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Sensor-Enabled Reduction of Stereotypy

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Abstract

The goal of this study was to create and implement an intervention to reduce stereotypic behavior in a child with Autism. The participant was chosen based on a high occurrence of target behavior and was recruited through his treatment center. The target behaviors were selected based on the subjective evaluation of his treatment provider and parents. The dependent variable in this study was hand-flapping. The independent variable was DRO training that included a buzzer and a chime noise contingent on the presence or absence of stereotypy respectively. A Microsoft Kinect© 2.0 was used to track occurrence of target behavior and interact with a software program to deliver the IV contingent on the occurrence of the dependent variable. It is expected that the IV will result in a decreased frequency of the target behavior. This study will demonstrate the potential for automated implementation of a behavior plan to reduce stereotypic responses in children diagnosed with autism. The software and sensor keep interval time and signal a successful or failed interval; therefore making it easier for tutors, teachers, or parents to implement behavioral interventions, such as DRO, with children.

Keywords: stereotypy, autism, sensor, Kinect

Sensor-Enabled Reduction of Stereotypy

Stereotypy is a broad term that covers many different physical and vocal behaviors. These can include hand clapping or eye poking (Hansen & Wadsworth, 2014), hand mouthing or body rocking (Rapp, 2005), or vocal echolalia (Brusa & Richman, 2008). Stereotypy is likely maintained by automatic reinforcement, making it especially challenging to reduce. These behaviors become problem behaviors worthy of reduction when they disrupt a child's learning experience, cause social stigmatization, or cause self-injury. Frequent hand flapping can occupy time that could be spent learning to mand with sign language or to use a picture exchange communication system. Vocal echolalia could bring unwanted attention to a child, marking the child as different and resulting in the child's being treated differently than his or her peers. Stereotypic movements are one of the most common behaviors seen in individuals with Autism Spectrum Disorder (ASD) (Goodwin et al., 2008). It is therefore necessary to conduct studies that attempt to reduce stereotypic behaviors in children with ASD.

Many different interventions have been used in attempting to reduce stereotypy in children and adults with ASD. Environmental enrichment strategies aimed at reducing motivating operations associated with stereotypy have proven to be effective, stressing the importance of creating antecedent interventions based on the functions and topography of stereotypic behavior (Hansen & Wadsworth, 2014). A therapy developed by Boyd et al. called Family-Implemented Treatment for Behavioral Inflexibility (FITBI) was proven effective in reducing stereotypy, and also highlighted the importance of creating an intervention that can be implemented by parents (2011). Self- recording and self-management procedures, however, have not yielded results that show a reduction in stereotypic behavior (Fritz et al., 2012). Although self-management has not been effective, other studies have attempted to maintain a level of autonomy in participants of interventions intended to reduce stereotypy. Brusa and Richman conducted discrimination training that allowed participants to ask for breaks in which they were allowed to emit stereotypic behaviors (2008). In this way, the child was able to discriminate between a classroom environment and a break environment, and was able to learn to ask for breaks to avoid the disruption of learning.

Much research has been conducted on the contingencies that maintain stereotypy. Contingent time-out has proven to be effective in the reduction or some stereotypic behaviors (Rapp, 2005). With the discovery by Rincover et al. that human mediation is unnecessary in the reduction of stereotypy (1979), the use of sensors has become a viable and effective option for the passive collection of data (Goodwin et al., 2008).

The purpose of this study was to combine the findings of Rapp (2005), Goodwin et al. (2008) and Rincover et al. (1979) to create an intervention that would reduce stereotypy in individuals diagnosed with ASD. The intervention used in the study was Differential Reinforcement of Other Behavior (DRO) training that included a buzzer tone and a chime tone contingent on the presence or absence of stereotypy respectively. A laptop computer equipped with a Kinect sensor monitored stereotypic responses of children with ASD and collected data on operationally defined forms of stereotypy. A companion software program automatically provided the buzzer and chime tones when the children exhibited target stereotypic responses.

This study expands previous research on the reduction of stereotypy in individuals with ASD by determining whether or not a sensor-enabled DRO procedure is an easy and effective way to reduce stereotypic behaviors in children with ASD. The study advances the previous research by evaluating an intervention that can be used in a variety of settings. This allows for the continued use of the intervention by parents of children with ASD. This study is a step towards creating an easily accessible, sensor-enabled intervention that families and education centers can use daily to aid in the reduction of behaviors that might otherwise inhibit the acquisition of functional skills.

Methods

Design

The study used a reversal design. Initial baseline was collected from previous semesters. Additional baseline was conducted with the addition of the new stimulus without the addition of the IV to the environment. The participant played in a playroom with a tutor, occasionally running Discrete Trial Training (DTT). A camera was set up to record video and audio for the duration of every session. Sessions were twenty-minute sessions conducted three times per week.

The baseline condition consisted of the participant behaving in the same room in which the experimental conditions were held. The Kinect was set up exactly as it was during intervention phases, but only the natural contingencies of stereotypy were present. There were two baseline conditions, one without the presence of the Kinect and a later one with the physical presence of the Kinect in the environment.

The independent variable was a DRO procedure. With a timer running, if no stereotypy was exhibited for 30 seconds, a chime sound was played. Following the chime, the tutor provided the participant with praise and an edible reinforcer. If the participant engaged in stereotypy at any point during the interval, a buzzer tone was played, and the timer reset. Software specifically designed for the intervention measured occurrences of stereotypy and temporarily disabled the video and audio playback of the preferred program. The data from the software contained signifiers indicating when the IV was in effect. Over time, predetermined phase change criteria was followed, and the interval was increased by 10 seconds with each successive phase change.

An individualized response definitions was developed based on the topography of the stereotypic behavior the participant. The primary target was hand flapping. This was operationally defined as repetitive rotation of the wrist with at least two direction changes per second. A non-example was moving from palm up to palm down position. Dependent variables were also defined by the software used to implement the intervention. It defined target behaviors based on a complex mathematical interpretation of video input during sessions. Target behaviors that followed another by more than 2 seconds were counted as separate occurrences. The frequency, rate, and duration of stereotypic responses was measured by the software. The primary measure analyzed will be frequency.

Participant

The study included one participant. The participant attended a private autism center run through Western Michigan University. The participant engaged in some form of stereotypy an average of 50 times over the course of an eight hour school day and had been engaging in it for at least a year. The participant was recruited through his center and was referred for inclusion based on his level of stereotypic behavior. Informed consent was obtained from the parents/guardians of the participant.

Procedure

Sessions were conducted 3 times a week and lasted twenty minutes each. At the beginning of the session, the Kinect™ sensor was connected to the laptop and set up so that it could adequately capture the participant's movements. A video camera was also set up to record audio and video of the participant for the duration of the session. The laptop screen displaying the Kinect interface was also recorded using a screen capture program on the laptop, in order to assess the reliability of the Kinect program's tracking of the participant's movement. During the session, a tutor conducted Discrete Trial Training (DTT) procedures with the participant. If no stereotypy was detected by the sensor for 30 seconds, a chime sound was played and the tutor provided praise and an edible reinforce to the participant. If the sensor detected an instance of stereotypy, a buzzer tone was played. The timer was reset following the delivery of this tone, and continued to reset until the sensor no longer detected stereotypy. Phase change criteria were three consecutive sessions with 20% or less of intervals containing stereotypy, or two consecutive sessions with 10% or less of the intervals containing stereotypy. Data were collected automatically by the software. Observers later took data by marking tallies on a data sheet on Google Drive while watching the audio and visual recordings of the session taken by the camera and the screen recording.

Setting and Materials

The study was conducted at the Kalamazoo Autism Center (KAC), a private autism center run by Western Michigan University. The participant and his tutor were sitting in a play area surrounded by shelves containing toys. The classroom contained other students and their tutors. The Kinect™ sensor was placed so that it was facing the participant as directly as possible without disrupting the participant or tutors.

Software that was created especially for the intervention was used to recognize instances of stereotypy and deliver the chime or buzzer tone. The software was used in conjunction with a laptop computer and a Kinect™ sensor to measure the participant's responses. A video camera was used to record audio and video for the duration of the session. The recordings from this camera were viewed by observers in order to take data.

Results

Baseline data showed the frequency of stereotypy to be between one and eight occurrences for most sessions, with one outlier of seventeen occurrences in the second session. In the phase of the 30-second DRO procedure, involving automatic delivery of the tones, responding in a session generally alternated between three and eleven occurrences of stereotypy. In the alternate sessions of high responding, frequency of stereotypy gradually increased to a high of thirteen occurrences in a session. In the subsequent baseline phase, frequency of stereotypy decreased to between eight and zero occurrences in most sessions. During the final 10 and 15-second DRO procedure phases, in which the tones were manually delivered, frequency of stereotypy generally remained below three occurrences in a session, with an outlier of nine. Reliability remained at 80% or higher throughout the sessions.

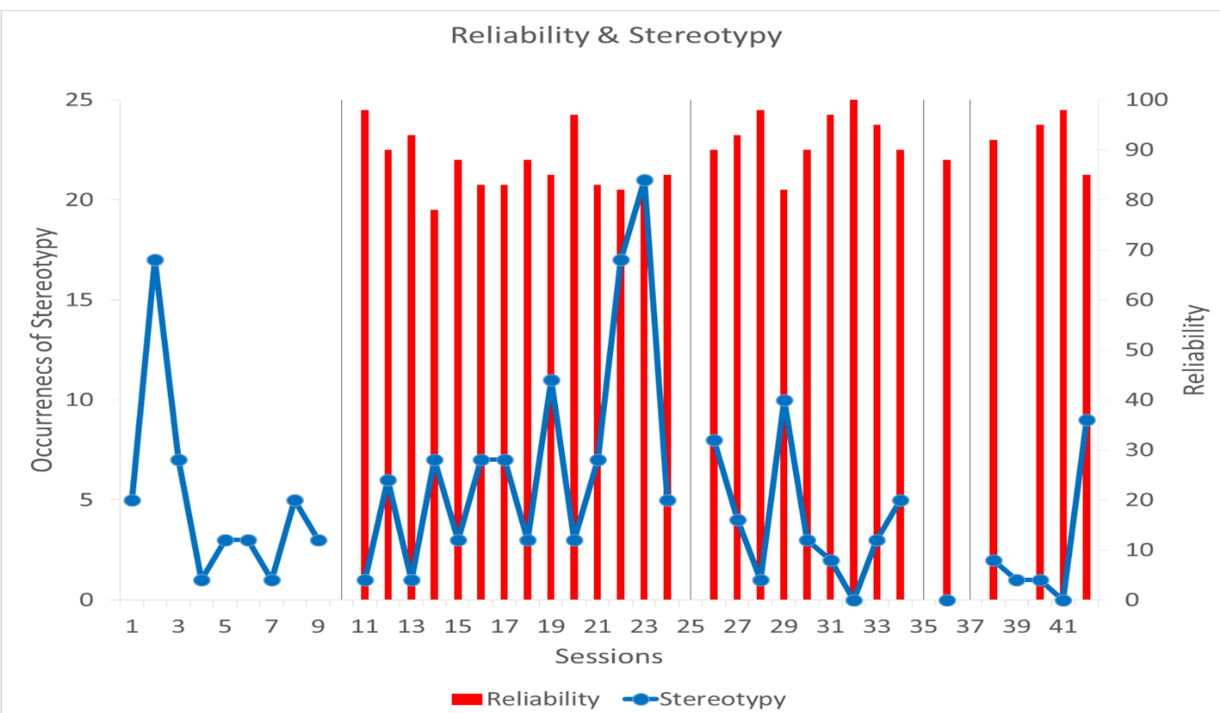

Figure 1. Graph illustrates occurrences of hand flapping in each session, as well as the reliability percentage of each session.

Discussion

Most limitations to the study involved problems with the Kinect and the program used to track hand flapping. One of the most substantial limitations was the frequency of false positives. The program would issue the buzz when no hand flapping had occurred. These false positives were caused by the Kinect's misrepresentation of the skeleton frame imposed on the participant and tutors on the display screen. The skeleton tracking the participant would often glitch and move rapidly away from the participant's body and back again. This often occurred because the Kinect could not easily track the participant if the participant was not upright and facing the sensor. Because the program would also often track the tutor, the tutor's skeleton would glitch, which interfered with the tracking of the participant. The researchers attempted to fix this problem by using items to block the Kinect from tracking the tutor. Another less frequent type of false positive occurred when the participant would move his hands in an appropriate way, such as waving to someone. The false positives meant that appropriate behaviors were sometimes punished. Buzzes issued by the program in the absence of occurrences of stereotypy caused the tutor to mistrust the program. This meant that when the program delivered accurate buzzes, the tutor would sometimes fail to acknowledge them. False negatives also occurred frequently, as the program would fail to deliver a buzz in the presence of hand flapping.

The technology used was another limitation to the research. The laptop and Kinect used sometimes malfunctioned. This caused loss of video, gaps in the video, and/or delays in the sessions. This technology was also expensive, so parents or educators wishing to utilize the intervention would need a considerable amount of money available. Also, because of the amount of technology utilized, much time was required to set up and take down the experiment before and after session. This makes the intervention difficult to replicate.

Other limitations arose from the environment in which the study took place. Because the classroom was noisy and the participant was often focused on playing, the participant either did not hear or did not attend to the buzz or chime sounds. When the participant did attend to the buzzer, the researchers sometimes observed an increase in stereotypy contingent on the buzz, suggesting that the buzz sound may have reinforced hand flapping behavior. Intervals were sometimes interrupted because of the movement of other students and tutors in the classroom environment. Students and tutors would walk in front of the Kinect and interrupt the feed, thus resetting the interval timer. The timer would also reset when the participant left the area that the Kinect was tracking. The program itself sometimes lost track of the participant's skeleton, which also interrupted the interval timer as it would not restart until the skeleton came back on the display screen. A potential confound to the study arose due to the play room environment. When the participant spent more time playing with toys, there were less instances of hand flapping. This suggests that playing with toys may have decreased stereotypic behavior.

Another limitation was the use of a reinforcer that was not in the same stimulus class as stereotypy. Working under the assumption that the participant's stereotypy was automatically maintained, an edible reinforcer was delivered.

A final limitation was that effort was required to track the participant, making the study more intrusive and environment less natural. Because of all of the above limitations, steps were taken to ensure that the participant and tutors were in the best position possible in order for the program to work properly. The researchers communicated with the tutors during sessions, suggesting ways in which they could position themselves or the participant so that the Kinect could better track the participant. The tutors often told the participant to sit up or face the Kinect, which made for an inorganic play environment. This may have altered the participant's behavior in an unintended way.

After seeing a trend of increased frequency of stereotypic behavior in the 30-second automatic DRO procedure, the researchers returned to baseline in order to rule out the possibility of the buzzer tone's reinforcing hand flapping behavior. The following phases of 10 and 15-second manual DRO procedures were then added to establish better stimulus control of hand flapping. The automatic programs delivered too many false positives, which may have decreased the buzzer tone's stimulus control of the hand flapping behavior.

The researchers observed many variables that may have affected the rate of stereotypy. Which location the session was conducted in, which tutor the participant worked with, and which toys the participant played with all may have had some effect on the rate of stereotypy. For example, when the participant played with food toys, a higher rate of stereotypy was generally observed. Similarly, the presence particular tutor seemed to elicit a higher rate of hand flapping behavior. What type of work the child was doing during sessions and the temporal proximity to reinforcement also seemed to influence the frequency of hand flapping.

Future research could involve conducting this experiment in a more controlled environment, in order to limit many of the limitations listed above. This would allow the researchers to focus more on the reduction of stereotypy. However, studies such as this one conducted in natural play or classroom environments are worth replicating in order to learn more about the limits of sensor enabled tracking of stereotypy.

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Appendices

Appendix A: Intervention Data Sheet

			Conditions:				
Interval	Occurrence	Buzz	Agree	Skeleton on?	Distance?	Poor track?	Real distance in inches
:00 - :09			yes				4.666666667
:10 - :19			yes				4.666666667
:20 - :29			yes				4.666666667
:30 - :39			yes				4.666666667
:40 - :49			yes				4.666666667
:50 - :59			yes				4.666666667
1:00 - 1:09			yes				4.666666667
1:10 - 1:19			yes				4.666666667
1:20 - 1:29			yes				4.666666667
1:30 - 1:39			yes				4.666666667
1:40 - 1:49			yes				4.666666667
1:50 - 1:59			yes				4.666666667
2:00 - 2:09			yes				4.666666667
2:10 - 2:19			yes				4.666666667
2:20 - 2:29			yes				4.666666667
2:30 - 2:39			yes				4.666666667
2:40 - 2:49			yes				4.666666667
2:50 - 2:59			yes				4.666666667
3:00 - 3:09			yes				4.666666667
3:10 - 3:19			yes				4.666666667
3:20 - 3:29			yes				4.666666667
3:30 - 3:39			yes				4.666666667
3:40 - 3:49			yes				4.666666667
3:50 - 3:59			yes				4.666666667
4:00 - 4:09			yes				4.666666667
4:10 - 4:19			yes				4.666666667
4:20 - 4:29			yes				4.666666667
4:30 - 4:39			yes				4.666666667
4:40 - 4:49			yes				4.666666667
4:50 - 4:59			yes				4.666666667
5:00 - 5:09			yes				4.666666667
5:10 - 5:19			yes				4.666666667
5:20 - 5:29			yes				4.666666667
5:30 - 5:39			yes				4.666666667
5:40 - 5:49			yes				4.666666667
5:50 - 5:59			yes				4.666666667
6:00 - 6:09			yes				4.666666667
6:10 - 6:19			yes				4.666666667
6:20 - 6:29			yes				4.666666667
6:30 - 6:39			yes				4.666666667
6:40 - 6:49			yes				4.666666667
6:50 - 6:59			yes				4.666666667
7:00 - 7:09			yes				4.666666667
7:10 - 7:19			yes				4.666666667
7:20 - 7:29			yes				4.666666667
7:30 - 7:39			yes				4.666666667
7:40 - 7:49			yes				4.666666667
7:50 - 7:59			yes				4.666666667
8:00 - 8:09			yes				4.666666667
8:10 - 8:19			yes				4.666666667
8:20 - 8:29			yes				4.666666667
8:30 - 8:39			yes				4.666666667
8:40 - 8:49			yes				4.666666667
8:50 - 8:59			yes				4.666666667
9:00 - 9:09			yes				4.666666667
9:10 - 9:19			yes				4.666666667
9:20 - 9:29			yes				4.666666667
9:30 - 9:39			yes				4.666666667
9:40 - 9:49			yes				4.666666667
9:50 - 10:00			yes				4.666666667
Totals	0	0					