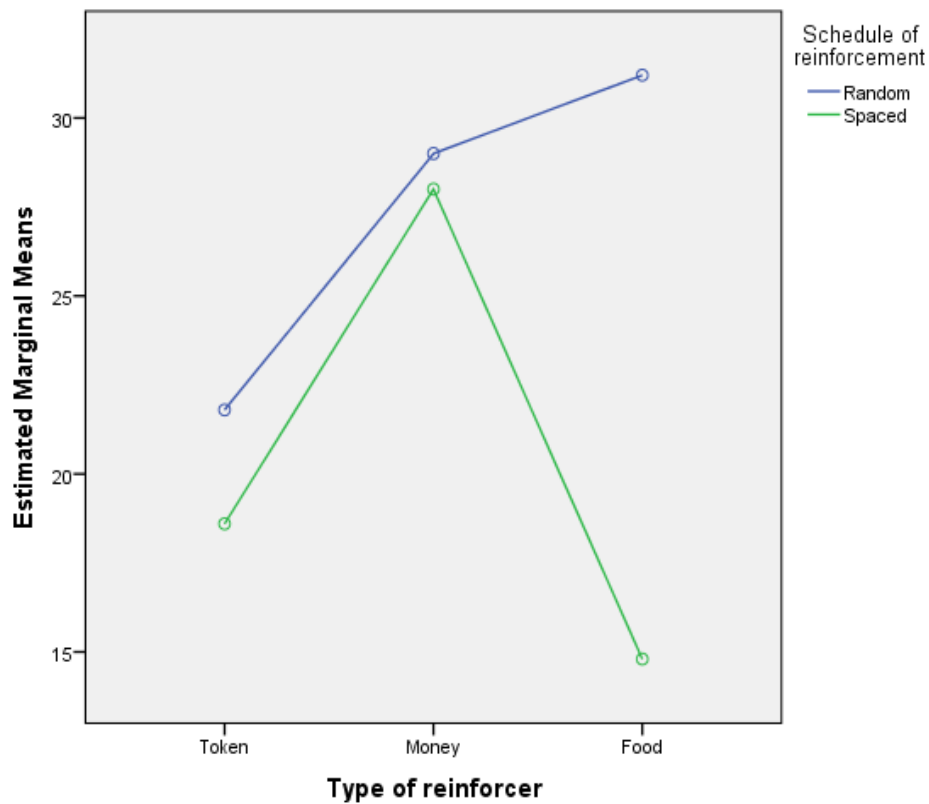


Figure 1. Arithmetic performance score for male second graders separated by type of reinforcer and schedule of reinforcement.

When using a token as a reinforcer, sex alone was significant, $F(1,16) = 8.736$, $p < .009$, $\eta^2 = .353$. Analysis of simple main effects found that males, ($\bar{x} = 20.20$) scored significantly lower than females, ($\bar{x} = 26.40$). Figure 3 displays the mean arithmetic scores for a token reinforcer separated by sex and schedule.

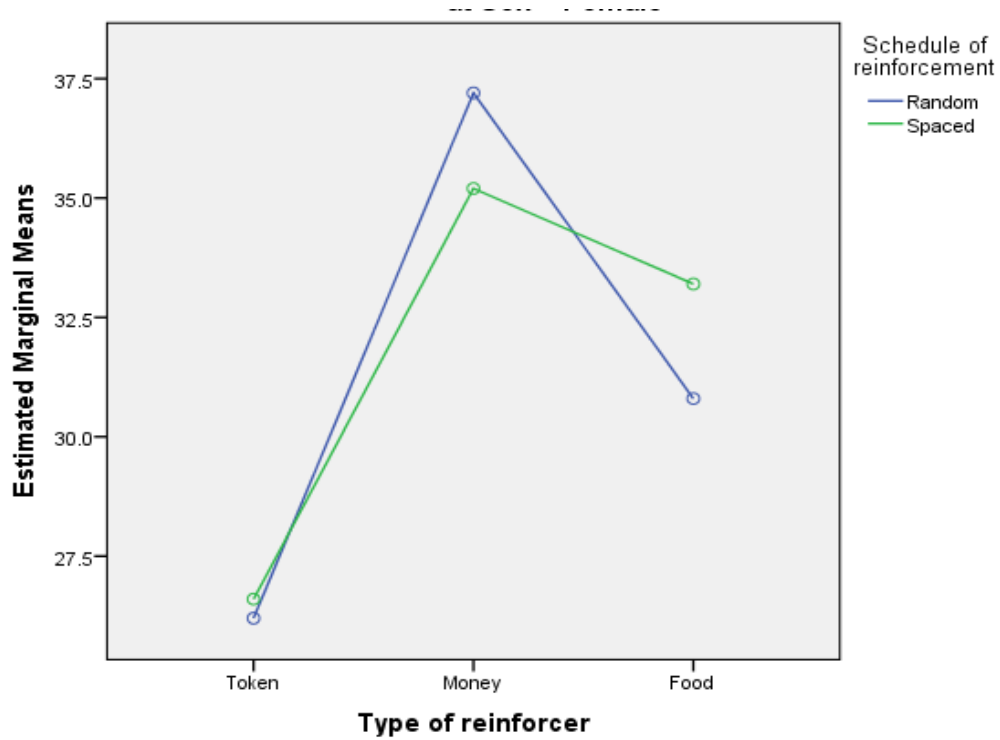


Figure 2. Arithmetic performance score for female second graders separated by type of reinforcer and schedule of reinforcement.

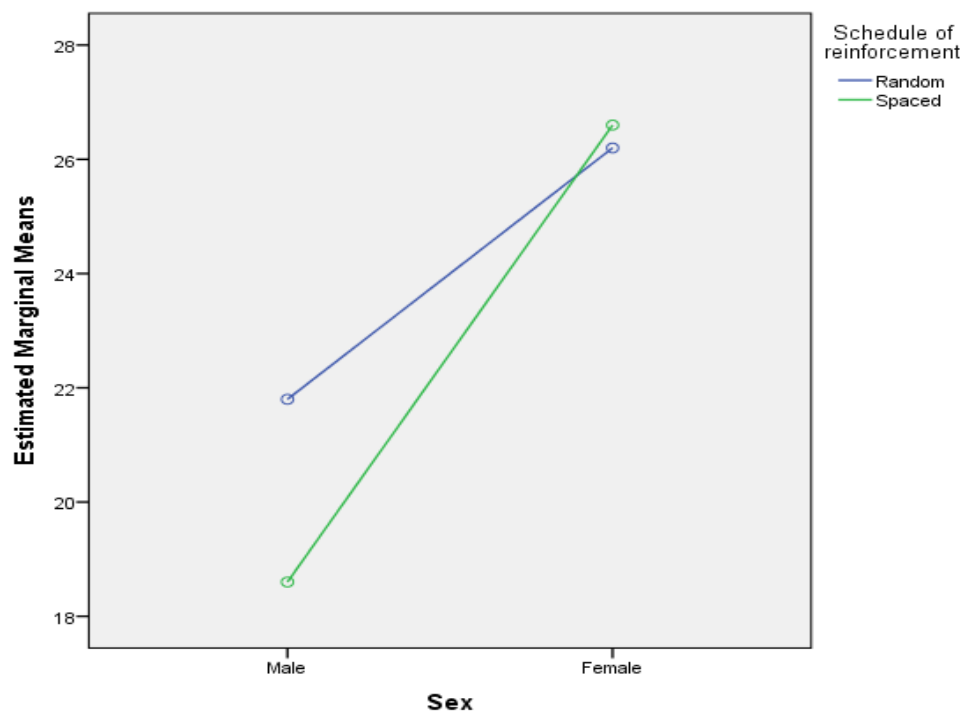


Figure 3. Estimated marginal mean arithmetic performance scores for a token reinforcer separated by sex and schedule.

Likewise, when using money as a reinforcer, again only sex was significant, $F(1,16) = 14.658$, $p < .001$, $\eta^2 = .478$. Similarly, it was found that males, ($\bar{x} = 28.50$) scored significantly lower than females, ($\bar{x} = 36.20$).

As seen in Figure 4, when using food as a reinforcer, the interaction of sex by schedule was significant, $F(1,16) = 57.377$, $p < .001$, $\eta^2 = .782$. Males who had a random reinforcement schedule ($\bar{x} = 31.20$) scored higher than males on a spaced schedule, ($\bar{x} = 14.80$), $F(1,16) = 87.325$, $p < .000$, $\eta^2 = .845$. Additionally, females on a spaced schedule, ($\bar{x} = 33.20$) scored higher than males on a spaced schedule, ($\bar{x} = 14.80$), $F(1,16) = 109.922$, $p < .001$, $\eta^2 = .873$.

Table 1 displays the mean arithmetic problem solving performance scores broken down by sex and type of reinforcement for a random reinforcement schedule. The sex by type of reinforcement interaction was significant for a random reinforcement schedule, $F(2,16) = 3.66$, $p < .041$, $\eta^2 = .234$. Analysis of simple main effects found that when money was used as reinforcer, males scored significantly lower than females, $F(1,24) = 13.271$, $p < .001$, $\eta^2 = .356$.

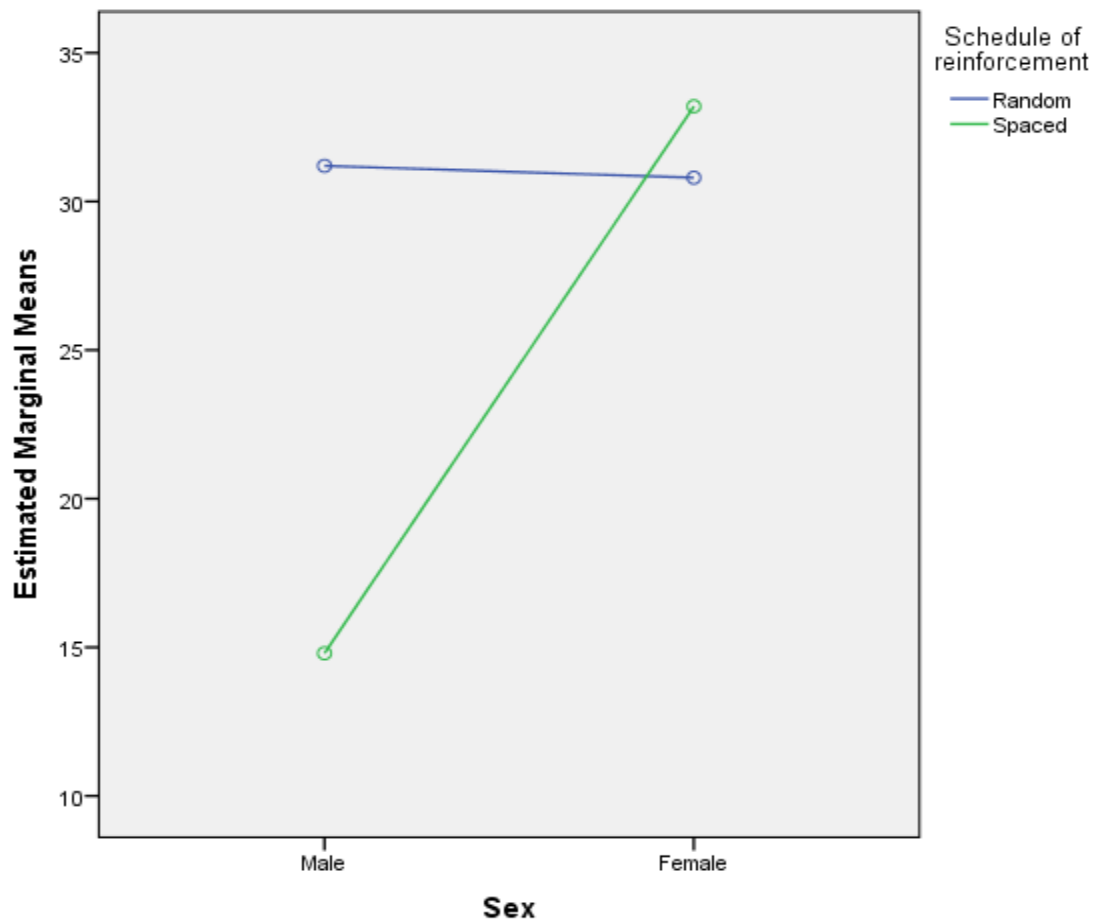


Figure 4. Mean arithmetic performance score for food as a reinforcer separate by sex and schedule.

Continuing in the random reinforcement schedule, reinforcer type was significant for males, $F(2,24) = 9.542$, $p < .001$, $\eta^2 = .443$. Using the Holm's sequential Bonferroni procedure to control for Type I error at the .05 level, $(.05/3 = .017)$, analysis of simple main effects showed that using money resulted in higher scores than using a token as a reinforcer, $p < .004$ (as compared to .025). Also, using food as a reinforcer resulted in higher scores than using a token, $p < .001$ (as compared to .017). Figure 5 displays the estimated marginal means for arithmetic scores separated by sex and reinforcer for a random schedule.

Table 1. The mean arithmetic problem solving performance scores for a random reinforcement schedule separated by sex and type of reinforcement.

Sex	Reinforcer		
	Token	Money	Food
Male	21.80	29.00	31.20
Female	26.20	37.20	30.80

For females using a random reinforcement schedule, reinforcer type was also significant, $F(2,24) = 12.047$, $p < .000$, $\eta^2 = .501$. An analysis of simple main effects was conducted using the Holm's sequential Bonferroni procedure to control for Type 1 error at $\alpha = .05$. When a token was used as a reinforcer, females scored lower than when money was used, $p < .001$ $(.05/3 = .017)$. Additionally, when food was used as a reinforcer, females scored higher than when using a token $p < .009$ $(.05/2 = .025)$.

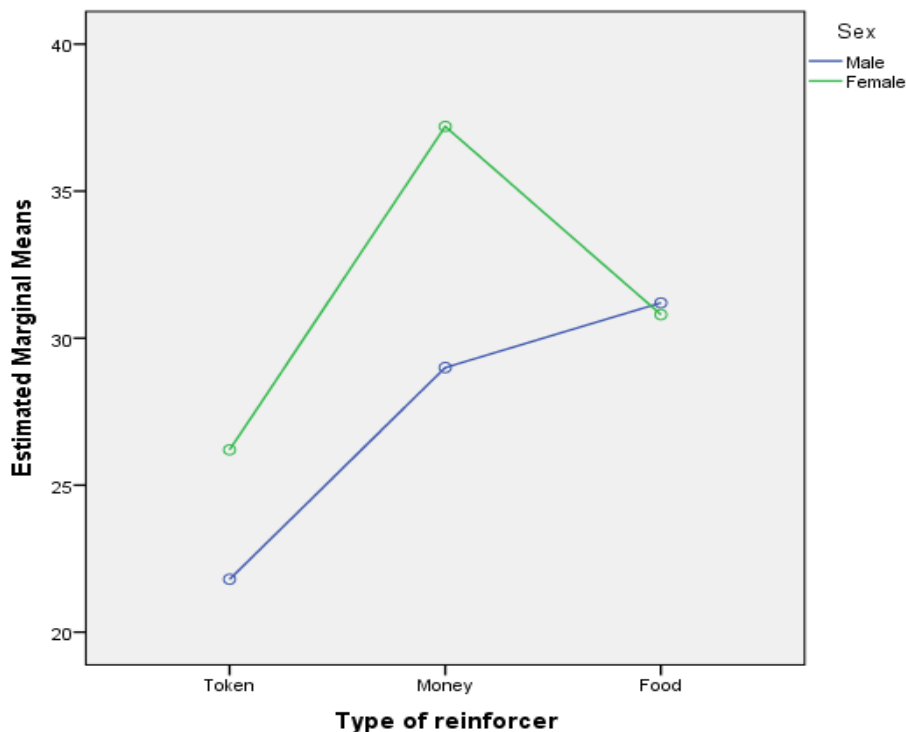


Figure 5. Arithmetic performance score for a random schedule separate by sex and reinforcer.

When a spaced reinforcement schedule was used, the interaction of sex by reinforcement type was significant, $F(2,24) = 4.734$, $p < .018$, $\eta^2 = .283$. Table 2 displays means for arithmetic performance scores separated for this interaction. Analysis of simple main effects found that within the spaced reinforcement schedule, males scored lower than females when using a token as a reinforcer, $F(1,24) = 7.761$, $p < .010$, $\eta^2 = .244$. In a similar fashion, males scored lower than females when using money as a reinforcer, $F(1,24) = 6.286$, $p < .019$, $\eta^2 = .208$. Furthermore, males scored lower than females when using food as a reinforcer, $F(1,24) = 41.054$, $p < .001$, $\eta^2 = .631$.

Table 2. The mean arithmetic problem solving performance scores for a spaced reinforcement schedule separated by sex and type of reinforcement.

Sex	Reinforcer		
	Token	Money	Food
Male	18.60	28.00	14.80
Female	26.60	35.20	33.20

For the same spaced reinforcement schedule, reinforcer type was significant for males, $F(2,24) = 11.198$, $p < .001$, $\eta^2 = .483$. Three pairwise comparisons were made and the Holm's sequential Bonferroni procedure was used to control for Type 1 error at $\alpha = .01$. When tokens were used as a reinforcer, males scored lower than when money was used, $p < .003$ ($.01/2 = .005$). Similarly, tokens also scored lower than food in males, $p < .001$ ($.01/3 = .003$). Figure 6 displays the mean arithmetic performance scores for second graders on a spaced reinforcement schedule broken down by sex and reinforcer type.

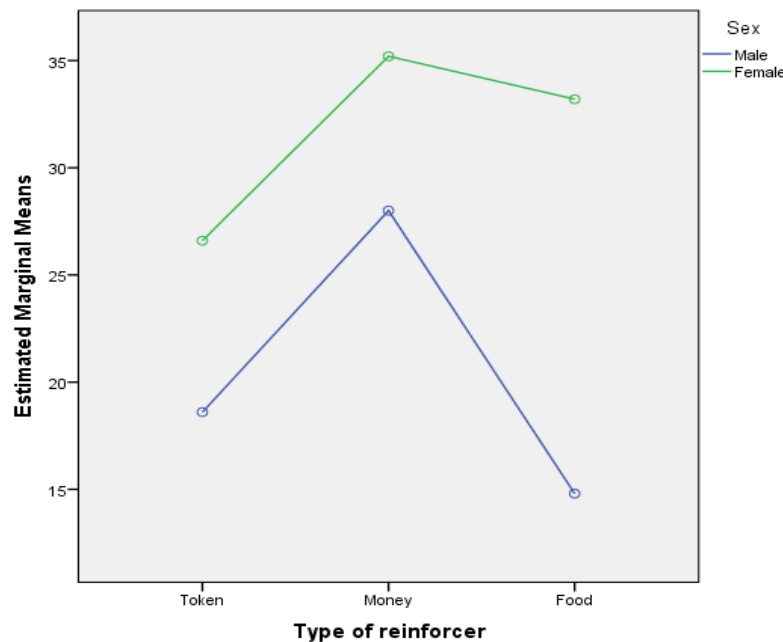


Figure 6. Mean arithmetic performance score for a spaced schedule separated by type of reinforcer and sex.

Once again using the spaced reinforcement schedule, reinforcer type was significant for females, $F(2,24) = 4.912$, $p < .016$, at $\eta^2 = .290$. Three pairwise comparisons were made and the Holm's sequential Bonferroni procedure was used to control for Type 1 error at $\alpha = .05$. However, the p-value for the second pairwise comparison was not within criterion to be declared significant, $.05/2 = .025$. Therefore none of the comparisons were considered significant.

When considering males, the interaction schedule by reinforcement type interaction was significant, $F(2,24) = 8.643$, $p < .001$, $\eta^2 = .419$. The mean arithmetic problem solving performance scores for males separated by schedule and reinforcer is found in Table 3. Analysis of simple main effects revealed that a spaced reinforcement schedule and food as reinforcer scored higher than a random schedule and food, $F(1,24) = 33.508$, $p < .001$, $\eta^2 = .583$.

Again, while considering only males, reinforcer type was significant for a random reinforcement schedule, $F(2,24) = 6.023$, $p < .008$, $\eta^2 = .334$. Following analysis of simple main effects and the Holm's sequential Bonferroni procedure to correct for Type 1 error at the .05 level, it was found that using money as a reinforcer resulted in a higher score than using a token, $p < .018$ ($.05/2 = .025$). Likewise, using food resulted in a higher score than using a token, $p < .003$ ($.05/3 = .017$).

Table 3. The mean arithmetic problem solving performance scores for males broken down by reinforcement schedule and type of reinforcement.

Schedule	Reinforcer		
	Token	Money	Food
Random	21.80	29.00	31.20
Spaced	18.60	28.00	14.80

Remaining with males, reinforcer type was also significant for a spaced reinforcement schedule, $F(2,24) = 11.505$, $p < .001$, $\eta^2 = .489$. The Holm's sequential Bonferroni procedure was used to control for Type 1 error at $\alpha = .01$ while analyzing the simple main effects. It was found that for a spaced schedule, males scored higher when using money as a reinforcer than when using a token, $p < .003$ ($.01/2 = .005$). Similarly, males scored higher when using money rather than food as a reinforcer, $p < .001$ ($.01/3 = .003$).

Finally, for females the interaction of schedule by reinforcement type was significant, $F(2,24) = 18.290$, $p < .001$, $\eta^2 = .604$. Using the Scheffé post-hoc multiple comparisons, it was found that using both money ($\bar{x} = 32.00$) and food ($\bar{x} = 36.20$) as reinforcers resulted in higher scores than using a token ($\bar{x} = 26.40$), $p < .05$.