The Effects of Ratio and Escalating Reinforcement Schedule on Walking Behavior among College Students

Changseok Lee, Heewon Kim, Seoi Lee, Kyong-Mee Chung

Department of Psychology, Yonsei University, Seoul, Korea

Background

- Reinforcement schedule, a set of rules that determine the conditions under which behaviors are reinforced, has gained attention as an effective strategy to promote physical activity, which is an essential for healthy life (Hills, Anderson, & Byrne, 2011; Rethorst & Trivedi, 2013).
- Ratio reinforcement schedule, one of the basic reinforcement schedules, has been used frequently in health-related behavior (Chaudhri et al., 2007). Recently, escalating reinforcement schedule, a complex reinforcement schedule, which is characterized by providing an incremental reward for the consecutive behavior achievement, while in case of failure, returning the reward to the lowest level (Roll & Shoptaw, 2006), has also been gained attention as an effective way of modifying human behaviors (Cassidy et al., 2018). However, due to the lack of studies about reinforcement schedule and physical activity, it is impossible to conclude which type of reinforcement schedule is the most effective.
- Mobile technology developed with 4th industrial revolution accurately measures physical activity such as walking steps and provides immediate feedback through in-device sensing technology (Dallery, Kurti, & Erb, 2015; Fanning, Mullen, & McAuley, 2012). Because of these features, mobile technology are suitable tool to apply reinforcement schedule to physical activity.

Purpose

- The purpose of this study is to verify the effectiveness and the efficiency of reinforcement schedules in increasing walking behavior by using mobile devices.

Method

- **Participants**: 88 female/male college students, aged 19 to 32 years
- **Experimental Design**: Randomized Controlled Trial (RCT)
  - All participants were randomly assigned to four groups of two (Fixed-ratio vs. Variable-ratio reinforcement schedule) by two (Escalating vs. Constant reinforcement schedule) factorial design.

	Escalating	Constant
Fixed Ratio	Escalating-Fixed Ratio (E-FR, n = 23)	Constant-Fixed Ratio (C-FR, n = 22)
Variable Ratio	Escalating-Variable Ratio (E-VR, n = 20)	Constant-Variable Ratio (C-VR, n = 23)

  - In the FR, points were given each time participants achieved a fixed number of steps. In the VR, points were given each time participants achieved a varied number of steps.
  - In the E, if the time interval between achieving walking goals was less than 3 days, the points provided were increased by 100. Otherwise, points provided were return to 100, which is the initial value. In the C, points provided were always 1,050.
- **Measure:** Step counts; mobile application(Pacer) was used to measure participant's daily step counts.
- **Procedure:** After 5 days of baseline period, participants were randomly assigned to the 4 groups. Depending on the group condition, they were provided cash-changeable points based on their step counts for 6 weeks.
- **Data Analysis:** Three-way mixed measure ANOVA and Two-way ANOVA was conducted using SPSS 25.0 ver.

Results

- Three-way mixed measure ANOVA was conducted to analyze the effect of intervention. Results showed the significant main effect of the intervention, but the all three-way and two-way interactions were not significant.
- Two-way ANOVA was conducted to analyze the differences in the amount of points provided between groups. Results indicate that the Escalating reinforcement schedules were more efficient than Constant reinforcement schedules.

Table 1. Descriptive analysis between all groups

	Baseline step counts		Intervention step counts		Mean points provided	
	M	SD	M	SD	M	SD
C-FR (n = 22)	6505.96	2484.08	8333.82	2275.10	14747.73	5279.69
C-VR (n = 23)	6736.68	2466.86	8136.25	1716.44	14060.87	4196.89
E-FR (n = 23)	6757.63	2272.24	8235.25	2476.99	6878.26	6188.40
E-VR (n = 20)	6820.45	2419.54	8607.91	2099.64	7870	7290.81

Table 2. Three-way mixed measure ANOVA results

Predictor	df_{num}	df_{Den}	Epsilon	SS_{num}	*F*	*p*	η^2_g
(Intercept)	1.00		1.00	9911935056	1394.35	.00	.94
Intervention	1.00	84.00	1.00	115543042.90	34.25	.00	.29
C/E	1.00	84.00		1376083.99	.19	.66	.00
FR/VR	1.00	84.00		601957.11	.09	.77	.00
Intervention x C/E	1.00	84.00		3885.95	.00	.97	.00
Intervention x FR/VR	1.00	84.00		38449.72	.01	.92	.00
Intervention x C/E x FR/VR	1.00	84.00		1493445.18	.44	.51	.01

Table 3. Two-way ANOVA results using "Mean Points Provided" as the criterion

Predictor	SS	*df*	Mean Square	*F*	*p*	partial η2
(Intercept)	1.040E+10	1	1.040E+10	309.22	.00	.79
C/E	1083777704	1	1083777704	32.22	.00	.28
FR/VR	509578.084	1	509578.08	.015	.90	.00
C/E x FR/VR	15446910.04	1	15446910.04	.459	.50	.01

Discussion

- These results indicate that both the ratio and the escalating reinforcement schedules are effective to increase physical activity. Specifically, all reinforcement schedules increased participants' step counts about 30% compared to the baseline for 7 weeks. However, since these effects are likely to vary depending on the number of participants or the duration of intervention, further study is recommended.
- Especially, escalating reinforcement schedule is more efficient because it increased approximately 30% of step counts with about 50% less rewards. The findings imply practical advantages of using escalating reinforcement schedules in the area of mobile healthcare.

References

• Cassidy, R. N., Jackson, K. M., Rohsenow, D. J., Tidey, J. W., Barnett, N. P., Monti, P. M., ... & Colby, S. M. (2018). Contingency management for college student smokers: The role of drinking as a moderator and mediator of smoking abstinence during treatment. *Addictive Behaviors*, *80*, 95-101.

• Chaudhri, N., Caggiula, A. R., Donny, E. C., Booth, S., Gharib, M., Craven, L., ... & Sved, A. F. (2007). Self-administered and noncontingent nicotine enhance reinforced operant responding in rats: impact of nicotine dose and reinforcement schedule. *Psychopharmacology*, *190*(3), 353-362.

• Dallery, J., Kurti, A., & Erb, P. (2015). A new frontier: integrating behavioral and digital technology to promote health behavior. *The Behavior Analyst*, *38*(1), 19-49.

• Fanning, J., Mullen, S. P., & McAuley, E. (2012). Increasing physical activity with mobile devices: a meta-analysis. *Journal of Medical Internet Research*, *14*(6).

• Hills, A. P., Andersen, L. B., & Byrne, N. M. (2011). Physical activity and obesity in children. *British Journal of Sports Medicine*, *45*(11), 866-870.

• Rethorst, C. D., & Trivedi, M. H. (2013). Evidence-based recommendations for the prescription of exercise for major depressive disorder. *Journal of Psychiatric Practice*, *19*(3), 204-212.

• Roll, J. M., & Shoptaw, S. (2006). Contingency management: schedule effects. *Psychiatry Research*, *144*(1), 91-93.

This study has been supported by Yonsei University, Brain Korea 21, The Ministry of Science and ICT of the Republic of Korea and the National Research Foundation of Korea (NRF- 2017M3C4A7083533)