

Increasing Compliance with Wearing a Medical Device in Children with Autism

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Abstract

Health professionals often recommend the use of medical devices to assess the health, monitor the well-being, or improve the quality of life of their patients. Children with autism may present challenges in these situations as their sensory peculiarities may increase refusals to wear such devices. To address this issue, we systematically replicated prior research by examining the effects of differential reinforcement of other behavior (DRO) to increase compliance with wearing a heart rate monitor in 2 children with autism. The intervention increased compliance to 100% for both participants when an edible reinforcer was delivered every 90 s. The results indicate that DRO does not require the implementation of extinction to increase compliance with wearing a medical device. More research is needed to examine whether the reinforcement schedule can be further thinned.

Keywords: autism, compliance, differential reinforcement, heart rate monitor, intervention

Increasing Compliance with Wearing a Medical Device in Children with Autism

Health professionals may require that their patients wear a medical device (e.g., heart rate monitor, prosthesis, prescription glasses, medical bracelet, electroencephalograph) to assess their health, to monitor their well-being, or to improve their quality of life (Cuvo, 2011). Children with autism spectrum disorders (ASD) who have limited, or no, means of communication may benefit from such technology, as they may be unable to report important medical information (e.g., abnormal internal sensations, feelings of anxiety, allergic reactions). One potentially relevant area of application is for the measurement and monitoring of stress. Researchers have suggested that health professionals may assess the stress levels of children with ASD who have no functional form of communication, by monitoring heart rate in combination with other measures (Gabriels et al., 2013; Hollocks, Howlin, Papadopoulos, Khondoker, & Simonoff, 2014). Notably, these devices (e.g., heart rate monitors, electrodermal sensors) can detect and report increases in levels of stress and anxiety (Fletcher et al., 2010; Poe, Swenson, & Picard, 2010), and may be used to suggest interventions to prevent these manifestations (Liu, Conn, Sarkar, & Stone, 2008).

When an individual has limited means of communication, using heart rate monitors allows for the collection of data on levels of stress that could not have been recorded with other traditional methods (questionnaires, interviews). In addition to monitoring physical health, cardiac measurements have the potential for increasing the understanding of challenging behavior, and eventually guiding the selection of interventions. As stress and anxiety may function as motivating operations (MOs) for challenging behavior, behavior analysts should consider their behavioral and physiological manifestations as problems of social significance (Friman, Hayes, & Wilson, 1998). If additional research is conducted to support this approach,

practitioners and researchers may eventually use heart rate to monitor the presence or absence of physiological MOs. That said, children with ASD may have increased rates of refusal to wear such devices (Johnson & Rodriguez, 2013).

Researchers have shown that behavioral interventions are effective at increasing compliance with wearing medical devices in children with developmental disabilities (Cook, Rapp, & Schulze, 2015; DeLeon et al., 2008; Richling et al., 2011). For example, DeLeon et al. (2008) implemented noncontingent reinforcement (NCR) to increase the wearing of prescription glasses in four participants with intellectual disabilities. Their results indicated that NCR alone increased compliance with one participant, whereas the addition of response blocking and response cost were necessary for the remaining participants. In a replication and extension, Richling et al. (2011) found that NCR alone increased compliance with wearing foot orthopedics and hearing aids in two children with developmental disabilities. More recently, Cook et al. (2015) reported that differential negative reinforcement of other behavior (DNRO) increased compliance with wearing a medical bracelet in one child with autism. Their DNRO procedure consisted of removing the device and praising the child when he was compliant during a predetermined interval. At any other times, the trainer blocked attempts at removing the bracelet.

Both DeLeon et al. (2008) and Cook et al. (2015) implemented response blocking as part of their intervention, which can be a limitation for some individuals. The use of response blocking to implement escape extinction may not be possible or desirable in certain settings or with specific individuals (Athens & Vollmer, 2010). For example, response blocking may lead to aggression (e.g., Hagopian & Toole, 2009), which may prevent its implementation. When NCR alone is ineffective (e.g., DeLeon et al., 2008) and response blocking is not an option,

practitioners and researchers may require alternatives to increase compliance with wearing medical devices.

Differential reinforcement of other behavior (DRO) is an alternative intervention that does not require response blocking. That is, the DRO procedure may prevent the occurrence of challenging behavior that are evoked by the response blocking procedure implemented in DNRO. Researchers have used DRO alone and as part of treatment packages, to increase compliance with medical procedures (Carton & Schweitzer, 1996; Cuvo, Godard, Huckfeldt, & DeMattei, 2010; Cuvo, Reagan, Ackerlund, Huckfeldt, & Kelly, 2010; Goetz, Holmberg, & LeBlanc, 1975; Shabani & Fisher, 2006), but we found no study that focused solely on wearing a medical device. As children with ASD may need to wear medical devices for assessment and treatment of some co-occurring conditions, examining the effects on an intervention that does not require response blocking appears important. The current study is a systematic replication of prior research that implemented interventions to increase compliance with wearing different medical devices (Cook, Rapp, & Schulze, 2015; Richling et al., 2011). Even though several studies demonstrated the effectiveness of behavioral procedures in increasing compliance, we aimed to extend this knowledge by assessing whether a DRO schedule was effective in the absence of an extinction component. Therefore, the purpose of the study was to assess the effects of DRO on compliance with wearing a heart rate monitor.

Method

Participants and Settings

Two children, diagnosed with ASD by an independent multidisciplinary team, participated in the study. The two participants were part of a larger study that required them to wear a heart rate monitor for 30-min periods. More specifically, the university's research ethics

board approved the larger study aimed to identify behavioral correlates of physiological stress. To participate in the larger study, the children had to: (a) already have a diagnosis of ASD, and (b) have a score of 3.5 or more on the verbal communication subscale of the Childhood Autism Rating Scale (CARS-2; Schopler, Van Bourgondien, Wellman, & Love, 2010). This score indicates that speech may be absent or, if present, verbal communication takes the form of peculiar language (jargon or echolalia; Schopler et al., 2010). We included the latter criterion as the larger study focused on children with limited or no functional means of communication. As the larger study involved the measurement of heart rate as a main dependent variable, all children who refused to wear the device (i.e., pull the heart rate monitor off their chest when clipped it on) participated in the present study.

Leo was a 5-year-old boy with severe symptoms of ASD (according to the CARS-2) who did not use functional mands or tacts to communicate. Adam was a 9-year-old boy who also presented severe symptoms of ASD and had no functional means of communication. To our knowledge, neither of the participants used an augmentative and alternative communication system. All sessions took place in each participant's home. Leo's sessions occurred in his basement playroom and Adam's sessions occurred in his family's living room. During the sessions, participants had access to toys they typically interacted with at home. Both participants had access to blocks, three to four books, and a tablet. These items remained consistent across sessions and no other toys were available.

Data Collection and Interobserver Agreement (IOA)

The trainer (i.e., the first author) recorded each session on video and subsequently measured the duration that each participant complied with wearing the heart rate monitor and the frequency of device removal. *Compliance* with wearing the device was defined as the heart rate

monitor being in direct contact with the participant's chest. The participant could touch the device and still be in compliance, but a *noncompliance* occurred as soon as he pulled on the heart rate monitor so that it was no longer in contact with his chest. *Device removal* was defined as the trainer unclipping the heart rate monitor and taking it off the participant contingent on noncompliance. The trainer used continuous recording to measure the duration of compliance with wearing the device as well as the frequency of device removal. For the analyses, she converted the duration measure into a percentage of time by dividing the duration of compliance by the duration of the session (300 s) and multiplying the quotient by 100. A second observer scored 33% of sessions for each participant. The experimenters calculated IOA by using the block-by-block method with 10-s intervals (Mudford, Taylor, & Martin, 2009). The mean IOA scores for compliance and device removal, respectively, were 94% (range, 89% to 97%) and 99% (range, 98% to 100%) for Leo, and 94% (range, 83% to 98%) and 100% for Adam.

Experimental Design and Procedures

The experimenters used a nonconcurrent multiple baseline across participants to evaluate the effects of DRO intervention on compliance with wearing the heart rate monitor and on device removals. Each child first participated in a preference assessment to identify the reinforcer delivered during DRO. Then, the experimenters monitored compliance and device removals across baseline and DRO sessions. The trainer typically conducted 1 to 4 sessions per day, once or twice per week with each participant.

Preference assessment. Prior to baseline, the trainer evaluated each participant's preference for five edible items (M&MsTM, SkittlesTM, Gummy bearsTM, nachos, potato chips) using a paired-choice assessment procedure (Fisher et al., 1992). The parents proposed some of the five edible items, but the trainer made the final selection so that it remained consistent across

participants. All possible pairs were presented in random order with position of placement counterbalanced. The experimenters chose arbitrary rather than functional reinforcers (i.e., escape) because edibles could be consumed in a shorter amount of time and it prevented the use of response blocking. Leo and Adam preferred the potato chips and the nachos, respectively.

Baseline. Each baseline session lasted 5 min and began when the trainer fitted the participant with the heart rate monitor (a Polar H7 Bluetooth Heart Rate Sensor & Fitness Tracker). The therapist started the 5-min timer simultaneously. Although the participant ultimately had to wear the device for 30 min for the larger study, the experimenters targeted 5 min for the current experiment as it was easier to conduct multiple short sessions with the participants to start. Fitting the device involved clipping the strap below the chest muscle while ensuring that the sensor was in contact with the skin. Like the escape condition described in the recent study by Cook et al. (2015), the trainer removed the heart rate monitor for 30 s each time the participant pulled on it so that it was no longer in contact with the skin of his chest. At the end of the 30 s, the trainer refitted the participant with the monitor. The timed 5-min session continued to run whether the participant pulled on the sensor or not. The session ended when 5 min had elapsed

Differential reinforcement of other behavior. The DRO condition was similar to the baseline condition: the session lasted 5 min, the 30-s escape contingency remained in effect and the participant had access to the same toys. However, the trainer simultaneously implemented the DRO intervention. During DRO, the participant received his preferred edible reinforcer if the heart rate monitor stayed in contact with his chest skin for the entire duration of the interval. If the participant met the criterion, the trainer said, “Congratulations”, provided a small piece of edible reinforcer, left the sensor on the participant’s chest, and restarted the timer. As soon as the

participant pulled on the device so that it was no longer in contact with the chest, the trainer removed the sensor for 30 s without saying anything. Following 30 s, the trainer fitted the sensor to the participant and reset the DRO interval. Unlike Cook et al. (2015), the trainer did not provide access to escape based on compliance, nor did the trainer block any attempt to remove the device. Escape remained contingent on noncompliance (i.e., pulling the monitor off his chest).

Whenever the participant achieved the criterion to receive his reinforcer for three consecutive intervals, the trainer increased the duration of the schedule. Contrarily, the participant returned to the previous denser schedule when he failed to achieve the criterion for three consecutive intervals. The duration of the DRO schedule could increase or decrease within a session. The trainer implemented within-session changes in the DRO schedule as it allowed more rapid increases in the interval schedule duration, which could in turn reduce the time required to meet the terminal criterion. The DRO schedules were 5, 10, 15, 20, 30, 40, 45, 60 and 90 s. The experimenters chose 90 s as the terminal DRO schedule because it was deemed realistic to provide the reinforcer on a 90-s schedule within their larger study (which required that the child wear the heart rate monitor for 30 min).

When 5 min elapsed, the session ended regardless of whether the participant was in the middle of an interval. The starting interval criterion of each session was determined based on the last interval applied in the previous session. For example, if the participant met the criterion at 15 s for three consecutive intervals towards the end of the second session, the starting interval criterion of the third session would be 20 s. The participants reached the termination criterion when they wore the heart rate monitor 100% of the time for three consecutive sessions at the 90-s schedule.

Results

Figure 1 presents the results for Leo and Adam. During the baseline phase, Leo (upper panel) wore the heart rate device between 0% and 20% of the sessions ($M = 6\%$) and the trainer removed the device a mean of 10 times per session. The duration of compliance increased rapidly after the implementation of the DRO sessions, leading Leo to comply with wearing the device between 43% and 100% of the sessions ($M = 79\%$). The frequency of device removal decreased consequently to a mean of 1.8 per DRO session. It took 13 sessions (i.e., 65 min of training) for Leo to comply with wearing the device 100% of the time with the 90-s intervals. Adam wore the heart rate monitor between 3% and 29% ($M = 11\%$) of the baseline sessions and the trainer removed the device a mean of 7 times per session during this phase. During the DRO sessions, he wore the device between 28% and 100% ($M = 79\%$) of the session and we removed the device approximately 1.5 times per session. Adam required 27 sessions to reach the termination criterion (i.e., 125 min of training).

Discussion

The results indicate that DRO, without an extinction component, increased compliance with wearing the heart rate monitor for both participants. The participants only required 65 to 125 min of training to reach the termination criterion (i.e., wearing the device for 100% of the session while on a 90-s DRO schedule). Most importantly, the intervention did not require the implementation of response blocking or escape extinction. Conceptually, wearing a medical device does not involve engagement in a specific behavior (i.e., no movement or control of muscles), which is why DRO is well suited to explain the changes that we observed in the current study. The delivery of the preferred edible reinforced engagement in behavior other than attempting to remove the heart rate monitor. The increase in compliance in the absence of an

extinction component also suggests that the preferred edibles were reinforcers that could effectively compete with the escape contingency.

This study extends previous research regarding the relevance of behavioral procedures in training children with developmental disabilities to comply with wearing medical devices (e.g., Cook et al., 2015; DeLeon et al., 2008; Richling et al., 2011). These findings also remain consistent with prior research on the effectiveness of positive reinforcement without an extinction component in increasing compliance (Lalli et al., 1999; Piazza et al., 1997). From a practical standpoint, the results of this study contribute to the research literature by showing that DRO may be an alternative to DNRO and NCR for increasing compliance with wearing a medical device. Practitioners may consider DRO as an intervention when implementing response blocking and escape extinction is unfeasible or counterproductive, or when NCR alone is ineffective. Considering that no response blocking was needed, DRO may be a useful procedure for the practitioner to use in a variety of contexts, particularly when blocking evokes challenging behavior.

In the current study, the trainer delivered an arbitrary reinforcer, as providing escape in DNRO would have required the implementation of response blocking. Response blocking may evoke other challenging behaviors (Hagopian & Toole, 2009), which the experimenters wanted to avoid. That being said, prior research has shown that the quality of the reinforcers may influence the response to an intervention (Lalli et al., 1999). Thereby, the choice of arbitrary reinforcers may have influenced the effectiveness of the DRO. To address this issue, researchers should compare a function-based intervention (DNRO) with a non-function-based intervention (DRO) in the future.

The main limitation of the study is that the intervention ended when the participant met the termination criterion with a 90-s DRO schedule. However, health professionals may require that some devices (e.g., hearing aids, prescription glasses) be worn all day in which case the schedule would need to be considerably thinner. Future research should address this issue as a priority by further increasing the duration of the DRO schedule. Moreover, the experimenters did not conduct a functional analysis prior to implementing DRO as this type of intervention should be effective regardless of function. Performance during baseline indicated that compliance was low during the escape contingency, but the analysis does not rule out the possibility that the behavior was multiply controlled. Future research should address this limitation by conducting a functional analysis beforehand. Another limitation is that the small sample size and nonconcurrent nature of the design could have affected the internal validity. In sum, researchers should replicate these procedures with a larger sample, with other types of devices and with a more rigorous design, while further thinning the reinforcement schedule to extend the generality of the findings.

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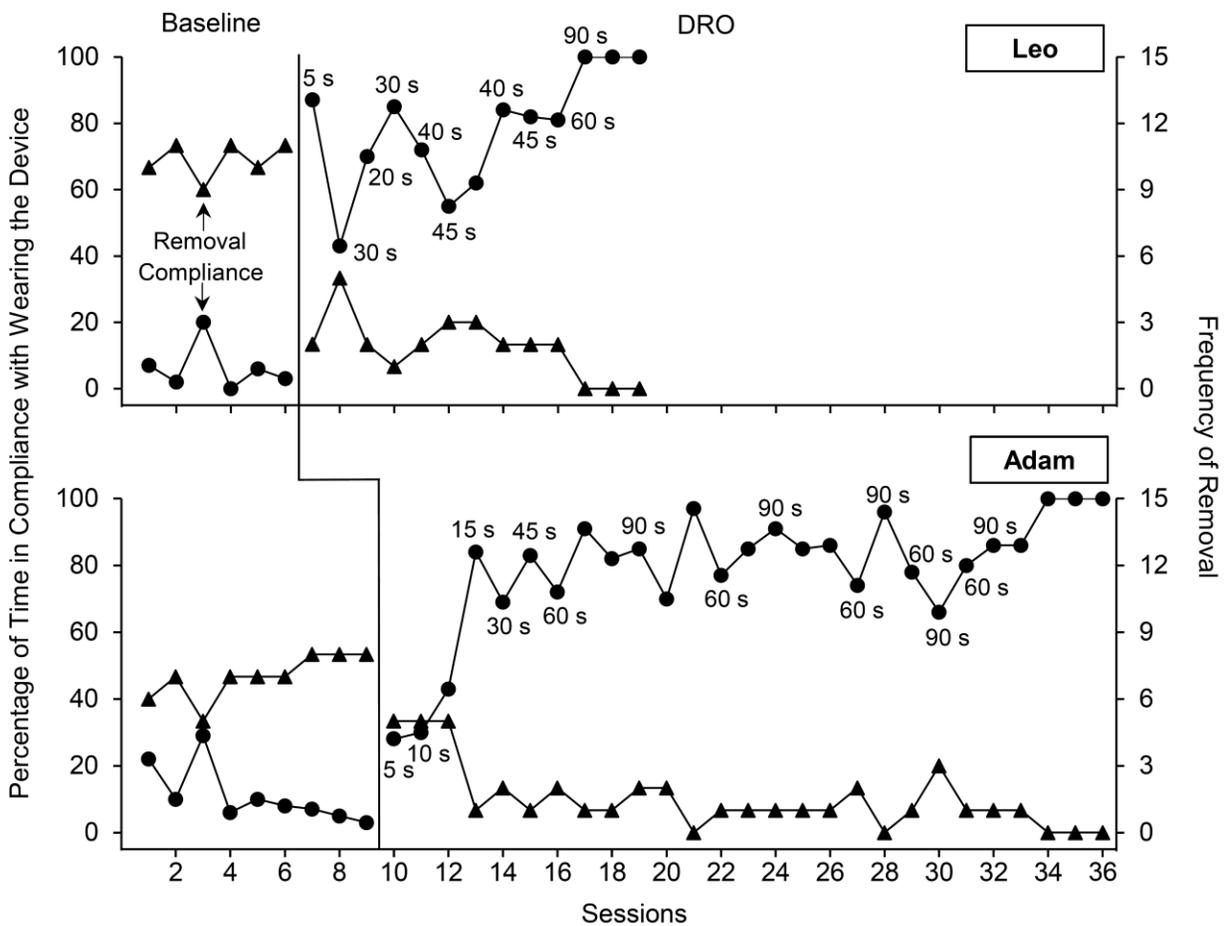


Figure 1. Percentage of time complying with wearing the heart rate monitor (primary y-axis) and frequency of device removal (secondary y-axis) for Leo (upper panel) and Adam (lower panel) during baseline and differential reinforcement of other behavior (DRO) sessions. The values above or below the data points identify the duration of the DRO schedules at the start of sessions. The absence of value indicates that the starting schedule was the same as in the previous session.