Research in Autism Spectrum Disorders 7 (2013) 1481–1488

Contents lists available at ScienceDirect

Research in Autism Spectrum Disorders

Journal homepage: http://ees.elsevier.com/RASD/default.asp

Increasing response variability in children with autism spectrum disorder using lag schedules of reinforcement☆

Clodagh Murray, Olive Healy *

National University of Ireland Galway, University Road, Galway, Ireland

ARTICLE INFO

Article history:
Received 4 July 2013
Accepted 16 August 2013

Keywords:
Response variability
Lag schedules
Reinforcement
U-Value statistic

ABSTRACT

Individuals with autism spectrum disorder (ASD) often present with deficits in variability in responding across multiple repertoires. However, research to date has resulted in little empirical evaluation of remediation strategies for such deficits. We investigated the effects of lag schedules of reinforcement on response variability using a computer-based task designed for the purpose of the study. The *U*-value statistic was used as a measure of variability in responding to determine if increasing the lag criterion would correspondingly increase levels of variability. Participants included children with ASD (Group 1) and neurotypical children (Group 2). Results showed that *U*-values were higher when reinforcement was contingent on increased variability, indicating the effectiveness of higher lag values on response variability. A significant difference in response variability between groups provided evidence for the disparity in such responding in children with ASD compared to their neurotypical peers. Group 1 showed consistently lower *U*-values than Group 2 indicating lower response variability. However, data from this study clearly show that lag schedules of reinforcement may be employed to increase response variability in ASD.

1. Increasing response variability in children with autism spectrum disorder using lag schedules of reinforcement

Lag schedules of reinforcement have been used to increase variability in responding in both the basic (Cherot, Jones & Neuringer, 1996; Neuringer & Huntley, 1992) and applied (Cammilleri & Hanley, 2005; Napolitano, Smith, Zarcone, Doodkin & McAdam, 2010) research fields within behavior analysis. Lag schedules involve the delivery of reinforcement if a response, or sequence of responses, differs from a pre-determined previous number of responses (Page & Neuringer, 1985). For example, under a lag 3 schedule, a response would be reinforced if it differed from the previous three responses, while under a lag 10 schedule a response would be reinforced if it differed from the previous 10 responses.

Lag schedules have also been used to investigate the operant nature of variability, commonly compared to a control condition where reinforcement is provided independent of variability. To date, the majority of investigations involving lag schedules have been in the area of basic research. Increasingly, these data have begun to inform the applied research field, with several studies emerging in recent years detailing the use of lag schedules to increase variability in play and language in a clinical population (e.g., Cammilleri & Hanley, 2005; Lee & Sturmey, 2006; Napolitano et al., 2010). The progression in utilizing

☆ This research was conducted by the first author under the supervision of the second author in partial fulfilment of the requirements for her PhD degree in Applied Behaviour Analysis at The National University of Ireland Galway.

* Corresponding author at: School of Psychology, University Road, National University of Ireland, Galway, Ireland. Tel.: +353 49 3457; fax: +353 91 521355.
E-mail address: olive.healy@nuigalway.ie (O. Healy).

1750-9467/$ – see front matter © 2013 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.rasd.2013.08.004

such procedures to increase variability in response patterns, from basic to applied research, is indicative of the value that researchers and practitioners are now placing on variability as a target behavior in humans. Furthermore, lag schedules may offer an efficient and reliable tool for increasing response variability when this type of responding is necessary or desirable.

While several studies have emerged that employ lag schedules to increase variability, the majority of research reported has been limited to a lag 1 schedule. In light of the outcomes that basic researchers have demonstrated, e.g., inducing marked increases in response variability with pigeons using lag 5, 10 and 50 schedules (Abreu-Rodrigues, Lattal, Dos Santos & Matos, 2005; Page & Neuringer, 1985), the use of the higher lag values with human participants is a worthwhile area for further investigation.

In 2012, two studies (Heldt & Schlinger, 2012; Susa & Schlinger, 2012) involved the use of lag schedules to increase variability in the verbal behavior of participants with developmental disabilities. Susa and Schlinger (2012) used increasing lag schedules of reinforcement (lag 1, lag 2 and lag 3) in a changing criterion design to increase the variability of responses to a social question, "How are you?" The participant was a boy diagnosed with Autism. The authors observed that the average number of previous responses from which each response varied increased as the lag schedule value increased. Heldt and Schlinger (2012) sought to increase variability in the tacting responses of two boys, one of whom had mild intellectual disability and one of whom had Fragile X Syndrome. In this study, a lag 3 schedule was implemented directly following the baseline phase. The authors found that variability in tacting increased for both participants and these gains were maintained at a three-week follow up.

Individuals with autism spectrum disorder (ASD) have been shown to demonstrate deficits in variability in responding across multiple repertoires (Boucher, 1977; Lee, McComas & Jawor, 2002; Mullins & Rincover, 1985). The current research aimed to identify possible remediation strategies for this. To this end, it investigated the effect of lag schedules of reinforcement on the variability of response sequences on a computer-based task. The task involved a computer program in the form of a game that required participants to fulfill a lag criterion in order to progress through it. A primary aim of the study was to determine if increasing the lag criterion would increase the level of variability as measured by the *U*-value statistic. The *U*-value statistic is perhaps the most widely used measure of variability in responding across the basic research literature. It determines the distribution of probabilities of a response, with equal probabilities indicating high variability and unequal probabilities indicating low variability (Neuringer, Kornell & Olufs, 2001). In other words, higher *U* values (closer to 1) indicate higher variability while lower *U*-values (closer to 0) indicate lower variability.

In the current study, it was expected that *U*-values would be higher when reinforcement was contingent on increased variability, i.e., higher lag values would produce higher *U*-values. A secondary aim of the study was to compare variability in responding on the computer-based task across two groups of participants, one comprised of neurotypical children and one comprised of children with ASD.

2. Method

2.1. Participants

Ten children with a diagnosis of ASD and ten neurotypical (NT) children participated in this study. The participants ranged in age from 5 years 2 months (62 months) to 15 years 1 month (181 months) at the time of the study (mean age = 107.5 months, SD = 43.8 months). The ASD group was labeled Group 1 while the NT group was labeled Group 2. In Group 1, four of the participants attended an Applied Behavior Analysis (ABA) School for children with ASD, three attended a special school for children with ASD that did not have ABA as its primary methodology and three of the participants attended mainstream school and received some additional resource hours. All of the children received a diagnosis of ASD according to the DSM-IV criteria from a psychologist who was independent of this study. There were nine boys and one girl in Group 1. All of the participants in Group 1 were reported to have basic literacy skills.

The participants in Group 2 all attended a mainstream school. None were diagnosed with ASD or any other developmental or behavioral disorder. None of the participants in Group 2 were in receipt of additional supports in their school. The participants in this group ranged in age from 6 years, 1 month (73 months) to 12 years 1 month (145 months) at the time of the study (mean = 113.4 months, SD = 8.5 months). Group 2 was comprised of eight boys and two girls. All of the participants in Group 2 had basic literacy skills.

Table 1 describes the participant characteristics of the two groups, including scores from the Autism Diagnostic Observation Schedule – Generic (Lord et al., 2000) for the participants of Group 1. These scores indicate a diagnosis of autism spectrum for Participants 1, 2, 5 and 6 on this measure, while the other participants met the criteria for a diagnosis of autism.

2.2. Apparatus

2.2.1. Program hardware

A Hewlett-Packard laptop (HP Pavillion dv6000) using Windows Vista operating system was used in this study. It had 512.0 MB RAM with processing speed 1600.0 MHz. The screen measured 33 cm × 22 cm.

2.2.2. Response hardware (input device)

An Ergodex DX1 input system with programmable response keys was placed two cm in front of the laptop. It had four keys placed in a row and each were 2 cm apart.