

Comparison of the Relative Effectiveness of Different Kinds of Reinforcers: A PEM Approach

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Abstract

The purpose of the present study was to apply the percentage of data points exceeding the median of baseline phase (PEM) approach for a meta-analysis of single-case experiments to compare the relative effectiveness of different kinds of reinforcers used in behavior modification. Altogether 153 studies were located, which produced 1091 effect sizes. The grand mean of the 153 PEM scores was .92. The main finding was that among the positive reinforcers, “activities” was the most effective (PEM score = .95) while “objects” and “edibles” were relatively less effective (PEM score = .85 and .83, respectively). The results of the present study are of importance in respect to the choice of reinforcer for use in intervention in behavior modification.

Keywords: meta-analysis; positive reinforcement; single-case experiments

Introduction

In educational settings, it is desired that all students know the value of knowledge and skills and are intrinsically motivated to learn, but it is rarely the case. Therefore, teachers in school settings often have to employ extrinsic reinforcers to motivate students to learn. After the frequent use of reinforcement on good school performance, it can be expected that the act of learning will become a conditioned response, and after the teacher applies intermittent reinforcement or the student acquires natural consequence of success in education or carrier, it is hoped that the learning can become intrinsically motivated with less extrinsic reinforcement.

Reinforcement can be classified into four kinds: (a) positive reinforcement (giving positive reinforcer), (b) punishment (giving negative reinforcer), (c) punishment (withdrawing positive reinforcer), and (d) negative reinforcement (withdrawing negative reinforcer). The present study concentrated mostly on the comparison of the effectiveness of positive reinforcers including edible foods, tangible objects, activities, and tokens. Less attention is paid to the effectiveness of negative (aversive) reinforcers, but the mean effect sizes of punishment were presented for the purpose of comparison.

There have been many studies reporting success in the use of primary reinforcers to modify the behavior of participants (e.g., Forness, Kavale, Blum, and Lloyd, 1997; Kern, Ringdahl, Hilt, and Sterling-Turner, 2001; Osborne, 1969; and Williams, Koegel, and Egel, 1981).

Cameron and Pierce (1994) conducted a meta-analysis to address the issue of whether extrinsic reinforcement is harmful to the intrinsic motivation and found that rewards given for task completion or for quality of performance are not detrimental to intrinsic motivation.

According to the principle of behavior modification, in order to expect a desirable behavior to happen in the future, three conditions must be fulfilled as follows: a discriminative stimulus must be present; there must be a contingency for reinforcement of the target behavior, and the reinforcer must be able to satisfy the need of the individual. Researchers in behavior analysis have paid more attention to the third condition recently. Neef and Lutz (2001) found that the effect of more preferred reinforcers was higher than that of less preferred reinforcers. The results of Pace, Ivancic, Edwards, Iwata, and Page's (1985) study confirmed that the success of reinforcement depends on the selection of suitable reinforcement schedules and contingencies. Glynn (1970) found that the effect of self-determined and experimenter-determined token intervention on the learning of history and geography material was superior to that of chance-determined and no-token interventions.

It may be alternatively hypothesized that the effect size of an intervention would be larger when the reinforcer can better meet the needs of the participant and serve as a mechanism to increase his or her motivation.

The tool used to measure the effectiveness of different reinforcers was the percentage of data points exceeding the median of baseline phase (PEM) approach (Ma, 2006). By far, the most widely used method for measuring the effect size from single-case experimental designs is the percentage of nonoverlapping data (PND) approach proposed by Mastropieri and Scruggs (1985-1986). The strength and weakness of the PEM approach and its superiority over the PND method has been discussed by Ma (2006) and empirically confirmed by Gao and Ma (2006); Chen and Ma (2007); Ma (2009) and Preston and Carter (2009). Therefore, it was decided to apply the PEM approach to compare the relative effectiveness of different reinforcers used in the field of behavior modification.

Method

Procedures for Locating Studies

The single-case experimental studies investigating the effect of reinforcers analyzed in this synthesis were obtained through a computer-assisted search of the relevant databases, including EBSCOhost, ERIC, and ProQuest. There was a large overlap of studies located from the databases of EBSCOhost and ProQuest. Descriptors included token economy, token system, reinforcement, or reinforcer. A hand search of relevant journals of behavior analysis such as *Journal of Applied Behavior Analysis*; *Behavior Disorders*; *Behavior Modification*; *Behavior Assessment*; *Behavior Therapy*; *Behavior, Research and*

Therapy; and Journal of Special Education were conducted. Additionally, manual searches of the reference lists of articles identified were carried out to locate further studies. Studies that met the criterion that the data of baseline and treatment phases of a reversal or a multiple-baseline design were graphically displayed for individual participants in a time series format enabling the computation of PEM scores were included in this synthesis. Studies which employed an AB design were excluded because that such a design lacks internal validity and alternative interpretations of a result can not be ruled out. Altogether 153 studies were included in the meta-analysis. The publish years of located studies ranged from 1968 to 2006.

Procedure for Coding a Sample Study

Variables in each of the following areas were coded:

1. Original author(s)' conclusion on the overall effectiveness of an intervention: 2 = effective, including "highly effective", "successful intervention", "all data points of inappropriate behavior during the treatment phase were below the mean that occurred during the baseline phase", "noticeable reduction of inappropriate behavior"; 1 = moderately effective, including slightly effective, gradually improved", "above baseline level but was unstable, was not immediately effective but effective later"; and 0 = questionable or not effective. Because it is hard to distinguish between questionable and no effect, they were combined together in this present study.
2. Categorization of independent variables: The reinforcers were coded regardless of whether they were delivered by the interventionist or by the participant him- or herself in the case of an intervention with self-management. The coding number and operational definition of the independent variables are listed as following (the coding numbers are not continuous because they are numbered in accordance with their categories):
 11. Edibles: Providing food or varied edible reinforcers.
 12. Objects: Providing objects, such as a toy; obsession (those items that the participants continually sought out or verbally requested).
 13. Activities: Providing activities, such as interactive play; allowing a choice of activities; incorporating echolalia into a task response; presenting varied tasks instead of constant tasks; choosing books or stories to be read by the experimenter; sitting in a therapy ball instead of in a traditional classroom chair; playing electrovideo games; choice of preferred game (or toy); free time after remaining in seat; given preferred reading material; rhythmic entertainment; music; puzzles.
 14. Giving secondary reinforcer: Praise; attention (making statement or physical gesture to the participant); nonverbal approval, such as a smile and physical contact.
 21. Giving negative reinforcers: Giving aversive stimulus including a reprimand; a stern "No"; icing on facial area contingent on bruxism; over-correction; positive practice overcorrection; loud noise;

- response blocking; shock; electric stimulation (Self-Injurious Behavior Inhibiting System); suppression (sharply saying “No” and briefly holding the part of the child’s body when the child performed self-stimulation); requiring the child to stand up and sit on the floor five to ten times contingent on an inappropriate behavior.
22. Withdrawal of positive reinforcers: Time out (isolating the participant from the reinforcing situation); extinction (ignoring the inappropriate behavior); using earlier curfew contingent on late entering a residence; withdrawal of attention; escape extinction (participant could escape only after a completing task); brief escape from dental treatment contingent upon co-operative behavior; break from the task only after completion of a part of the overall task; and sensory extinction.
23. Differential reinforcement of alternative appropriate behavior (DRA) with reinforcers other than tokens: Extinction of inappropriate target behavior and reinforcement of appropriate behavior.
30. Package of positive reinforcement and punishments other than removal of token: Reinforcement contingent on desirable behavior and punishments with the exception of removal of token contingent on the undesirable behavior as a package.
40. Token: Tokens which can be redeemed for back-up preferred primary reinforcers at a later point in time, including points, lottery, and money.
41. Package of token reward plus withdrawal of token: Token reinforcement contingent on appropriate behavior and removal of token contingent on inappropriate behavior.
42. Package of token reward plus punishments other than removal of token: Token reinforcement contingent on appropriate behavior and other kind of punishments (other than removal of token) contingent on inappropriate behavior.
43. Differential reinforcement of alternative appropriate behavior (DRA) with tokens: Extinction of inappropriate target behavior and reinforcement of alternative appropriate behavior with tokens as a package.
3. Categorization of dependent variables: Target behaviors were classified into six categories:
51. Quality of academic behavior as measured by accuracy, including: The learning of sign language, making appropriate verbal responses, showing skills in matching, and fluency in speaking.
52. Quantity of academic behavior as measured by the number of tasks completed, including: Instruction following, and percentage of taking medication.
53. Socially desirable behavior: Class attendance; attending behavior in the classroom; engagement in interactive play; following of a dressing routine in the family; being on-task; showing compliance; making eye contact; making appropriate requests; being in-seat; appropriately recruiting teacher attention; payment of fines; and consumption of tokens.
61. Problem behavior: Anti-social behavior; returning too late to the dormitory; disruptive behavior; tantrums; perseverative speech; making a noise; not attending; making inappropriate movements of the body; talking rudely; packing food into the mouth without swallowing; thematic ritualistic

- activities; being off-task; expulsion and refusals during mealtime; social avoidance behavior; aggressive behavior; stealing; and stamping.
62. Self-injury: Bruxism; and ingesting pills.
63. Self-stimulation: Rocking and hand-flapping; stereotyped behaviors; hand-clapping; object-mouthing; thumb-sucking; and excessive alcohol consumption.
4. Settings: Intervention settings were classified as (a) home; (b) institution, including clinic and various therapeutic centers, laboratory, residential facility, hospital classroom, room in an institution, infirmary playroom, home-style rehabilitation setting, and achievement placement; (c) school, including facilities in different levels of school, such as classroom and cafeteria, day-care program, co-operative student dormitory; and (d) other places, including unspecified room or playroom, semi-naturalistic setting, facilities in the community, such as outdoor cafeteria, factory, recreation center, and empty meeting room.
5. Interventionists: Interventionists were classified into: (a) experimenter, including treatment provider, facilitator; research assistant, and nonprofessional staff, educational staff, observer, and recorder; (b) specialist, including author, researcher, therapist; instructor; counselor, clinician, and teaching parent; (c) teacher, including swimming coach and trainer; (d) tutor, including peer teacher and home tutor; and (e) parents, including caregivers.
6. Participants: Participants were classified as those with: (a) Attention deficit hyperactivity disorder (ADHD); (b) Autism Spectrum Disorder, Asperger's syndrome, Down Syndrome; (c) mental illness, including psychiatric and psychotic patients; (d) emotional or behavior disorders; (e) learning disabilities; (f) mental retardation of different degrees of severity including mongoloid, educable mental retardation, developmentally disabled, global developmental delay, organic brain syndrome, left hemiparesis, a left visual field defect, brain injury, multiple handicaps, speech and language development delay, and developmental disabilities; (g) "typical" intelligence including participants with disruptive behaviors or deficient in sustaining attention, pre-delinquent behaviors, asthma, psychological problems, physically handicapped; and (h) deafness and hearing impairment.
7. Age of participant. Age was divided into five groups: Below 7, 7-12, 13-15, 16-18, and beyond 18 years old.
8. The length of the treatment phase was coded in order to examine whether a longer treatment phase has a higher effect.
9. The first pair of baseline-treatment phases and the pairs after that were coded so that the effect of the orthogonal slope change on the effect size of the second pair of baseline-treatment phases described by Scruggs, Mastropieri, and Casto (1987) could be examined. They assumed that the data points of an appropriate target behavior in the second baseline would have a gradual downward trend and that in the second treatment would have a gradual upward trend, and hence forming an orthogonal slope change.
10. Methods of assessing the preference of reinforcers: This moderator refers to the approaches taken by

the original authors to choose a reinforcer that would satisfy the needs of a participant: 0 = no mention of assessment (it was assumed that the reinforcer was decided by the author either based on a review of the literature or on his or her professional judgment); 1 = the reinforcer was suggested by significant others of the participant such as parent or teacher (the information was gathered through interview or questionnaire); 2 = the reinforcer was chosen based on a functional analysis (after an informal interview and observation, an experimentally manipulated multi-element design was conducted to investigate the environmental events that led to subsequent behavior changes in order to identify the factor which critically reinforced the problem behavior; 3 = preference test (a list of potential reinforcers was compiled and arrayed to let the participant show his or her preference by consuming them or playing with them), including pair-wise comparison of preference; the reinforcer list was decided by the participant or formulated through discussion with the participant; the participant was able to redeem tokens in a “store” of back-up reinforcers; provision of choice-making opportunities in arranging the schedule of activities; observation of the behavior of the participant to comprehend what the participant preferred as reinforcers; use of the Premack principle (use of a high frequency activity as a reinforcer to reinforce less preferred activities); incorporating thematic ritualistic behaviors preferred by the child with autism into games to facilitate social play; 4. = using money as reinforcer.

Computation of PEM scores. To compute the PEM scores, one needs only to draw a horizontal median line in the baseline phase. This horizontal median line will hit the median when the number of data points in the baseline phase is odd and fall between the two middle points if the number of data points is even. The median line will then stretch out horizontally to the treatment phase. Then the percentage of data points of treatment phase above the median line can be calculated as the effect size scores. The null hypothesis is that if the treatment is not effective, then the data points in the treatment phase would fluctuate around the stretched median line and each data point would have a probability of .5 above the line. If instances of the undesired behavior are expected to decrease after the intervention is introduced, then the PEM score will be the percentage of data points below the median line in the treatment phase. Figure 1 illustrates the method of calculation and comparison of the PEM and PND scores with artificially generated data. It shows the effect of reinforcement consisted of access to a play activity on the acquisition of three elements of social skills (appropriate requesting, commenting, and sharing) in the kindergarten class. In the upper panel of Figure 1, the median of the baseline is 18%, two data points were above and two other points below the median. Twelve data points in the treatment phase were above the stretched median line, hence the PEM scores was $12/15 = .8$, a moderate effect. According to the criterion set by Scruggs, Mastropieri, Cook, & Escobar (1986), a score greater or equal to .9 is highly effective, a score greater than or equal to .7 but less than .9 is moderately effective, and a score less than .7 is questionable or not effective. Because there was an outlier data point (50%) in the baseline phase and the highest data point in the treatment phase was also 50%, no data point in the

treatment phase exceeded the highest point in the baseline phase, therefore the PND score is $0/15 = .0$ (not effective). This is the reason why the PEM approach is more justifiable than the PND approach. The middle and the lower panel of Figure 1 show a PEM score of high and no effect of treatment, respectively.

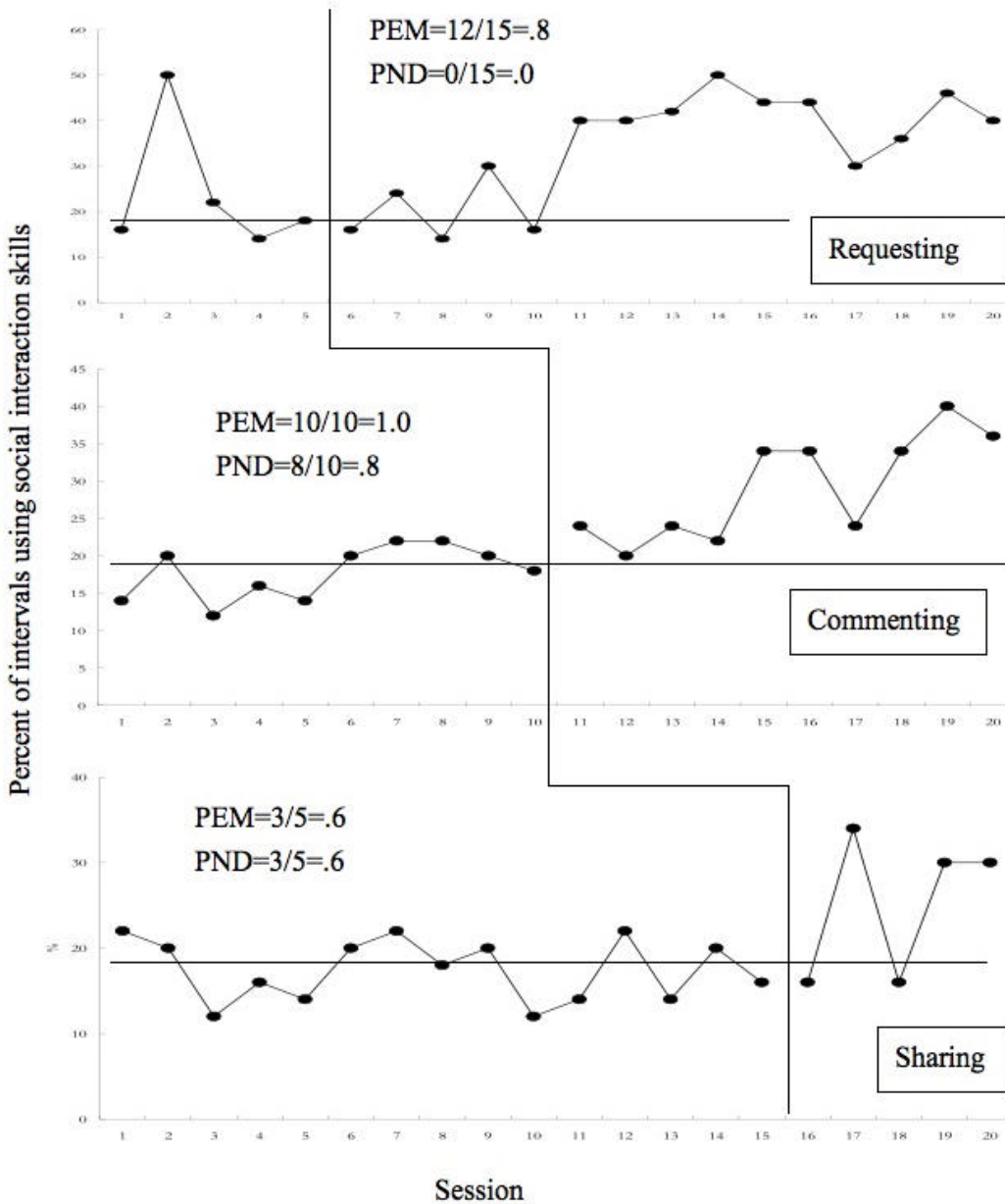


Fig. 1. The effect of reinforcement consisted of access to a play activity on the acquisition of three elements of social skills in the kindergarten class.

Reliability. One student in a doctoral program and one in a master's program in education serving as part-time research assistants independently conducted the calculation and coding of 42% of the scores of the PEM scores and judgment of original author(s). The percentage of agreement is calculated by the formula: agreements / (agreements + disagreements). The reliabilities of coding for the reinforcer data were as follows: PEM scores = $344 / 449 = .77$, judgment = $428 / 449 = .95$. For the token data, PEM scores = $346 / 365 = .95$, and judgment = $.83$. In order to let the reliability approach 1.00 in the last results of the present study, the two assistants were asked to carry out all the calculation and coding of all of the PEM scores and judgment scores and the present author made the last check and resolved the disagreements.

Results

In the use of statistics to analyze the data of a meta-analysis for the single-case experimental designs and to explain the findings, the three basic assumptions of parametric statistics (normality, independence, and variance homogeneity of the distribution of residuals) should not be violated; otherwise, a nonparametric statistic should be used, such as employing the Kruskal-Wallis analysis of variance by ranks to test the significance of difference between multiple groups and applying the Mann-Whitney U test to test that of two groups. The Levene statistic which is available in the SPSS package can be used to test the assumption of the variance homogeneity of the residuals.

When a mean effect size was used to represent the effect size of each located study, the lag 1 autocorrelation (the correlation between i and $i + 1$ of the same set of data) of $-.09$ with a standard error of $.08$, $p > .05$, depicted that the data was independent and did not violate the assumption of the independent distribution of the residuals, which were produced by subtracting the mean PEM score of each study from the grand mean of the 153 studies. A t-test for single group resulted in $t(152) = 54.94$, $p < .01$ indicating that the grand mean effect size of $.92$ was significantly different from the hypothetical $.5$ PEM score. When every effect size in each located study was used as a unit of analysis, then there were 1091 effect sizes from the 153 studies. The lag 1 autocorrelation of $.16$ with a standard error of $.03$, $p < .05$, was significantly different from zero, indicating that that the data violated the assumption of the independent distribution of the residuals. Therefore, non-parametric statistics had to be employed to analyze the 1091 effect sizes.

Validity

The Spearman's rank correlations between the judgments and the PEM scores were $r(1082) = .39$, $p < .01$. Table 1 exhibits that all three categories of the mean effectiveness judged by the original authors fall into the criteria suggested by Scruggs et al. (1986), that is, ninety percent (970 effect sizes) of treatments with reinforcement showed a high effectiveness with a mean effect size of $.93$, seven percent (78 effect sizes) of that was moderately effective with a mean effect size of $.79$, and only three percent (35 effect sizes) of that had no or questionable effect with a mean effect size of $.33$.

Analyses of Independent Variables, Dependent Variables, and Moderators

The results of the analyses of independent variables, dependent variables, and moderators are displayed in Table 1.

Table 1

Analyses of independent variables, dependent variables, and moderators

Subcategories of variables with coding number	<i>N</i>	Mean	<i>SD</i>	Mean rank
Independent Variables				
13. Activities	148	0.95	0.12	624
30. Positive reinforcer plus punishment	25	0.93	0.22	620
21. Negative reinforcer	140	0.94	0.16	612
40. Token	190	0.92	0.19	586
43. DRA with token	50	0.91	0.23	565
42. Token plus punishment	18	0.96	0.05	525
22. Withdrawal of positive reinforcer	92	0.88	0.21	509
23. DRA	24	0.86	0.27	503
14. Praise	73	0.89	0.17	490
41. Token plus removal of token	165	0.84	0.30	488
11. Edibles	142	0.83	0.29	470
12. Objects	24	0.85	0.25	458
Total	1091	0.90	0.22	
Dependent variables				
63. Self-stimulation	94	0.92	0.20	589
52. Quantity of academic behaviors	105	0.90	0.24	584
53. Social behaviors	267	0.92	0.17	556
62. Self-injury	71	0.90	0.23	556
61. Problem behaviors	352	0.90	0.22	543
51. Quality of academic behaviors	202	0.85	0.26	494

Moderators				
Settings				
Home	83	0.94	0.14	587
Other place	77	0.91	0.18	544
Institution	328	0.88	0.26	531
School	583	0.90	0.21	531
Interventionists				
Teacher	386	0.92	0.16	551
Parent	47	0.91	0.16	547
Assistant	358	0.89	0.24	539
Specialist	260	0.87	0.26	514
Tutor	20	0.76	0.35	449
Category of participants				
Deaf	6	1.00	0.00	711
Mental patient	34	0.96	0.17	653
Normal intelligence	257	0.92	0.17	548
With autism	402	0.88	0.25	544
Mental retardation	251	0.90	0.21	537
Learning disability	14	0.84	0.28	517
Emotional disorder	42	0.89	0.24	576
ADHD	78	0.87	0.23	508
Age of participant				
7 - <13	432	0.92	0.19	548
< 7	321	0.88	0.24	521
≥ 18	121	0.87	0.28	518
13 - <16	152	0.88	0.22	502
16 - <18	30	0.90	0.23	500

Order of pair of phases				
Second pair	286	0.91	0.20	577
First pair	805	0.89	0.23	535
Assessment of reinforcer				
Preference test	329	0.90	0.24	571
Decided by author	411	0.90	0.21	546
Functional analysis	179	0.91	0.18	541
Using money	57	0.92	0.16	525
Parent's suggestion	115	0.84	0.28	493
Gender of participant				
Female	308	0.89	0.22	469
Male	666	0.89	0.23	496
Kind of design				
Reversal	677	0.91	0.20	564
Multiple	414	0.87	0.25	516

Note. The independent variable "punishment" refers to the punishments other than removal of token.

The Mean Effect Size of Independent Variables

The grand mean effect size of 1091 effect sizes was .90 with a standard deviation of .22. By testing the homogeneity of variances of residuals of the 12 categories of independent variables (interventions or treatments), a Levene statistic revealed $F(11, 1079) = 10.97, p < .01$, indicating that the assumption of the homogeneity of variances of residuals was also violated. Applying the nonparametric statistic demonstrated that the difference between the mean rank of effect sizes of 12 categories of independent variables was significant, Kruskal-Wallis analysis of variance by ranks, $\chi^2(11, N = 1091) = 57.79, p < .01$. The independent variables, of which the mean effect size were higher than .90 were "activities", "token plus punishment", "negative reinforcer", "token", "DRA with token," and "positive reinforcer plus punishment". The most effective reinforcer was "activities, while the relatively less (moderate) effective interventions were those that involved using edibles, tangible objects, and token plus removal of token.

There were 148 effect sizes resulting from the intervention "activity". Further analysis exhibited no significant difference between the mean ranks of effect size of the six dependent variables, with Kruskal-Wallis analysis of variance by ranks, $\chi^2(5, N=148) = .77, p = .98$. This result depicts that an intervention "activities" can be as effective when used for the establishment of desirable behaviors as for eliminating undesirable ones. Multiple post hoc comparisons of independent variables by means of the Mann-Whitney U test resulted in $(13, 30, 21, 40) > (14, 41, 11, 12)$; $13 > (42, 22, 23)$; $(21, 40) > 22$; $43 > 11$; and $21 > 23$. The numbers represent the coding number of each subcategory of independent variable in Table 1. The number in the parentheses refers to the fact that the mean rank of these subcategories are all

significantly larger than that of subcategories behind the “>”. Within the parentheses, though their mean ranks are arranged in ranking order, their differences are not significant from each other. For instance, (21, 40) > 22 represents that the mean rank of the effect sizes of “negative reinforcer” and “token” were significantly higher than that of “withdrawal of positive reinforcer”, and that the mean rank of effect sizes of “negative reinforcer” was higher than that of “token”, but the difference was not significant. Table 1 shows that among the positive reinforcers, “activities” was the most effective while the “edibles” and “objects” the relatively less effective.

Normally, the rank order of the mean effect sizes corresponds with that of the mean ranks; however, inconsistency can occasionally occur due to the different number of effect sizes as well as the variability and outliers of effect sizes in the treatment phase of the categories to be compared. For example, the reason why the category “token plus punishment” showed a higher mean effect size (.96) than that of “activities” (.95), but showed a lower mean rank of 525 when compared to the 624 of “activities” may be due to the different number of outlier effect sizes of both categories. Among the 18 effect sizes of the “token plus punishment” there were 10 (55.56%) effect sizes with a PEM score of 1.00 while out of 148 effect sizes of the “activities” there were 125 (84.46%) effect sizes with a PEM score of 1.00.

The mean effect size of the token-reinforcement program (.89) with a standard deviation of .24 was slightly lower than that of immediate consumption of reinforcers ($M = .90$, $SD = .21$), but the difference was not significant. A Mann-Whitney U test showed $Z = -.38$, $p = .70$. This demonstrates that the deference of the delivery of a reinforcer showed only a scarce reduction in the power of the reinforcement, but it can also prevent the participant from becoming satiated with primary reinforcers.

By comparing the package of “token plus punishment” with that of “token plus removal of token,” it was found that the former strategy was more effective than the latter one. A Mann-Whitney U test showed that $Z = -2.11$, $p = .04$, depicting that the difference was significant. The rationale may be that by removing a token as a punishment, the token was then associated with an aversive experience and hence its power of reinforcement is diminished.

In the analysis of the assessment of preference for reinforcers, the difference between the mean ranks of effect sizes was on the edge of significance. A Kruskal-Wallis analysis of variance by ranks showed that $\chi^2(4, N=1091) = 8.42$, $p = .08$. But the post hoc comparison displayed a significant difference between “preference test” and “parent’s suggestion” in favor of the former. The Mann-Whitney U test showed $Z = -2.72$, $p < .01$.

The Mean Effect Size of Dependent Variables

A test by means of Kruskal-Wallis analysis of variance by ranks revealed a significant difference between the mean effect sizes of the six dependent variables, $\chi^2(5, N = 1091) = 13.88, p = .02$. A Mann-Whiney U test showed that $(63, 52, 53, 61) > 51$, expressing that there was no significant difference among the effectiveness of interventions on the four dependent variables “self-stimulation”, “completed works”, “desirable social behaviors”, and “problem behaviors”, as well as that all the effectiveness on the four dependent variables were significantly higher than that of “works demanding accuracy”. This result implicates that to improve the accuracy of works is more difficult than to change other kind of dependent variables because the accuracy of work is a matter of “can” rather than only “will”.

The Effect of Other Moderators

By employing the Kruskal-Wallis analysis of variance by ranks to test whether the effectiveness of interventions on the dependent variables was influenced by moderators, no significant difference was found for the moderators of setting, interventionist, category of participants, age and gender of participants, implying that the effectiveness of interventions on dependent variables can be generalized to different settings, interventionists, categories of participants, and ages and genders of participants.

In a test as to whether it was the case that the longer the length of the treatment the higher the effectiveness, a Pearson correlation coefficient was calculated and no significant correlation between the length of treatment phase and the effect size was found, $r(1089) = -.01, p = .78$.

The only two moderators which showed significance were the order of pair of phases and the kind of design. The second pair of the reversal designs showed a significantly larger mean effect size than the first one. The Mann-Whiney U test showed that $Z = -2.36, p = .02$. The results in the research employing reversal design demonstrated a higher mean effect size than those using multiple-baseline designs. The Mann-Whiney U test showed that $Z = -2.98, p = .01$.

Discussion

The effectiveness in terms of mean effect size of the 12 reinforcing strategies investigated in the present study ranges from .83 to .96, i.e., from a moderate to large effect size as compared with the criterion suggested by Scruggs et al. (1986).

The finding that the effectiveness of “activities” and “token” were significantly higher than that of “edible”, and “object.” can be explained as the American participants in the relevant studies were not deprived personally in ordinary daily life in respect to food and object reinforcers, and thus it may not necessarily be possible to generalize the finding to individuals of less wealthy countries.

The finding that there was no significant correlation between the length of treatment phase and

effectiveness is the same as in the results of the study conducted by Vegas, Jenson, and Kircher (2007). What is important for the magnitude of effectiveness is not the length of the treatment phase but the power of reinforcement of a reinforcer. The result of the present study that the mean rank of effect size of the second pair of baseline-treatment phases was higher than that of the first pair can serve to reduce concern on the orthogonal slope change mentioned by Scruggs, Mastropieri, & Casto (1987). They anticipated that the orthogonal slope change would threaten the effect size of the second baseline treatment pair. But the result of the present study demonstrated that it is not the case. The larger effectiveness of treatment in the second pair might be attributed to the accumulated effect of the treatment.

The result that not all positive reinforcers have the same effectiveness also justifies the importance of the element of positive reinforcement that the reinforcer must satisfy the need (or reduce the deprivation) of the individual. This conclusion was also partially supported by the result of the present study that an intervention showed a higher effectiveness if the reinforcer was determined through a preference test rather than simply by asking for the suggestion of significant others such as the parent. The finding that the reinforcer "activities" had the highest mean effect size (.95) confirmed indirectly the Premack principle, which states that a high frequency activity can be used to reinforce a low frequency activity. Logically inferred, the Premack principle can be alternatively expressed as using the strong intrinsically motivated activity of a student as an extrinsic reinforcer to motivate him or her to learn his or her weak intrinsically motivated but important academic as well as social behaviors. This finding has practical implication. As suggested by Kern, Babara, and Fogt (2002), academic activities can be associated with choice-making opportunities, such as choice of activity, choice of teaching of learning materials, and choice of task sequence, to modify class-wide curricula. Their research demonstrated that the curricular modification resulted in increased levels of engagement and decreased levels of destructive behavior and that it can be compatible with school policy.

The present study does not address the controversy between intrinsic and extrinsic motivation. However, all the studies located for this present research were conducted to improve behaviors of task-completion or quality related performance and were based on the assumption that the participant had weak intrinsic motivation. Thus the results of the present study imply that extrinsic reinforcement may motivate participants with a weak intrinsic motivation to improve quantitatively and/or qualitatively in their academic or social behaviors.

The feasibility of the PEM approach suggests that PEM scores can be used to describe quantitatively in complement to visual inspection of trend and variability of the data points in the treatment phase of article employing a single-case experimental design and judge the effectiveness in accordance with the criterion set by Scruggs et al. (1986).

The number of studies located for use in the present investigation is still too small to further analyze whether different schedule, duration, intensity, or amount of reinforcement produces different effects, and researchers should pay attention to these issues in future studies.

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