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Investigating Maintaining Variables of Physical Activity

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Investigating Maintaining Variables of Physical Activity

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Abstract

Engagement in physical activity can assist with the prevention of a variety of serious health complications. Although there is evidence for the many benefits of physical activity, percentages of engagement in physical activity among adults around the world are low. Through the use of an experimental analysis, we investigated what environmental conditions maintain physical engagement with two neurotypical adults. The conditions evaluated included attention, no interaction, escape, and tangible. These conditions were compared to a control condition. Results of this study indicated physical activity engagement was maintained by automatic reinforcement for each participant. Evaluating these controlling variables can assist clinicians in promoting healthy behaviors such as physical activity engagement among adults.

Keywords: apple watch, experimental analysis, fitness, function, health, obesity, physical activity engagement, reinforcement, workout

Investigating Maintaining Variables of at Home Physical Activity

The prevalence of obesity is at an all-time high at 42.4% of adults in the United States in 2018 (Centers for Disease Control; CDC, 2020). Obesity has serious health complications associated with it, such as heart disease due to excessive and abnormal fat accumulation. Obesity is generally defined as having a Body Mass Index (BMI) equal to or above 30 (World Health Organization; WHO, 2020). Specifically, obesity rates worldwide have virtually tripled from 1975 to now (WHO, 2020). Obesity is therefore an increasing problem of high social significance that must be addressed.

There are variety of contributing factors to obesity, each of which suggests ways in which obesity can be targeted. A few major contributing factors include caloric intake and caloric expenditure, which can be defined as the number of calories one consumes through foods and the number of kilocalories used during any physical activity, respectively. Increasing one's physical activity is a common solution for increasing one's caloric expenditure. Physical activity also has a multitude of benefits for not only one's physical health but one's psychological well-being as well (Teixeira et al., 2012). Unfortunately, although there is evidence that there are many benefits to engaging in physical activity and exercise, it has been found that many individuals do not frequently engage in physical activity and exercise behaviors (Global Health Organization; GHO, 2018). This lack of physical activity comes from changes in lifestyle, such as an increase in more passive forms of transportation and more sedentary forms of leisure activities. According to the WHO in 2018, 28% of adults (ages 18 and over) and 80% of adolescents (ages 11-17) were insufficiently active. Furthermore, insufficient physical activity is one of the leading risk factors for death worldwide, reporting an approximate 3.2 million deaths a year (WHO, 2018).

Behavior analysts have the appropriate skill set to promote healthy behavior engagement among members of society. Through experimental analysis, behavior analysts can analyze and depict the maintaining variables of physical activity engagement. Once the behavior analyst identifies what reinforcers maintain a target behavior, they can then create behavioral intervention programs that facilitate continued reinforcement for these healthy behaviors in an individualized manner. Behavior analysts can also make the necessary changes and manipulate the schedule of reinforcement to ensure that physical activity engagement is maintained as well as resistant to extinction.

Previous behavioral researchers have evaluated physical activity engagement and its maintenance through a variety of data collection methods including direct observation and mechanical measurement instruments (Van Camp & Hayes, 2012). Intervention research has largely focused on increasing physical activity through the use of procedures such as exergaming, self-management, and feedback (VanWormer, 2004; Normand, 2008; Donaldson & Normand, 2009; Shayne et al., 2012). These interventions are designed to increase low levels of physical activity in individuals who are often sedentary. Usually these interventions are deemed successful in increasing physical activity although it is challenging to determine the extent of the success when using measures such as step count.

A different approach to the study of physical activity is to determine what reinforcers maintain exercise on an individual basis. In general, interventions based on the maintaining function of an individual's behavior are more effective and can be maintained over longer periods of time (Cooper et al., 2018). To determine causal relationships between behaviors and consequences, behavior analysts can conduct experimental analyses. The term *experimental analysis*, first described in relation to behaviorism by Skinner in 1938, in laymen terms simply refers to the relation between the environment and behavior (Schlinger & Normand, 2013). The use of experimental analysis was later crafted into a systematic

methodology as a tool in order to assess the environmental variables that influence and maintain problematic self-injurious behavior by Iwata et al. (1982/1994; Hanley et al., 2003). Although experimental analyses, or functional analyses, are typically used to identify the reinforcers maintaining problem behavior, another goal of behavior analysis is to increase adaptive behavior. Experimental analyses of behavior in practice aren't often used to increase behaviors, but there is certainly inarguable value in doing so. Finding the cause or function of a specific behavior allows a practitioner to identify what can evoke and also potentially maintain the behavior.

With respect to identifying the variables maintaining physical activity, Larson et al. (2013) designed a study in which they conducted a functional analysis in order to examine the relation between moderate-to-vigorous physical activity (MVPA) and a variety of consequent variables with young preschool aged children. The conditions assessed during the study included alone, escape from demands, attention, and adult interaction. The results indicated that children were most active when receiving social positive reinforcement in the form of attention and interactive play contingent on MVPA (Larson, 2013).

Furthermore, in regard to social positive reinforcement and function-based interventions for maintaining physical activity, Zerger et al. (2016) conducted a study in which a functional analysis was used to assess which social consequence would increase levels of MVPA in young preschool aged children. They assessed the social consequence provided contingent upon as well as independent of MVPA. Results indicated that the specific social consequence identified as the reinforcer through the prior functional analysis is the one that should be provided as a social consequence in order to increase levels of MVPA (Zerger et al., 2016).

Along with consequent social positive reinforcement, Gonzales et al. (2020) designed a study in which the researchers manipulated environmental variables in the form of peer

presence. The researchers assessed MVPA levels in three preschool aged children across a variety of conditions including no adult, attention, and interactive play, both with and without peer presence. Results of the study indicate that all three participants displayed higher levels of MVPA during the interactive play condition in the presence of peers (Gonzales, 2020).

Much of the previous functional analysis research on physical activity involves trained observers and a coding system for data collection, which has a high observer burden and requires multiple individuals in addition to the participant and experimenter to be present for each research session. Other studies on physical activity involved quantitative measures of data collection of physical activity through the use of mechanical instruments, such as pedometers (Normand, 2008; VanWormer, 2004). Although mechanical data collection is typically very easy to use and has a very low observer burden, these forms of data collection do not provide information on the qualitative aspects of the physical activity, such as activity type and setting (Camp & Hayes, 2012). Recently, newer mechanical technology that can assist with these shortcomings, include a variety of apps on both Apple® and Android® operating systems, have been developed. These apps allow individuals to categorize their activities. Furthermore, a variety of brands (e.g., Fitbit, Garmin, Fossil Sport, Samsung watch) have smart technology available, which can not only sense and register a variety of physical activities but can also allow manual categorization of activity prior to engagement. Both the qualitative and quantitative data from these devices can then be exported for analysis.

Currently there is limited research on the function of physical activity engagement for a broader population. More information is needed in regard to the function of adult physical activity. Identifying the function of adult physical activity would allow for the possibility of more successful intervention planning, along with the creation of environmental factors to sustain engagement in physical activity behavior. Therefore, the purpose of the current study

is to extend the work of Larson et al. (2013) to investigate the maintaining effects of consequent environmental factors on at-home physical activity in neurotypical adults using mechanical data collection. Maintaining effects of physical activity will be analyzed through engagement in the form of duration of physical activity and will be observed in five conditions: attention, no interaction, escape, tangible, and control.

Method

Participants and Setting

The participants in this study were two adult individuals with no predetermined underlying medical conditions, all of whom reported to engage physical activity. Exclusionary criteria included individuals with insufficient engagement in physical activity defined as less than 30 min three times a week, as physical activity engagement was required by participants in order for the experimenters to conduct an experimental analysis. Participants needed a generic doctor's note of approval, confirming that the participant was of appropriate health status and was allowed to participate in physical activity before proceeding with participation in the study along with a signed consent form. Participants needed to have an Apple iPhone® with text message capabilities.

The setting of the study was each participant's own natural environment (e.g., own home, neighborhood, nature trail, gym). Although physical activity within a gym setting was acceptable, there was no gym requirement for participation in the study. Participants were provided with a study welcome email including links to resources, which provided a variety of free trials for apps and livestreams with at-home workouts for participants to choose from (e.g., obe fitness, Fhitting Room). Participants were not obligated to choose their workouts from the list provided.

Response Measurement

The target behavior in this study was engagement in physical activity. Physical activity engagement was defined as participation in any form of physical activity that was able to be recorded in the MapMyFitness® app. The dependent variable (DV) and property of the behavior that was recorded and analyzed was duration of engagement in physical activity in minutes, as recorded via MapMyFitness® app linked to an Apple Watch®. Each participant's MapMyFitness® account was then electronically linked to the researchers' MapMyFitness® account such that data could be shared between devices. This provided access to the participant's self-reported workout time stamps, from beginning to end, along with the workout type, the caloric expenditure, and the heart rate of the participant. The participant could choose any type of physical activity as long it was able to be tracked through the MapMyFitness® app.

In order to collect the duration of physical activity, the participant had to press the "start workout" timer button at the beginning of their workout (refer to appendix for each step). Once they had completed their workout, they pressed the "pause" button to end their workout and then held down the "hold to finish" button, followed by the "save workout" button. The MapMyFitness® app then displayed a duration of the workout, which could be viewed by the participant and by the researcher. The data were extracted from the app by the researcher recording this duration value displayed by the MapMyFitness® app into a spreadsheet for visual analysis. Participants were instructed to keep their Apple Watch® devices on their person at all times for accurate tracking of physical activity engagement.

Interobserver Agreement and Treatment Integrity

For the purpose of interobserver agreement (IOA), a second researcher accessed the data from the MapMyFitness® app and recorded the duration of engagement in physical activity in minutes for each participant for 100% of sessions. IOA was calculated using exact agreement IOA and was derived by dividing the number of agreements between both

researchers by the number of agreements plus disagreements and turning the product into a percentage. Exact count IOA was 98% for Participant 1 and 97% for Participant 2.

To monitor treatment integrity, consequence delivery from the researcher was recorded through the use of analysis of timestamps in text message sent to the participants during each session in the applicable conditions. The researcher compared the timestamps of the text messages with the Map My Fitness® start and end times of each workout in each session. Correct and incorrect (i.e. incorrect consequence delivery or no delivery) deliveries were recorded in an Excel document. All appropriate and timely consequence (text notifications) deliveries made with in 2 min of the participant reaching the response requirement were marked as correct responses by the researchers. Deliveries that were not captured through the use of text message were not delivered within 2 min were marked as incorrect. A treatment integrity coefficient was derived by dividing the number of correct (appropriate and timely deliveries) by the number of correct plus incorrect (deliveries that are not made or exceed the 24-hr delivery period) and converting the product into a percentage. Treatment integrity data was collected for 100% of sessions for each participant. Due to a technical glitch in the Map My Fitness® app along with a miscommunication among researchers' treatment integrity was 95% for Participant 1, and treatment integrity for Participant 2 was a 100%.

Experimental Design

The study was conducted in an multielement design embedded within an ABA reversal design. The first and last phase of the evaluation was a series of baseline sessions. In the multielement phase, the conditions were alternated in a randomized sequence and included attention, escape, tangible, no interaction, and control.

Procedure

A preference rank assessment (Wine, Kelley, & Wilder, 2014) was conducted with each participant prior to the beginning of the study in order to determine what gift card option would be delivered as a potential reinforcer during the tangible conditions. Similarly to Wine et al., the preference ranking assessment had a list of options for participants to rank from most preferred gift card options (score 1; i.e., willing to complete the most amount of work for this option) to least preferred gift card options items (score 3; i.e., willing to complete the least amount of work for this option). The list of gift card options included Dunkin Donuts, Panera, and Starbucks.

Each Sunday evening during the study, the participants scheduled four workout sessions to take place during the week; this allowed for three rest days, or "off-days", each week. Each session took place on one day. Each workout session was at least 30 min in duration and had to be scheduled on separate days (i.e., two workout periods could not occur on the same day). The session conditions were alternated through a random generator by the researcher across the pre-selected workout days in order to reduce the likelihood that a participant would be able to accurately predict a future day's contingency. Control sessions took place on rest days.

At the start of each workout after confirming with the researcher through text message that they were beginning their workout, each participant was briefed by the researcher with a short text message including a description of what the scheduled condition for that day would entail. Participants were also reminded to save and end their workouts through the Map My Fitness® app at the end of their workout.

Baseline. The purpose of this condition was to determine what the participant's naturally occurring physical activity typically consisted of in the absence of social consequences implemented by the researcher. During this condition there were no programmed consequences for physical activity.

Attention. The purpose of this condition was to determine if the participant's engagement in physical activity was maintained by social-positive reinforcement in the form of attention. During this condition, once the participant began tracking their workout and 5 min had elapsed, they received praise in the form of a text message which read "Way to go! Keep it up!", "You're doing great!", "Awesome! Keep going!", etc. The participant continued to receive praise in the form of text message for every 5 min that they continued to engage in physical activity. When the individual completed their engagement in physical activity by selecting "End" in their fitness tracker (which notified the researcher), they would receive immediate praise in the form of text message. If the participant did not engage in physical activity, they received no attention of any kind.

Escape. The purpose of this condition was to determine if the participant's engagement in physical activity was maintained through negative reinforcement in the form of escape from tasks. During the escape condition, the task assigned consisted of online learning modules through the Rollins College Learning Management System, Canvas®. These learning modules were related to overall health and fitness and provided participants with educational information and totaled approximately 30 min. The participants were instructed at the beginning of their workout period for the day that they could either complete their workout or complete learning modules. For every 5 min that the participant engaged in physical activity, a training module would be removed from their Canvas module to-do list. The participant received a text message notification within 2 min of every 5 min interval that they engaged in physical activity which read "Great job, keep it up! One learning module has been removed". After 30 min of engagement in physical activity all components of the online training module were removed. The participant received a text message notification informing them that all components of the online training module had been removed at the end of the 30 min mark of tracked engagement in physical activity. If the participant did not

engage in physical activity during their specified time, they received a notification every 10 min informing them that they needed to work on their online training modules. These notifications continued until the training modules were complete or 90 min from the start of their scheduled workout period had elapsed.

Tangible. The purpose of this condition was to determine whether engagement in physical activity was maintained by positive reinforcement in the form of tangible items. For every 5 min that the participant engaged in physical activity during their scheduled workout period, the participant received a text message indicating that they had received $1.00 toward their highest preferred reinforcer (determined from their survey). The text message read “Great job working out, keep it up, you have earned $1 dollar toward your gift card”. If the participant completed all 30 min of physical activity during their workout period, they earned $6.00 in the form of a gift card toward their tangible reinforcer. The tangible reinforcer was delivered virtually within 24 hr (i.e., money was added to a gift card that could be accessed by the participant). If the participant did not engage in physical activity, they did not receive any form of tangible item.

No interaction. The purpose of this condition was to determine if the behavior was maintained by nonsocial reinforcement. During this condition there were no programmed consequences for engagement or lack of engagement in physical activity; however, the participant was provided with an “okay” or thumbs up emoji response when they confirmed with the researcher that they were beginning their workout.

Control. The purpose of this condition was to function as a control for potential confounding social variables of the other conditions such as attention and researcher interaction. This condition was conducted on the scheduled rest or “off” days. During these pre-selected control condition days there were no programmed consequences.

Results

Figure 1 depicts the results for both participants across a multielement experimental design embedded within an ABA reversal. Participants 1 and 2 displayed automatically maintained physical activity, as evidenced by the undifferentiated data paths for both participants.

Participant 1 displayed a decreasing trend in duration of physical activity engagement during baseline. During the multielement phase there was a slight increase in duration of physical activity from baseline to the first series of experimental conditions, followed by a steep decreasing trend to 0 min of activity from session 19 to 25. The last two series depict an increasing trend at which duration of physical activity stabilizes with a moderate level ranging from 32.9 min to 38.8 min. Responding in each of the test conditions was differentiated from the control condition but was undifferentiated among all test conditions. The multielement phase was followed by a return to baseline during which a decreasing trend was observed.

Participant 2 displayed moderately high physical activity engagement with some variability during the first baseline condition. During the multielement phase of the experimental analysis Participant 2 engaged in moderate (i.e., 25 min) to high (63 min) durations of physical activity engagement across all conditions displaying an undifferentiated pattern of responding. There was slightly higher physical activity engagement in the last two sessions of the tangible and no interaction conditions compared to the control condition. This multielement phase was followed by the second baseline condition during which behavior was variable.

Discussion

In this study, we extended the research by Larson et al. (2013) to an experimental analysis of physical activity engagement with adults. Larson et al. (2013) conducted an experimental analysis that evaluated physical activity in typically developing preschool aged

children, using a coding system to decipher level of moderate-to-vigorous physical activity (MVPA). The four conditions evaluated were alone, attention contingent on MVPA, adult interaction contingent on MVPA, and escape from task demands contingent on MVPA; all of which were conducted on an outdoor playground at a day-care center. In the current study we also conducted an experimental analysis but with a different population; typically developing adults. Our study also used a different form of mechanical data collection, MapMyFitness® app through Apple Watch®, that alleviated the experimenter burden of having to learn and use the MVPA coding system. Unlike Larson et al. (2013), this study was conducted remotely due to the COVID-19 pandemic and therefore some of the conditions had to be altered. Rather than attention and adult interaction condition contingent on MVPA along with an alone and escape condition, the conditions of the current study included a no interaction, attention, tangible, and escape all of which were also compared to the baseline and control conditions.

Although it is not common practice within behavioral physical activity research, conducting an analysis of the maintaining variables in the environment has its benefits in that it provides more detailed information about the contingencies and their effects upon the behavior under analysis. This knowledge could help health and fitness behavior analysts to create successful intervention programs that their clients will be fully engaged in and allow them to contact true reinforcers rather than speculated or potential reinforcers.

The current study chose to measure the duration of physical activity as the DV, but it may have been sufficient to measure the presence or lack thereof of physical activity engagement as well. Future research may choose to evaluate physical activity through a trial-based FA. A challenge with using a trial-based FA is the heavier reliance on the establishing operations (EOs); therefore, we chose to use a standard FA instead.

As a whole the extent of experimental control for participant 1 and 2 is limited due to confounding variables throughout the study. Participant 1 displayed consistent levels of behavior for most experimental condition sessions but had a significant decrease in physical activity during sessions 19 through 25. It is hypothesized that the participant might have forgotten to work out or simply chose to skip out on physical activity engagement due to self-reports of being on vacation for the end of year holidays. It is interesting to note that Participant 1 often times engaged in physical activity in the no interaction condition but consistently did not engage in behavior in the control conditions, even though they have nearly identical consequences. This indicates that the precommitment response of telling the researcher when they were going to work out potentially had a significant effect on the participant's behavior rather than simply the independent variable of the environmental changes implemented. However, the differentiation from the test conditions in comparison to the control condition adds strength to the experimental control of the study.

Participant 2 displayed consistent levels of behavior throughout all experimental conditions including both baseline and control conditions, which further supports the likelihood of an automatic function for physical activity engagement. However, the lack of differentiation among test conditions in comparison to the control condition weakens the strength of the experimental control. Although the confound variables of the study question the overall strength of the experimental control, there is a slight demonstration of strength in the experimental control in that we see a potentially predictable change in behavior due to the increase in duration of physical activity engagement for participant 2 in the 2nd and 3rd out of the 3 tangible conditions. This indicates that the tangible item (IV) provided may have had the ability to increase the duration (DV) of physical activity engagement in these conditions of the experimental analysis, extending the sessions during this condition would help clarify if participant 2 may also display a tangible function.

The findings of this study impact both behavior analysts and fitness professionals alike, in that it further extends the current work of fitness professionals within behavior analysis and displays its applicability to other aspects of ABA. In regard to the field of fitness, it may be helpful to a personal fitness trainer to have a systematic method of evaluating what variables both increase behavior in their clients as well as what variables may have the ability to maintain physical activity long term. A trainer may find that (similarly to Participant 2) although a client may engage in physical activity due to automatic reinforcement, a client may have secondary functions to their behaviors such as access to tangibles. Evaluating and acquiring this kind of information about the behaviors of their clients further promotes success (e.g., increase in physical activity) not only for their clients but for the trainers themselves, as the success of their clients in turn brings the trainer even more opportunities.

Furthermore, an important contribution of this study is that to our knowledge this experimental analysis is the first application of functional analysis (FA) methodology with neurotypical adult individuals. The use of FA methodology with neurotypical adults attempts to further the current knowledge base and displays the significance of interdisciplinary research. This study although contains several confounding variables attempts to lay some groundwork for future researchers to build on.

Another strength of this study was the mechanical data collection used. Although it did incur some costs this method of data collection provided a multitude of dependent variables along with the duration measure that was used in the current study. A future study could choose to expand upon the current study and analyze other dependent variables that may be affected through the manipulation of the independent variables.

A major limitation of this study was the remote setting aspect of this study. Although it was a necessary component due to the COVID-19 pandemic, it added confounding

variables to the study that therefore weakened the internal validity of the study. The remote aspect of the study provides a benefit for participants in that they are in their own natural setting, but it also presents a challenge in that there is no way to confirm that the participants fully read the instructions that were provided to them, manipulated data collection in any way, or if they were even the actual individuals wearing the watches. Future studies could create "live tracking" options that are more efficient to locate, cost effective, and user friendly.

Another limitation of this study was the use of randomized trials instead of fixed trials or conditions because it is unknown if there would have been quicker or more distinguished differentiation in the data paths had there been fixed trials. Future studies could strengthen their ability to display experimental control by using fixed trials instead of randomized trials during their multielement conditions. It is also unknown how differentiated the conditions of the multielement phase may have been to the participants. During the escape condition, multiple consequences were provided (i.e., praise and removal of learning modules) in the written consequence "great job, a learning module has been removed". Future studies could evaluate the reinforcing value of escape alone by removing the "great job" and simply informing the participant "a learning module has been removed".

An additional limitation of this study is that if the participant elects to not engage in physical activity or simply forgets to work out (e.g., Participant 1 during sessions 19-25), they may never contact the environmental changes provided by the researchers. This was less likely to occur during the current study because the study requirements included that participants had to be currently engaging in physical activity regularly. The current study evaluated behavior that was already occurring rather than specifically increasing physical activity; however, future studies that evaluate variables creating an MO for evoking engagement in physical activity may have an increased likelihood of zero responding.

An additional potential limitation is that it is unknown if researcher attention in the form of praise functioned as a reinforcer for participants. Adults may engage in physical exercise to access attention via engagement on social media posts, for example; this form of attention would not be captured adequately in the consequence in the current experimental analysis. Future research could use the participant's friends or family to deliver reinforcement in order to control for the potential for researcher attention not functioning as a reinforcer.

Obesity poses a major health risk among society. Behavior analysis provides the technology to modify several health-related behaviors that contribute to the risk of developing obesity, including but not limited to caloric consumption, caloric expenditure, and types of physical activity. In the current study, we focused on the manipulation of physical activity in order to increase caloric expenditure and therefore assist in the aspect of preventative measures against obesity. Future research could target obesity by evaluating the assessment and manipulation of caloric consumption and expenditure. Furthermore, with an assessment of caloric consumption and expenditure, researchers could then create a program or methodology to systematically create caloric consumption behavior change programs in order to promote healthy eating habits.

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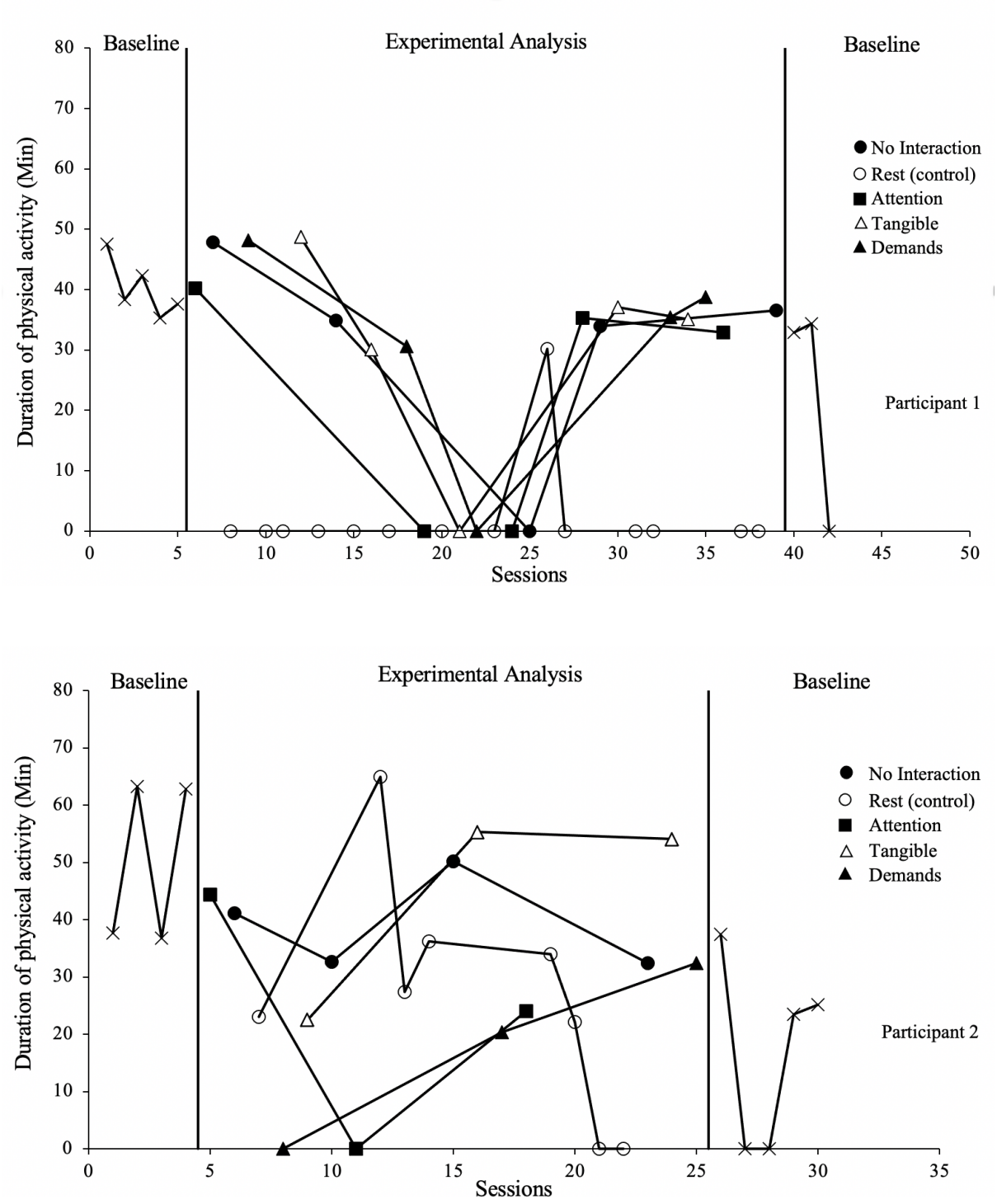
Figure 1

Experimental Analysis Results for Two Participants



Appendix: Map My Fitness® app