Active Videogames to Promote Traditional Active Play: Increasing the Reinforcing Value of Active Play Among Low-Active Children

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Abstract

Background: Exercise reinforcement predicts physical activity of children. Repeated exposures of physical activity may increase physical activity reinforcement (incentive sensitization). Active videogame (AVG) play produces light-to-moderate-intensity physical activity. Ideally, AVG play would transition to nonscreen-based active play through incentive sensitization of traditional active play (TAP), providing AVG does not increase sedentary videogame (SVG) reinforcement. Greater autonomy increases motivation toward traditional physical activity, but whether autonomy enhances incentive sensitization has not been studied.

Objectives: To determine whether autonomy over AVG play promotes incentive sensitization of TAP or SVG.

Methods: Inactive children (ages 8–12; 5th–97th body mass index percentile) were provided with AVG and SVG for 6 weeks and assigned to either a high autonomy ($n=25$) or low autonomy ($n=24$) group, differentiated by AVG choice and more freedom over amount of play. Both groups played AVG 3 days per week. SVG were played ad libitum. Participants completed an operant responding task to measure the relative reinforcing value (RRV) of AVG versus SVG ($RRV_{AVG \text{ vs. } SVG}$) and AVG versus TAP ($RRV_{AVG \text{ vs. } TAP}$) at baseline, 6 weeks, and 10 weeks.

Results: $RRV_{AVG \text{ vs. } SVG}$ increased over time ($P=0.056$) but did not differ by autonomy or autonomy $\times$ time ($P=0.184$). $RRV_{AVG \text{ vs. } TAP}$ decreased over time ($P=0.033$) but did not differ by autonomy or autonomy $\times$ time ($P=0.73$).

Conclusion: AVG play does not increase motivation toward SVG and increases motivation to play AVG relative to TAP. Providing higher autonomy did not promote incentive sensitization of play.

Keywords: Children, Physical activity, Relative reinforcing value, Videogames

Introduction

CURRENT HEALTH GUIDELINES recommend that children engage in exercise, sport, or active play for a minimum of 60 minutes per day.¹ Despite this, sufficient physical activity is rare; as only 26.1% of children in 2017 engaged in the recommended amount.² Alarming, this percentage further decreases during adolescence and into adulthood,³ increasing the risk of many later-onset illnesses.⁴ Encouraging greater physical activity in children is of great importance to both their current and future health.

Behavioral Choice Theory details that individuals have many competing options for how to spend their leisure time.⁵ One influential factor is the reinforcing value (RRV) of the alternatives.⁵ RRV may be operationalized as the amount of operant

responding, that is, “work,” a participant is willing to engage in to gain access to the desired “reward.” This is often measured through an operant conditioning task measuring the relative amount of time an individual earns toward either physical activity and a competing sedentary alternative. The ratio of physical activity time earned to total time earned in both options is termed relative reinforcing value (RRV). This paradigm has been successfully applied to understand greater usual physical activity participation in both children^{6,7} and adults.^{8,9} If physical activity is to be maintained long-term, children must find it more reinforcing relative to a non-exercise (sedentary) alternative. This may be accomplished by either increasing the RRV of physical activity itself, termed incentive sensitization, or by decreasing the RRV of the sedentary behavior so that the RRV of physical activity increases relative to sedentary behavior (RRV).

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A possible method of increasing physical activity of children is through playing active videogames (AVGs), a game system where the player's movements through the game space are displayed on a television screen. AVG may be ideal for promoting incentive sensitization of physical activity as children who engage in small amounts of physical activity may initially find AVG more reinforcing than traditional active play (TAP) by reducing concerns with coordination, sport-specific skills, social anxiety, and physical disabilities/illnesses that may make participation in TAP difficult or aversive.^{10,11} AVG mimic TAP, such as sports, dancing, and obstacle courses, and in doing so, promote light-to-moderate physical activity in children.¹² Studies of whether AVG play result in increased energy expenditure often show conflicting results, with some studies showing no increased energy expenditure over nonactive sedentary videogames (SVGs)¹³ and others showing increased physical activity.^{12,14} AVG energy expenditure appears to be particularly high in games facilitating lower body movements, such as running and kicking,^{12,15} but typically lower than occurs in TAP.¹⁶ Increased exposure to active play through AVG may promote incentive sensitization of AVG, TAP, or both; but this is not yet known. If AVG play produces greater increases in TAP reinforcement than AVG reinforcement, then children would be more likely to choose to try similar games in a more traditional context. Therefore, AVG play may act as a gateway to more TAP among children.¹⁷

While children find AVG enjoyable, often once the novelty wears off, their interest wanes and AVG play decreases.¹⁸ This is consistent with initial increase and subsequent decline of other exercise behavior in both adults and children.¹⁹ However, certain factors help maintain exercise motivation and behavior. Among them is exercise autonomy.²⁰ Increasing perceived autonomy increases internal motivation for exercise²¹ and predicts increases in short-^{22,23} and long-term exercise behavior.^{24,25} Increasing children's autonomy by giving them increased choices of physical activities to partake in AVG play may make AVG play more reinforcing and enhance incentive sensitization of AVG and/or TAP, which may lead to greater physical activity.^{22,26}

One of the most common alternatives to physical activity is screen-based sedentary activities, such as television, videogames, computer games, etc. These activities are very popular, with 65% of 4- to 11-year-old children using these devices for more than 2 hours per day.²⁷ Adolescents who play AVG are more likely to play SVGs, and engage in other sedentary screen-based behaviors such as watching television.²⁸ Therefore, it is equally possible that rather than increasing AVG or TAP reinforcement, children exposed to AVG may increase SVG reinforcement. This outcome would have the unintended consequence of increasing sedentary behavior, possibly enough to offset any activity gains by increasing AVG or TAP reinforcement.

This study examined AVG play in inactive children who were new to such games. We hypothesized that children who were given increased autonomy over their AVG play would show increased incentive sensitization toward AVG play, operationalized as a greater relative RRV. It was further hypothesized that exposure to AVG play would lead to increased reinforcement of both SVG play and TAP, relative to AVG play.

Materials and Methods

Study designs

This randomized controlled trial consisted of a two-group factorial design with autonomy condition treated as a between-subject variable (greater autonomy, low autonomy), with low autonomy considered as the control group. Study assessments were conducted by trained research staff and took place at the Grand Forks Human Nutrition Research Center or their community-based laboratory in a local fitness center between November 2016 and April 2018. AVG play, the study treatment, took place in participants' homes. RRV_{AVG vs. SVG} and RRV_{AVG vs. TAP} sessions took place on separate days, usually in the late afternoon or evening. This study received approval from University of North Dakota's Institutional Review Board and was registered at ClinicalTrials.gov (NCT02940431).

Participants

Participants were healthy inactive children (8–12 years of age). Participants were 51% female ($n=26$). The majority identified as white (76.9%, $n=40$), with minorities identifying as black (1.9%, $n=1$), Asian (7.7%, $n=4$), Hawaiian/Pacific Islander (1.9%, $n=1$), multiracial (9.6%, $n=5$), and Hispanic (1.9%, $n=1$). Of the 52 participants who entered the study, 1 withdrew before randomization, 2 withdrew after randomization, and 49 completed the study. Both non-overweight and overweight children (5th–97th body mass index [BMI] percentile) were included. Entry criteria included not currently trying to lose weight, no medical conditions which might impede physical activity, not playing an organized sport or engaging in leisure time moderate-to-vigorous physical activity more than three times per week for 1 hour at a time, not currently playing AVGs, and willingness to adhere to study treatments and measurement schedules. Families which indicated already owning an AVG system were permitted entrance in the study if they confirmed that their child used the AVG system for less than half an hour per week.

Procedure

Screening and consent visit. Initial screening took place online. The first in-person session included a review of answers to the online screening questions, study procedures, informed consent from the parent, and informed assent from the child. Parents were asked to provide demographic and health history information regarding their child. Children were measured for height and weight.

RRV assessments. Children were assessed for their RRV of active to SVGs (RRV_{AVG vs. SVG}) and RRV of AVGs to traditional active games (RRV_{AVG vs. TAP}). Participants completed both RRV assessment tasks at baseline, 6 weeks (postintervention), and 10 weeks (postfollow-up). During this task, children were instructed to complete a computer-based task, in which they could earn minutes to be spent in an AVG, SVG, or TAP of their choice (see Measurements section).

Intervention

Following baseline RRV assessments, families were provided with an Xbox[®] 360[™] game system with the necessary accessories, including a Kinect[™] motion detection system, which displays the player's outline on the television screen. Participants also received both AVG and SVG discs, with each disc containing a range of games and gaming options. AVG and SVG were chosen based upon popularity with the target demographic and age-appropriate ratings for 8- to 12-year-old children. AVG required active play-like body movements, better to simulate traditional play, such as running, kicking, and dancing.

Participants in both groups were instructed to play AVG three times per week. Participants in the high autonomy groups were given two AVG discs of their choice and instructed to play these games for at least 20 minutes per session. Participants in the low autonomy group were assigned one AVG disc from among their top 3 most-liked games and instructed to play the game for 20–40 minutes per session. Both groups could play SVG as they chose but could not play any videogames except those provided by the research team. Parents were instructed to not place limits on their children playing SVG. Every 2 weeks, participants received a new set of videogame discs. Participants were instructed to record their videogame playing time on a log sheet.

Following 6 weeks of treatment, children completed the postintervention RRV and entered a 4-week washout period. During washout, participants in both groups were supplied with two AVG and two SVG of their choosing. Children could play both game types ad libitum, and any other videogames that they might already have at home. After 4 weeks of washout, children completed their final RRV assessments, identical to those at baseline and 6 weeks. Following the assessment, participants were debriefed, asked for intervention feedback, and thanked for their time. The child received \$435 and the parent \$110 as compensation.

Measurements

Height and weight. Body weight was measured through a Tanita scale. Participants wore light clothing and no shoes during measurement. Height was measured using a stadiometer. BMI percentile was calculated based upon growth curves for each participant's age and gender.²⁹

Liking. Children were instructed to rate their liking of five AVG options (Kinect Dance 2015[™], Kinect Dance 2016[™], Kinect Sports Season 1[™], Kinect Sports Season 2[™], and Kinect Adventures[™]) and five SVG options (Minecraft[™], Lego Avengers[™], Lego Star Wars[™], NHL Legacy[™] edition, and NBA2K16[™]) on a 10-point scale (1=do not like it at all, 10=like it very much). When earning time for AVG or TAP, children were asked to rate the liking of the same five AVG and three TAP (soccer, mini basketball, racquetball).

Twenty-four-hour recall. As a check on compliance and method of quantifying minutes of play, children were instructed to fill out a recall measure describing the previous day's activities. Children were instructed to fill out the recall for two randomly selected weekdays and two weekend days.

Recalls were completed at baseline, at weeks 2 and 4 of the intervention, after the intervention (6 weeks), and after washout (10 weeks). The children were asked to report hours and minutes spent in activities, such as AVG, SVG, and TAP, in addition to school, chores, traveling by car/bus, etc. The recall was based upon a recall diary used to measure AVG play in adolescents.³⁰

Relative RRV and Pmax of AVG versus SVG. The most liked type of AVG and SVG activities were provided as alternatives for the RRV testing session. Participants played a slot machine-style game, in which three shapes of different colors appeared upon two computer screens. To better simulate real-world choices, in which multiple options are available, children could earn "points" toward either their preferred AVG by clicking a computer mouse at one computer or toward their preferred SVG or TAP by clicking a computer mouse at the other computer. The child clicked the shapes until the shapes/colors matched, moving freely between the two screens as they chose. Matches earned them points toward their preferred activity. Initially, points were delivered after every four clicks, but then the schedule of reinforcement doubled (4, 8, 16, 32, [...] 1024) each time five points were earned, so that ever-increasing amounts of work were required to earn more time in the desired activity. Each match earned one point, with points translating to minutes in each activity (in 5-minute increments). Children were permitted to play the game as long as they wished, earning as much time they were willing to play the game (either SVG, or AVG), up to a maximum of 45 minutes per game type. After completing the task, participants played their earned time of AVG and SVG, or earned time of AVG and most-liked TAP. AVG or SVG play took place in the laboratory, in single-player game mode.

Outcome measures included the breakpoint, or Pmax,³¹ which was the last schedule of reinforcement (i.e., 4, 8, 16, ...) completed for the behavior (AVG or SVG) and RRV_{AVG vs. SVG}, which was calculated as $[P_{max_{AVG}} / (P_{max_{AVG}} + P_{max_{SVG}})]$ and represents the RRV (amount of responding) of one behavior relative to the other. This final RRV score was considered an operationalization of AVG reinforcement. Similar methods of RRV of physical activity have been found to correlate with habitual physical exercise in both adults^{8,9} and children.⁷

Pmax and RRV_{AVG vs. TAP}. The RRV_{AVG vs. TAP} task followed a procedure identical to the RRV_{AVG vs. SVG} reinforcement task, except that participants could earn time toward either AVG or TAP. TAP was completed indoors at a local fitness center and, to provide some context of the social aspect of the sport, the participant played against a member of the research team (K.U. or K.D.F.). Order of RRV_{AVG vs. SVG} and RRV_{AVG vs. TAP} was counterbalanced among participants.

Analytic plan

Baseline group differences for demographics, including gender, BMI, BMI percentile, and weight were tested using chi-squares and independent sample *t*-tests. Participants were blocked randomized on gender (male vs female), BMI (above 85th percentile vs. below 85th percentile), and

TABLE 1. BASELINE DEMOGRAPHICS BY GROUP

	<i>Low autonomy,</i> N=25	<i>High autonomy,</i> N=26
Age, years	9.64 ± 1.15	10.12 ± 1.18
Weight, kg	39.43 ± 10.76	41.58 ± 15.35
BMI, kg/m ²	18.96 ± 3.22	18.91 ± 4.08
BMI percentile	65.66 ± 26.28	58.29 ± 30.59
Gender, %		
Male	21.57	27.45
Female	25.49	25.49

Data are mean ± SD.

No significant differences at baseline.

BMI, body mass index; SD, standard deviation.

baseline liking of AVG (7 and lower vs. 8–10 on a 10-point scale) using Taves minimization.

The primary outcomes were conducted through a series of generalized linear mixed models because RRV data does not follow a normal distribution. P_{maxAVG} , P_{maxSVG} , P_{maxTAP} , $\text{RRV}_{\text{AVG vs. SVG}}$, and $\text{RRV}_{\text{AVG vs. TAP}}$ were each analyzed as the dependent variable in separate equations. For each equation, the between-subject variable was autonomy group (high vs. low autonomy), the within-subject variable was time point (baseline, 6 weeks, 10 weeks), and baseline RRV or Pmax scores were used as a covariate.

Based upon prior research and conservative estimates for multivariate effects,^{16,32} a prior power analysis suggested a sample size of $N=25$ per group to achieve power exceeding $1 - \beta = 0.90$. Because our final sample met this amount, it was assumed to have adequate power. All statistics were performed with SAS 9.4³³ using Proc Glimmix, which allows for an intent-to-treat estimate of means. Major analyses were performed with an intent-to-treat analysis. However, because only two participants withdrew from the study following randomization, one from each autonomy condition, selective attrition is not believed to be of concern.

Results

Chi square and *t*-tests confirmed that autonomy groups did not differ at baseline in gender ($P=0.668$), BMI percentile

for age and gender ($P=0.362$), BMI ($P=0.960$), age ($P=0.151$), weight ($P=0.567$) (Table 1), as well as likings for AVG, SVG, and TAP at baseline, 6 weeks, and 10 weeks (Table 2). Participants' time per day spent in AVG, SVG, and TAP at baseline, 6 weeks, 10 weeks, as well as during the intervention itself are detailed in Table 3. Because participants did not play AVG every day, length of each session was also calculated, with the high autonomy group playing for an average of 64 minutes per session in the second week and 32 minutes per session in the fourth week. The low autonomy group played AVGs on an average of 32 minutes per session in the second week and 40 minutes per session in the fourth week.

AVGs versus SVGs

P_{maxAVG} showed an autonomy × time interaction ($P=0.041$). Specifically, for the high autonomy group, P_{maxAVG} decreased from baseline to 6 weeks and 6 to 10 weeks, whereas for the low autonomy group, P_{maxAVG} increased from baseline to 6 weeks and decreased from 6 to 10 weeks (Table 4). The effects of autonomy ($P=0.684$) and time ($P=0.163$) were not significant (Table 4). There were no differences between groups at any time point by Tukey/Kramer contrasts ($P=0.118$). Cross-group differences across time points also did not reach significance ($P=0.070$).

P_{maxSVG} showed an effect of time ($P<0.001$), but not autonomy ($P=0.836$) or their interaction ($P=0.438$). P_{maxSVG} decreased 57.8% ($P<0.001$) from baseline to 10 weeks. No changes were observed from baseline to 6 weeks (-33.2% , $P=0.139$) or from 6 to 10 weeks (-36.8% , $P=0.077$). $\text{RRV}_{\text{AVG vs. SVG}}$ showed a borderline significant increase over time ($P=0.056$), but there was no effect of autonomy ($P=0.578$) or their interaction ($P=0.184$). Across both autonomy groups, $\text{RRV}_{\text{AVG vs. SVG}}$ showed little change from baseline to 10 weeks ($P=0.072$) (Table 5).

AVGs versus TAP

P_{maxAVG} showed an effect of time ($P=0.001$), but not autonomy ($P=0.590$) or their interaction ($P=0.604$). When tested against sport activities, P_{maxAVG} decreased from baseline to 10 weeks ($P=0.007$) and from 6 to 10 weeks ($P=0.002$), but not baseline to 6 weeks ($P=0.926$). P_{maxTAP}

TABLE 2. LIKING SCORES BY AUTONOMY GROUP ACROSS TIME

<i>Autonomy condition</i>	<i>Liking</i>	<i>Baseline</i>	<i>6 Weeks</i>	<i>10 Weeks</i>
AVG vs. SVG				
High	AVG	8.31 (7.72–8.90)	8.69 (8.24–9.15)	8.50 (7.87–9.13)
Low	AVG	8.21 (7.50–8.91)	8.36 (7.70–9.03)	8.13 (7.41–8.85)
AVG vs. SVG				
High	SVG	8.54 (7.76–9.32)	8.03 (7.07–9.00)	7.96 (7.03–8.89)
Low	SVG	8.50 (7.72–9.28)	8.50 (7.69–9.31)	7.91 (6.98–8.84)
AVG vs. TAP				
High	AVG	8.19 (7.72–8.66)	8.73 (8.14–9.32)	8.44 (7.77–9.11)
Low	AVG	7.88 (6.98–8.77)	8.17 (7.49–8.86)	8.17 (7.44–8.91)
AVG vs. TAP				
High	TAP	9.00 (8.52–9.48)	8.88 (8.28–9.49)	8.35 (7.63–9.06)
Low	TAP	7.96 (6.97–8.95)	7.91 (7.02–8.81)	7.74 (6.79–8.69)

Data are mean with 95% confidence interval.

No significant differences between autonomy groups at all time points.

AVG, active videogame; SVG, sedentary videogame; TAP, traditional active play.

TABLE 3. AVERAGE MINUTES SPENT PER DAY IN ACTIVE VIDEOGAMES, SEDENTARY VIDEOGAMES, AND TRADITIONAL ACTIVE PLAY BY TIME POINTS

Autonomy group	Activity	Baseline (preintervention)	Week 2 (during intervention)	Week 4 (during intervention)	Week 6 (postintervention)	Week 10 (postwashout)
High	AVG	3 ± 14	32 ± 74	19 ± 18	19 ± 27	6 ± 15
	SVG	37 ± 60	17 ± 32	20 ± 35	21 ± 35	22 ± 44
	TAP	42 ± 122	35 ± 50	33 ± 51	54 ± 192	45 ± 63
Low	AVG	3 ± 10	17 ± 19	17 ± 26	15 ± 25	8 ± 19
	SVG	71 ± 90	25 ± 50	32 ± 62	35 ± 68	34 ± 62
	TAP	47 ± 80	27 ± 43	16 ± 28	29 ± 60	21 ± 37

Data are mean ± SD.

Data are from four randomly selected days (two weekend days and two weekdays) at each time point.

showed no effect of autonomy ($P=0.636$), time ($P=0.593$), or their interaction ($P=0.985$) (Table 4). $RRV_{AVG \text{ vs. } TAP}$ showed a significant effect of time ($P=0.033$), but not autonomy ($P=0.947$) or their interaction ($P=0.727$). Across both groups, $RRV_{AVG \text{ vs. } TAP}$ showed a borderline significant decrease from baseline to 10 weeks ($P=0.058$) and from 6 to 10 weeks ($P=0.059$) (Table 5).

Discussion

Contrary to our predictions, exposure to AVGs did not increase SVG reinforcement in children. When completing the $RRV_{AVG \text{ vs. } SVG}$ task, reinforcement for both AVG and SVG declined at 6 and 10 weeks. Because SVG reinforcement decreased more, AVG reinforcement was greater relative to SVG postintervention. Declines in AVG reinforcement indicate that children were losing interest in the AVG games. This is not unexpected as others have demonstrated similar decline in AVG play once the novelty wears off,¹⁸ similar to the longitudinal decline in motivation common to other physical activity studies.¹⁹ However, these results indicate that AVG play decreases the RRV of SVG, a most encouraging result as sedentary behavior is implicated in increased BMI and poor health in both children³⁴ and adults.³⁵ Overall, these results indicate that parents, caretakers, and educators who wish to use AVGs to encourage children's active play need not worry about inadvertently increasing motivation to play SVG. Future research should investigate ways to slow declines in AVG interest, including a greater variety of games, encouraging group AVG play, and mixing AVG with TAP.

A second noteworthy result is that while $RRV_{AVG \text{ vs. } TAP}$ and $Pmax_{AVG}$ decreased, $Pmax_{TAP}$ showed no time effect.

While a null effect of $Pmax_{TAP}$ may seem unnoteworthy, it stands in contrast to $Pmax_{SVG}$ and $Pmax_{AVG}$, which decreased. Therefore, $RRV_{AVG \text{ vs. } TAP}$ decreased over time. This result could also be interpreted as the RRV of TAP [$Pmax_{TAP}/(Pmax_{TAP} + Pmax_{AVG})$] increasing relative to AVG, which argues that postintervention motivation to play TAP relative to AVGs was greater than at baseline. Because children often play active sports more intensely and expend comparatively more energy,¹⁶ increasing RRV_{TAP} would promote this choice and the health of children. Our results suggest that AVGs may act as a gateway to TAP, an open question suggested by other studies.¹⁷ Studies with adult populations have shown similar results, in which AVG play leads to greater postintervention exercise behavior.¹⁴ Possibly, this occurs because playing AVG, rather increasing the RRV of AVG, decreases the RRV of SVG, which then makes alternatives, such as TAP, more appealing. Alternately, this result may be largely due to postintervention decreases in $Pmax_{AVG}$. Future research may wish to examine whether there is a tipping point that RRV of sedentary behavior must reach before RRV of physical activity, either AVG or TAP, increases, and if so, what factors may help sedentary individuals reach this point.

AVG play did not differentially change across autonomy groups. This stands in contrast to past findings, where greater autonomy, operationalized by choice of games, leads to longer play time.¹⁶ There are several potential explanations. Some of these discrepancies may be due to differences in laboratory¹⁶ versus home-based play, as other studies have noted that AVG play motivation depends on factors in the immediate environment.³⁶ It is also possible that the construct of autonomy was not strongly varied to produce an autonomy

TABLE 4. Pmax RESULTS BY AUTONOMY GROUP AND TIME

Games compared	Pmax	Autonomy condition	Baseline	6 Weeks	10 Weeks
AVG vs. SVG	AVG	High	23.5 (15.4–35.8)	16.7 (11.0–25.5)	12.8 (8.4–19.5)
		Low	14.4 (9.4–22.2)	27.1 (17.6–41.7)	16.6 (10.7–25.7)
	SVG	High	32.5 (19.9–53.1)	28.4 (17.4–46.5)	15.2 (9.3–24.8)
		Low	39.4 (23.8–65.1)	20.2 (12.2–33.3)	15.0 (9.0–24.9)
AVG vs. TAP	AVG	High	19.0 (12.4–29.1)	22.9 (15.0–35.1)	12.2 (7.9–18.6)
		Low	21.3 (13.8–32.9)	20.7 (13.4–32.0)	8.9 (5.7–13.7)
	TAP	High	28.1 (17.1–46.3)	25.0 (15.2–41.1)	23.3 (14.2–38.3)
		Low	26.1 (15.7–43.4)	21.8 (13.1–36.1)	20.2 (12.2–33.5)

Data are mean with 95% confidence interval.

Pmax scores are $\log_2$ transformed and covaried for baseline scores.

Pmax, last schedule of reinforcement completed.

TABLE 5. RELATIVE REINFORCING VALUE RESULTS ACROSS BOTH GROUPS AND TIME

<i>Games compared</i>	<i>Autonomy condition</i>	<i>Baseline</i>	<i>6 Weeks</i>	<i>10 Weeks</i>
AVG vs. SVG	High	0.46 ± 0.05	0.46 ± 0.05	0.52 ± 0.05
	Low	0.34 ± 0.05	0.52 ± 0.05	0.49 ± 0.06
AVG vs. TAP	High	0.46 ± 0.06	0.50 ± 0.06	0.36 ± 0.05
	Low	0.49 ± 0.06	0.45 ± 0.06	0.36 ± 0.05

Data are mean ± standard error.

effect or that any increases in AVG reinforcement engendered by the two games versus one diminished in less than 6 weeks. Some high autonomy participants may have preferentially played games from one disc only, thereby making their treatment similar with low autonomy participants. Even greater variety may have been needed for the effects of autonomy to last long term. Furthermore, although the high autonomy group chose longer AVG sessions early in the intervention, by the intervention midpoint, the average session time had decreased until sessions were no longer than the time allotted to the low autonomy group (Table 3).

Another possibility is that other factors were needed to increase AVG reinforcement. During the RRV task, children played AVGs against the computer rather than an opponent. Many videogame systems allow the option of a single-player game against the computer or multiplayer games against siblings, friends, or even unknown individuals from online. Motivation toward AVGs is sustained more in multiplayer compared with individual player games,^{37,38} suggesting a social aspect to AVG play consistent with the social aspects of other forms of exercise. This social aspect may also extend to TAP. During the current study, children played TAP with a member of the research team, which may have served to make the TAP option more appealing compared with AVG. Furthermore, this laboratory-based testing situation was an artificial social situation, so suggesting that the social appeal of TAP may have been even greater in TAP play with siblings, friends, or parents. Motivation to be physically active is greater with a friend even within an artificial laboratory setting³⁹ and physical activity intensity tends to be greater in the presence of peers,⁴⁰ suggesting that the social context may be a critical factor in encouraging AVG and TAP.

This study has additional limitations. Our study was of limited duration; long-term exercise reinforcement over the course of months is necessary for establishing life-long healthy habits. Furthermore, these results may not generalize to other age groups, including younger children and adults. Although traditional exercise results in greater energy expenditure, adults rate AVGs as more enjoyable.⁴¹ Given the well-known decrease in physical activity during the adolescent years, future studies may wish to investigate the ability of AVGs to increase exercise reinforcement during this developmental phase. Our results also may vary based upon the types of games offered, including both videogame types and TAPs. It is possible that children would have responded differently had their preferred game/sport or a team-based context been offered. Furthermore, a wide variety of AVG systems and games are currently on the market. Energy expenditure, enjoyment, and other characteristics relevant for continued long-term usage vary between games and

systems,^{42–44} which suggests that results from a study utilizing Xbox[®] Kinects[™] may not generalize to other systems or games. Although low and high autonomy groups showed different patterns of Pmax_{AVG} when playing for AVG versus SVG, these discrepancies may have been largely driven by baseline differences across groups (Table 3). Future studies may wish to block based upon baseline Pmax scores, rather than baseline liking, which showed little variation.

In summary, providing inactive children with AVGs may be used as a method to increase their active play reinforcement. Despite concerns, increased AVG reinforcement does not increase but rather decreases relative reinforcement of SVG. Furthermore, AVG reinforcement does not displace TAP reinforcement, which remains robust even when paired with AVG play. Increased autonomy through greater game choice does not increase AVG play reinforcement and reinforcement of AVGs tends to decline over time; future research must examine other factors, which might help maintain AVG play long term.

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