Differential Reinforcement of Other Behaviors to Treat Challenging Behaviors Among Children With Autism: A Systematic and Quality Review

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Abstract
This review summarizes the literature regarding differential reinforcement of other behaviors (DRO) to treat challenging behavior among children with autism spectrum disorder (ASD) and determines the quality of studies among the current literature according to the 2014 Council for Exceptional Children (CEC): Standards for Evidence-Based Practices in Special Education. Studies that focused on the use of DRO in the treatment of challenging behavior for individuals with ASD were included for systematic analysis. Forty-five studies were identified for inclusion in this review and were evaluated using the eight quality indicators described by the CEC. To the authors’ knowledge, this is the only systematic review of the literature that evaluates DRO as an intervention for individuals diagnosed with ASD. Principle findings, practical recommendations, and areas of future research are discussed.

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Autism spectrum disorder (ASD) is a neurodevelopmental disorder characterized by deficits in social communication and social interaction across multiple contexts and nonverbal communicative behaviors, as well as deficits in developing, maintaining, and understanding relationships (American Psychiatric Association, 2013). Individuals diagnosed with autism also often engage in restricted, repetitive patterns of behavior (e.g., stereotyped or repetitive motor movements or use of objects) and/or demonstrate insistence on sameness and inflexibility (i.e., highly restricted and fixated interests). According to Jang, Dixon, Tarbox, and Granpeeshe (2011), 94% of children diagnosed with ASD exhibit some form of challenging behavior (e.g., aggression, stereotypy, tantrums, and self-injury). In addition, individuals who meet the criteria to be diagnosed with the most severe level of ASD (i.e., requiring very substantial support) often present with an impaired ability to communicate, thus limiting their access to the immediate environment even further (Christensen et al., 2012; Hill et al., 2014). This is particularly concerning due to the inverse correlation between communication ability and challenging behavior (Chiang, 2008; Matson, Boisjoli, & Mahan, 2009). Currently, behavioral interventions are the most effective treatments to decrease challenging behavior in individuals diagnosed with ASD (National Autism Center, 2009).

Differential reinforcement of other behaviors (DRO) is a behavioral, reinforcement-based procedure that consists of the delivery of a consequence contingent on the absence of challenging behavior, leading to a reduction of the future occurrence of the targeted challenging behavior (Wong et al., 2014). Reynolds (1961) described the DRO procedure as “reinforcement for not responding” (p. 59). In other words, after a designated interval has passed, reinforcement is delivered contingent on the absence of a target challenging behavior.

The application of differential reinforcement on challenging behavior to serve as a behavior reduction tool has been utilized for decades (Homer & Peterson, 1980; Jessel & Ingvarsson, 2016; Poling & Ryan, 1982; Whitaker, 1996). Reynolds (1961) first demonstrated that reinforcement contingent on the absence of target behavior with nonhuman subjects increased other behaviors that occurred during intervals that immediately preceded reinforcement. Nevin (1968) produced similar responding in nonhuman subjects by first training them to respond equally in the presence of two keys (i.e., one
white, one with a vertical line), then placing the key with a vertical line on extinction, while reinforcing the absence of pressing that key. DRO led to differentiated responding in the presence of the white key, as well as higher rates of responding to keys displaying lines of varying orientations (e.g., horizontal lines). Following these initial demonstrations in the laboratory with nonhuman subjects, DRO procedures have been used in many different settings to address challenging behaviors exhibited by human subjects (Homer & Peterson, 1980; Poling & Ryan, 1982; Whitaker, 1996).

**Previous Reviews**

The last systematic review of the literature on DRO procedures was conducted more than 20 years ago (Whitaker, 1996). This review summarized the number of participants in each included study, the severity of participant diagnosis, a description of the target behavior, rate of the behavior in baseline and postintervention, the experimental design employed, and the amount of time for the DRO procedure to be effective (in hours). Whitaker (1996) concluded that DRO is effective for individuals of varying ability levels; however, those diagnosed with severe to profound intellectual disabilities may require greater exposure to the contingencies before improvements are observed. Furthermore, the author suggested that DRO is possibly more effective for high frequency target behaviors, as the majority of studies included in the review targeted behaviors that occurred at a frequency of greater than once per minute.

Poling and Ryan (1982) evaluated general aspects of DRO schedules in therapeutic applications. Specifically, they extracted information from 19 studies in terms of participant description, target behaviors, consequences used, maximum DRO interval employed, response reduction procedures used in concurrence with the DRO schedule, procedures compared with the DRO intervention, and other behaviors that occurred during DRO intervals that were not part of the DRO contingency. Based on the variability identified across studies regarding these dimensions, the authors noted confusion concerning the operational characteristics of DRO, suggesting that implementing a DRO procedure may be more complicated than other behavior reduction procedures (Poling & Ryan, 1982). However, the majority of studies included in this review were viewed as effective by the authors, and it was recommended that DRO would be a valuable addition to behavior change technology in terms of ethical and practical utility. Although these reviews examined the application of DRO across multiple populations, they were not specific to individuals diagnosed with ASD (Poling & Ryan, 1982; Whitaker, 1996).
The National Standards Project (NSP) Phase 2 (National Autism Center, 2009) was comprised of a review of more than 400 studies of interventions for children diagnosed with ASD (NSP Phase 1 = 298; NSP Phase 2 = 155). DRO is listed among examples of established behavioral interventions, which are stated as the largest category of established interventions reviewed in the project. Although behavioral interventions were identified as an established intervention in the NSP, DRO was not specifically evaluated. Rather, DRO was grouped with other procedures that were informed by the principles of ABA to reduce challenging behavior for this population. The National Professional Development Center (NPDC) on ASDs conducted a similar review of studies with the purpose of identifying focused intervention practices for children with autism with evidence of effectiveness (Wong et al., 2014). Again, DRO was evaluated within a larger category focusing on procedures using various forms of differential reinforcement (i.e., differential reinforcement of alternative behavior [DRA], differential reinforcement of incompatible behavior, and DRO). Although differential reinforcement as a whole met the NPDC evidence-based criteria, DRO was not specifically evaluated in isolation.

Recent developments in DRO research were examined by Jessel and Ingvarsson (2016). The authors identified four procedural considerations with regard to specific implementation of DRO procedures, reinforcement considerations, and variations in reinforcers utilized during DRO procedures, along with variations in signal specification and momentary schedules (Jessel & Ingvarsson, 2016). Specifically, the authors recommended that practitioners avoid using signals when implementing a momentary DRO schedule, noting, however, that these schedules can be beneficial when some occurrence of the target response can be permitted. The authors supported the use of functional reinforcers as often as possible. Finally, the authors stressed that other behaviors (i.e., not only the target behavior) should be measured during implementation of a DRO procedure to identify whether appropriate behavior is being reinforced, or if variations of the challenging behavior emerge (Jessel & Ingvarsson, 2016).

**Quality of Research**

The Council for Exceptional Children (CEC) developed a process to identify methodologically sound research studies as well as criteria regarding whether practices identified in those studies can be considered an evidence-based practice. For a study to be included among those supporting a specific practice, it must meet eight quality indicators defined by the CEC. Table 1 includes a summary of the eight quality indicators used to evaluate the
### Table 1. Description of Quality Indicators.

<table>
<thead>
<tr>
<th>Quality indicator</th>
<th>Description</th>
<th>Number of studies that met this indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td><strong>Context and setting</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The study provides sufficient information regarding the critical features of the context or setting.</td>
<td>37</td>
</tr>
<tr>
<td>2.0</td>
<td><strong>Participants</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The study provides sufficient information to identify the population of participants to which results may be generalized, and to determine or confirm whether the participants demonstrated the disability or difficulty of focus.</td>
<td>14</td>
</tr>
<tr>
<td>3.0</td>
<td><strong>Intervention agent</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The study provides sufficient information regarding the critical features of the intervention agent.</td>
<td>4</td>
</tr>
<tr>
<td>4.0</td>
<td><strong>Description of practice</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The study provides sufficient information regarding the critical features of the practice (intervention) such that the practice is clearly understood and can be reasonably replicated.</td>
<td>35</td>
</tr>
<tr>
<td>5.0</td>
<td><strong>Implementation fidelity</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The practice is implemented with fidelity</td>
<td>6</td>
</tr>
<tr>
<td>6.0</td>
<td><strong>Internal validity</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>The independent variable is under the control of the experimenter. The study describes the services provided in control and comparison conditions and phases. The research design provides sufficient evidence that the independent variable causes change in the dependent variable or variables. Participants stayed with the study, so attrition is not a significant threat to internal validity.</td>
<td>3</td>
</tr>
<tr>
<td>7.0</td>
<td><strong>Outcome measures/dependent variables</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Outcome measures are applied appropriately to gauge the effect of the practice on study outcomes. Outcome measures demonstrate adequate psychometrics.</td>
<td>29</td>
</tr>
<tr>
<td>8.0</td>
<td><strong>Data analysis</strong></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Data analysis is conducted appropriately. The study reports information on effect size.</td>
<td>39</td>
</tr>
</tbody>
</table>

*Note.* Descriptions taken from Council for Exceptional Children: *Standards for Evidence-Based Practices in Special Education* (Cook et al., 2014).
quality of a study described in *Standards for Evidence-Based Practices in Special Education* (Cook et al., 2014).

To date, no review has systematically evaluated and analyzed DRO procedures to decrease challenging behavior exhibited by children diagnosed with ASD. In addition, no research has evaluated the extent to which previous DRO studies align with the quality indicators outlined by the CEC (Cook et al., 2014). Therefore, the purpose of this article is to review and summarize literature regarding DRO to treat challenging behavior among children with ASD and to evaluate the quality of existing studies according to the CEC quality indicators.

**Method**

**Search Procedures**

Systematic searches were conducted in the following electronic databases: *Academic Search Complete, PsychINFO, ERIC, Education Research Complete, PsychARTICLES,* and *Psychology and Behavioral Sciences Collection*. The search was restricted to English language and peer-reviewed studies. On all databases, “differential reinforcement” was inserted into the keyword field with the following terms in pairs utilizing Boolean operators and truncation: “other,” “zero rate,” “nonoccurrence,” or “omission” for a total of four search term pairs.

The titles and abstracts of the 896 resulting articles were reviewed to identify studies for inclusion. Next, an ancestry search was completed in which the reference lists for studies meeting these criteria were reviewed to identify additional articles for possible inclusion, which resulted in the identification of one additional study. Finally, both a hand search in the journal in which most studies were published (i.e., *Journal of Applied Behavior Analysis*) and an author search for the two authors with the highest number of publications (i.e., Haring, Lanovaz) was conducted to identify additional studies to be considered for inclusion in this review. No additional studies were identified in the hand search or author search.

**Inclusion and Exclusion Criteria**

All studies included in this review utilized DRO as the change agent (i.e., independent variable) for challenging behavior (i.e., dependent variable) exhibited by individuals with an ASD diagnosis (i.e., autism, Asperger syndrome, and pervasive developmental disorder [PDD]). For this review, a DRO intervention was defined as a reinforcement-based procedure in which consequences were
provided for the absence of challenging behavior (Wong et al., 2014). Challenging behavior was defined as behavior that was targeted for reduction within the reviewed studies. The most common topographies of challenging behavior across reviewed studies were consistent with previous literature defining challenging behavior in children with autism and included (a) aggression, (b) stereotypy, (c) tantrumming, (d) property destruction, and (e) self-injurious behavior (Jang et al., 2011; Matson, Wilkins, & Macken, 2009).

If a study utilized DRO as an intervention for individuals who had a diagnosis other than ASD, or if a diagnosis was not clearly labeled, the study was excluded. Finally, nonpeer-reviewed papers (e.g., dissertations) were excluded from the preset review. Figure 1 provides an illustration of the search process (Moher, Liberati, Tetzlaff, Altman, & The PRISMA Group, 2009).

**Data Extraction**

Once each identified study was assessed for inclusion, data were extracted on the following categories: (a) participants, (b) target behaviors, (c) DRO procedures, and (d) results. For participants, data were summarized regarding the total number of participants included in the study, as well as age, sex, and disability. To summarize targeted behavior, the topography, functional assessment procedures, and functional assessment results were identified. Various aspects of DRO procedures were noted, including the setting in which it was implemented, who served as the interventionist, and whether DRO was used in isolation or as part of a treatment package. Moreover, specific aspects of the DRO procedure were included, such as reinforcer selection, DRO schedule, signals, schedule resetting, and schedule thinning procedures.

After extracting the information described previously, the authors reviewed each included study against the 2014 CEC quality indicators. Each study was assessed against eight quality indicators, some of which included multiple features (Cook et al., 2014). Because all included studies utilized single-subject designs, each study was inspected for 22 features specific to single-subject designs. For each quality indicator to be considered as “met,” the study must have addressed the underlying intent of the indicator, and all reviewers agreed that the methodological issue has been addressed satisfactorily (Cook et al., 2014). For example, quality indicator 5.0, *Implementation Fidelity*, includes three features regarding how fidelity is measured throughout the study (Cook et al., 2014). For a study to have been considered as meeting this quality indicator, the reviewer must agree that sufficient information was provided to ensure that the features were addressed. The first and second author evaluated the studies included in this review against all eight quality indicators.
Data Analysis

To obtain an effect size of DRO, a proportion of nonoverlapping data (PND) was conducted on studies that compared DRO with a contiguous baseline.
Specific procedures for the PND analysis with regard to the various single-case designs used across included studies were defined based on recommendations by Schlosser, Lee, and Wendt (2008). Studies that used an ABAB design, or variations of this design, were evaluated by calculating the proportion of nonoverlap between the first baseline and first intervention phase followed by the baseline and intervention phases of subsequent AB sequences, then averaging these for a mean. Studies utilizing a multiple baseline or multiple probe design were analyzed by calculating the nonoverlap for each separate pair of baseline and treatment tiers, then averaging these for a mean. Alternating treatment designs with a baseline were evaluated by analyzing the data in each treatment condition relative to the preceding baseline. However, if a third, more effective, treatment phase was included following the alternating treatment phase, it was not included in the PND analysis. Multielement designs with a concurrent baseline condition were calculated by analyzing each treatment against the concurrent baseline condition. ABCAB designs were excluded from the analysis, as sequence effects cannot be ruled out when such designs are employed (Schlosser et al., 2008).

Additional considerations were defined prior to conducting the PND analysis (Schlosser et al., 2008). Specifically, the highest effect size was reported for studies that examined multiple variations of DRO. Data reflecting subsequent schedule thinning of a DRO interval were included as part of the PND analysis. Generalization data and maintenance data were not considered in PND calculations. Articles that failed to report session-by-session data, or studies in which DRO conditions were not compared with a contiguous baseline were excluded. Finally, if any portion of baseline or DRO conditions was not graphed, the study was not included for PND analysis.

**Interrater Agreement**

To assess the reliability of application of the inclusion criteria, the first and second authors independently conducted the electronic database search, identifying 896 potential studies to include in the review. After independently applying inclusion criteria to those 896 studies, inclusion/exclusion agreement was 98%. Discussion among all authors was used to resolve discrepancies.

To assess reliability of data extraction, the first and second author independently summarized 31% of studies included in the review. Each study was summarized according to 19 items. Mean agreement was 91%. To assess reliability of CEC quality indicator evaluation, the first and second author independently evaluated 31% of studies. Each study was summarized according
to 22 quality indicator features. Mean agreement was 92%. Discussion among all authors was utilized to resolve discrepancies.

Twenty-five studies met criteria previously described for inclusion in the PND analysis. Training among authors took place until all authors reached 100% agreement on independent PND analyses. To assess reliability of the PND ratings, the third author independently analyzed the ratings from 35% of studies. Interrater agreement for the PND analysis was 96%. Discussion among all authors was utilized to resolve discrepancies.

Results

The aforementioned search procedures resulted in the identification of 45 articles. Table 2 summarizes the following information: (a) whether reinforcement was matched to a function maintaining the target behavior, (b) a summary of the DRO intervention, (c) whether DRO was evaluated as a stand-alone intervention or imbedded within a treatment package, (d) the DRO schedule used, (e) the quality indicators that were met for each study, and (f) the PND effect size of each study included in the PND analysis.

Participants

A total of 72 individuals with ASD, ages 3 to 26 years, participated in the studies. The majority (75%) of the participants were male. In addition, the majority (54%) of participants were within the 6 to 12-year age range. Another 17% (n = 12) were preschool age (3-5 years) and another 17% (n = 12) were adolescents (13-18 years). Most participants (85%; n = 61) were diagnosed with autism or ASD; whereas, the remaining participants were diagnosed with Asperger syndrome (n = 2) and PDD-Not Otherwise Specified (n = 9). In addition, 11% of participants (n = 8) had a comorbid non-ASD diagnosis. The most common comorbid diagnoses included intellectual disability (n = 4) and attention deficit hyperactivity disorder (n = 3).

Target Behavior

Motor and vocal stereotypy were the challenging behaviors targeted most frequently in this collection of studies, displayed by 31% (n = 22) and 29% (n = 21) of participants, respectively. Other challenging behaviors included aggression (21%, n = 15), self-injury (15%, n = 11), property destruction (5%, n = 4), and tantrumming (5%, n = 4). Several other challenging behaviors were targeted in two or fewer participants each. These included yelling, falling to the floor, spitting, pica, rumination, mouthing objects, out of seat,
Table 2. Characteristics of Included Studies.

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of participants; gender</th>
<th>Function matched</th>
<th>Summary of DRO evaluation</th>
<th>DRO schedule</th>
<th>CEC Indicators met</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anderson and Le (2011)</td>
<td>1 male</td>
<td>No</td>
<td>DRO evaluated alone</td>
<td>Fixed interval</td>
<td>1, 4, 8</td>
<td>—</td>
</tr>
<tr>
<td>Azrin, Besalel, Jamner, and Caputo (1988)</td>
<td>1 male; 1 female</td>
<td>No</td>
<td>DRO evaluated alone</td>
<td>Fixed interval</td>
<td>4</td>
<td>—</td>
</tr>
<tr>
<td>Bergstrom, Tarbox, and Gutshall (2011)</td>
<td>1 male</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td>1, 2, 4, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Call, Pabico, Findley, and Valentino (2011)</td>
<td>1 male</td>
<td>Yes</td>
<td>Compared DRO alone with treatment package</td>
<td>Variable interval</td>
<td>1, 2, 4, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Charlop-Christy and Haymes (1996)</td>
<td>3 males; 1 female</td>
<td>No</td>
<td>DRO evaluated alone</td>
<td>Fixed interval</td>
<td>2, 4, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Della Rosa, Fellman, DeBiase, DeQuinzio, and Taylor (2015)</td>
<td>1 female</td>
<td>Yes</td>
<td>Treatment package</td>
<td>Variable interval</td>
<td>1, 2, 3, 4, 5, 6, 7, 8</td>
<td>.46</td>
</tr>
<tr>
<td>Doyle, DeRosa, and Roane (2013)</td>
<td>1 male; 1 female</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td>4, 7, 8</td>
<td>.94</td>
</tr>
<tr>
<td>Earles and Myles (1994)</td>
<td>1 female</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td>1, 2, 4</td>
<td>—</td>
</tr>
<tr>
<td>Hammond, Iwata, Fritz, and Dempsey (2011)</td>
<td>2 males; 1 female</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed momentary</td>
<td>1, 4, 7, 8</td>
<td>.79</td>
</tr>
<tr>
<td>Haring, Breen, Pitts-Conway, and Gaylord-Ross (1986)</td>
<td>2 males; 1 female</td>
<td>No</td>
<td>Treatment package</td>
<td>Variable interval</td>
<td>1, 2, 8</td>
<td>—</td>
</tr>
<tr>
<td>Harris and Wolchik (1979)</td>
<td>4 males</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed momentary</td>
<td>1, 2, 4, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Heffernan and Lyons (2016)</td>
<td>1 male</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed momentary</td>
<td>1, 4, 8</td>
<td>.97</td>
</tr>
<tr>
<td>Iskander and Rosales (2013)</td>
<td>2 males</td>
<td>Yes</td>
<td>Treatment package; compared with BL</td>
<td>Fixed interval</td>
<td>1, 4, 5, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Johnson, Johnson, and Sahl (1994)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package; compared with BL</td>
<td>Fixed interval</td>
<td>1, 4</td>
<td>—</td>
</tr>
<tr>
<td>Kennedy and Haring (1993)</td>
<td>1 male</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td>1, 4, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Lanovaz, and Argumedes (2009)</td>
<td>1 female</td>
<td>Yes</td>
<td>DRO evaluated alone</td>
<td>Fixed interval</td>
<td>1, 7, 8</td>
<td>—</td>
</tr>
<tr>
<td>Lanovaz and Argumedes (2010)</td>
<td>1 female</td>
<td>Yes</td>
<td>DRO evaluated alone</td>
<td>Fixed interval</td>
<td>4, 8</td>
<td>—</td>
</tr>
<tr>
<td>Lanovaz et al. (2014)</td>
<td>2 males</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td>4, 7, 8</td>
<td>.21</td>
</tr>
</tbody>
</table>

(continued)
<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of participants; gender</th>
<th>Function matched</th>
<th>Summary of DRO evaluation</th>
<th>DRO schedule</th>
<th>CEC Indicators met</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lustig et al. (2014)</td>
<td>1 female</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval 1, 2, 4, 7, 8</td>
<td>.88</td>
<td></td>
</tr>
<tr>
<td>Marcus and Vollmer (1996)</td>
<td>1 male</td>
<td>Yes</td>
<td>DRO evaluated alone</td>
<td>Fixed interval 1, 4, 8</td>
<td></td>
<td></td>
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<tr>
<td>Matson, LoVullo, Boisjole, and Gonzalez (2008)</td>
<td>1 female</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval 1, 2, 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McGonigle and Rojahn (1989)</td>
<td>2 males</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval 1, 4, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>McKeeagan, Estill, and Campbell (1987)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval 1, 4, 7, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moore (2009)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval 1, 4, 5, 6, 7, 8</td>
<td>.97</td>
<td></td>
</tr>
<tr>
<td>Napolitano, Blakkman, Kohl, Valles, and McAdam (2007)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval 1, 2, 4, 7, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Newman, Tuntigian, Ryan, and Reinecke (1997)</td>
<td>2 males; 1 female</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval 1, 4, 7, 8</td>
<td>.80</td>
<td></td>
</tr>
<tr>
<td>Nuernberger, Vargo, and Ringdahl (2013)</td>
<td>1 female</td>
<td>No</td>
<td>Treatment package; compared with BL</td>
<td>Fixed interval 1, 2, 4, 7, 8</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Patel, Carr, Kim, Robles, and Eastridge (2000)</td>
<td>1 male</td>
<td>Yes</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval 1, 4, 5, 7, 8</td>
<td>.97</td>
<td></td>
</tr>
<tr>
<td>Potter, Hanley, Augustine, Clay, and Phelps (2013)</td>
<td>3 males</td>
<td>No</td>
<td>Treatment package</td>
<td>Unknown                  1, 4, 7, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quinn, Nowosielski, Kitchen, and Belfiore (2014)</td>
<td>3 males</td>
<td>No</td>
<td>Treatment package</td>
<td>Variable momentary 1, 3, 4, 5, 6, 7, 8</td>
<td>0.0</td>
<td></td>
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<tr>
<td>Rapp, Cook, McHugh, and Mann (2016)</td>
<td>3 males</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval 1, 4, 7, 8</td>
<td></td>
<td></td>
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<tr>
<td>Reese, Sherman, and Sheldon (1998)</td>
<td>1 male</td>
<td>No</td>
<td>DRO compared with BL</td>
<td>Fixed interval 1, 2, 4, 8</td>
<td>.76</td>
<td></td>
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<tr>
<td>Roane, Falconata, and Fisher (2007)</td>
<td>1 male</td>
<td>No</td>
<td>DRO compared with BL</td>
<td>Fixed interval 1, 4, 7, 8</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Romanczyk, and Goren (1975)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package</td>
<td>Unknown                  1, 8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rosa, Fellman, DeBiase, DeQuinzio, and Taylor (2015)</td>
<td>1 female</td>
<td>Yes</td>
<td>Treatment package</td>
<td>Fixed interval 1, 2, 7, 8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued)
disruption, coprolalia, elopement, and inappropriate interactions with household pet.

The majority of studies (65%, n = 30) conducted a functional behavior assessment (FBA) or conducted initial components of an FBA (e.g., indirect assessments) prior to beginning intervention. Of those that conducted an FBA, 60% (n = 18) of studies conducted a functional analysis. Among the 41 participants who received an FBA, results indicated a potential function for 33 participants. Among the 41 participants who received an FBA, just below half engaged in challenging behavior that appeared to be maintained by automatic reinforcement (41%, n = 17). A total of five participants engaged in problem behavior maintained by attention. Likewise, five participants engaged in problem behavior maintained by access to tangibles; whereas, only one participant engaged in problem behavior maintained by negative reinforcement in the form of escape from demands. Another seven participants engaged in challenging behavior maintained by multiple functions. Five participants’ FBA results concluded other results such as challenging

<table>
<thead>
<tr>
<th>Authors</th>
<th>No. of participants; gender</th>
<th>Function matched</th>
<th>Summary of DRO evaluation</th>
<th>DRO schedule</th>
<th>CEC Indicators</th>
<th>PND</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rozenblat, Brown, Brown, Reeve, and Reeve</td>
<td>1 male; 2 females</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Variable interval</td>
<td></td>
<td>.89</td>
</tr>
<tr>
<td>(2009)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Scalzo et al. (2015)</td>
<td>1 male</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td></td>
<td>1, 4, 8</td>
</tr>
<tr>
<td>Schmidt et al. (2016)</td>
<td>2 males</td>
<td>Yes</td>
<td>Treatment package; compared with BL</td>
<td>Fixed interval</td>
<td></td>
<td>1, 3, 4, 7, 8</td>
</tr>
<tr>
<td>Shabani, Wilder, and Flood (2001)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package; compared with BL</td>
<td>Fixed interval</td>
<td></td>
<td>1, 3, 4, 7, 8</td>
</tr>
<tr>
<td>Sills-Zaleski and Vesloski (2010)</td>
<td>1 male</td>
<td>No</td>
<td>Treatment package</td>
<td>Fixed interval</td>
<td></td>
<td>1, 2, 3</td>
</tr>
<tr>
<td>Taylor, Hoch, and Weissman (2005)</td>
<td>1 female</td>
<td>No</td>
<td>DRO evaluated alone</td>
<td>Fixed interval</td>
<td></td>
<td>4, 7, 8</td>
</tr>
<tr>
<td>Tiger, Fisher, and Bouxsein (2009)</td>
<td>1 male</td>
<td>No</td>
<td>DRO evaluated alone; compared with BL</td>
<td>Fixed interval</td>
<td></td>
<td>1, 4, 7, 8</td>
</tr>
<tr>
<td>Toussaint and Tiger (2012)</td>
<td>1 male</td>
<td>No</td>
<td>Variable momentary DRO compared with BL</td>
<td>Variable momentary</td>
<td></td>
<td>1, 4, 7, 8</td>
</tr>
<tr>
<td>Waters, Lerman, and Hovanetz (2009)</td>
<td>2 males</td>
<td>No</td>
<td>Treatment package</td>
<td>Variable interval</td>
<td></td>
<td>4, 7, 8</td>
</tr>
</tbody>
</table>

Note. DRO = Differential Reinforcement of Other Behaviors; CEC = Council for Exceptional Children: Standards for Evidence-Based Practices in Special Education (Cook et al., 2014); PND = proportion of nonoverlapping data; BL = baseline.
behavior maintained by compliance with the participants’ demands. Finally, one FBA produced mixed results.

**Intervention**

Approximately half of the studies (46%) evaluated the effects of DRO as a stand-alone intervention ($n = 21$). Out of the studies that evaluated DRO as a stand-alone intervention, 13 (62%) compared rates of challenging behavior during DRO conditions with baseline rates. A total of 7 out of those 13 found DRO to effectively decrease challenging behavior as a stand-alone intervention. DRO was most commonly utilized within an intervention package (56%, $n = 25$) along with the following interventions: (a) DRA, (b) self-monitoring/self-management, (c) token economy/response cost, and/or (d) response blocking.

Treatment was implemented most commonly by an experimenter across 33% of studies and by a therapist across 28% ($n = 13$) of studies. Other implementers included teachers (11%, $n = 5$) and parents (4%, $n = 2$). Treatment was conducted in a school setting in 41% of studies ($n = 19$) and in a clinic setting in 22% of studies ($n = 10$). Another 15% of studies implemented DRO in the home setting ($n = 7$).

A great deal of variation occurred across DRO procedures. One such variation was the schedule arrangement used. The most common schedule arrangement was a fixed-interval DRO implemented in 74% of studies ($n = 34$). In a fixed-interval schedule, the amount of time that elapses prior to reinforcement remains constant (Hanley & Tiger, 2011). The second most frequently employed schedule was the variable-interval DRO, implemented in 13% of studies ($n = 6$), in which the amount of time that elapses prior to reinforcement varies around a defined mean (Poling & Ryan, 1982). Momentary DRO schedules appeared less frequently. Total of 7% of the studies ($n = 3$) implemented a fixed-momentary DRO, providing reinforcement contingent on the absence of problem behavior at a specific moment at the end of a predetermined interval. However, 4% of studies ($n = 2$) utilized a variable-momentary DRO, providing reinforcement contingent on the absence of problem behavior at a moment within the interval that varied around a defined mean (Lindberg, Iwata, Kahng, & DeLeon, 1999).

Other noted variations include the reinforcer utilized with the DRO, the use of signals, the use of schedule resetting, and schedule thinning. Only 30% of studies ($n = 14$) matched the reinforcer used during DRO to the function of challenging behavior identified during the FBA. It should be noted that if a study did not report that an FBA was conducted, it was assumed the DRO
reinforcer was not matched to the function of challenging behavior. The majority of studies (61%; \( n = 28 \)) did not provide participants with a rule or signal communicating DRO contingencies and/or when DRO contingencies were in place. Just more than half of studies utilized nonschedule-resetting DRO procedures (54%, \( n = 25 \)). In other words, the schedule was not reset if an instance of challenging behavior occurred during the interval. The remaining studies utilized a schedule-resetting procedure. Specifically, the schedule was reset and the interval started over after an instance of challenging behavior. Schedule thinning, a procedure in which the DRO schedule is altered by gradually increasing the response ratio or duration of the interval over time was employed and reported in half of the studies (54%, \( n = 22 \)).

**Outcomes**

To be classified as evidence-based, a practice must be supported by experimentally sound literature. The quality indicators described by the CEC can be used to evaluate whether a study is methodologically sound (Cook et al., 2014). Many studies included in this review addressed several of the quality indicators described by the CEC (see Table 2 for a list of the quality indicators that each study addressed); however, to be considered methodologically sound per CEC standards, every quality indicator must be met (Cook et al., 2014). Only one study in this review satisfactorily addressed all eight quality indicators. The study by Della Rosa, Fellman, DeBiase, DeQuinzio, and Taylor (2015) addressed all features across the quality indicators defined by the CEC (Cook et al., 2014), and as a result was considered to be methodologically sound.

The quality indicators most commonly addressed in the reviewed studies were 1.0 Context and setting (82%, \( n = 37 \)), 4.0 Description of practice (78%, \( n = 35 \)), and 8.0 Data analysis (87%, \( n = 39 \)). The indicators that were addressed the least frequently were 3.0 Intervention agent (9%, \( n = 4 \)), 5.0 Implementation fidelity (13%, \( n = 6 \)), and 6.0 Internal validity (7%, \( n = 3 \)).

**Data Analysis**

Seventeen studies were included in the PND analysis based on the inclusion criteria outlined by Schlosser et al. (2008). This analysis identified eight studies with a PND of .90 or higher (Schlosser et al., 2008; Scruggs et al., 1987). The aggregated PND for all included studies was .78. Table 2 provides the PND score for each study included in the analysis.
Discussion

The purposes of this review were to (a) summarize the literature regarding DRO to treat challenging behavior among children with ASD and (b) determine the quality of studies among the current literature according to the 2014 CEC standards. Although 45 studies were included in this review, only one acceptable quality investigation was identified per the 2014 CEC standards (Cook et al., 2014). Although several applications of DRO included in this review produced positive outcomes with regard to the individuals who participated in each study, the literature provides insufficient evidence to suggest DRO as an evidence-based treatment for challenging behavior among children with ASD (Cook et al., 2014).

This review extends the findings of previous reviews of the DRO literature in two ways. First, this study was the first to review the DRO literature on the application of DRO procedures specifically to individuals diagnosed with ASD. Second, this is the only systematic review of the literature that evaluates DRO for treating challenging behavior among children with ASD according to the quality indicators delineated by the CEC (Cook et al., 2014).

Principle Findings

DRO as a stand-alone intervention. As noted previously, DRO procedures have been shown to be a positive contribution to treatments for individuals with disabilities when evaluated within a larger category of behavioral interventions (National Autism Center, 2009) or differential reinforcement methods (Wong et al., 2014). Therefore, to gain additional information regarding the efficacy of DRO procedures, the current review not only specifically examined DRO, but also examined whether DRO procedures were used in isolation, or were imbedded within a treatment package.

Study outcomes did improve markedly when DRO was used in combination with other elements as part of a treatment package. However, given the number of studies supporting the use of DRO as a stand-alone intervention, more research should be conducted in this area to evaluate the conditions under which DRO may serve as an effective treatment option for treating challenging behavior.

Schedule arrangements. The schedule arrangement most frequently used during DRO procedures was fixed-interval DRO. Fixed-interval schedules, although effective, can be more difficult to implement in the natural environment due to issues of practicality regarding the constant monitoring of
behavior and consequence delivery (Poling & Ryan, 1982). Variable and momentary DRO schedules may prove to be a viable alternative to fixed-interval DRO procedures where reinforcement is not always provided on a fixed or predictable schedule. There are some studies that have examined the relative effectiveness of variable-momentary schedules (Quinn, Nowosielski, Kitchen, & Belfiore, 2014), fixed-momentary schedules (Hammond, Iwata, Fritz, & Dempsey, 2011), and variable-interval schedules (Rozenblat, Brown, Brown, Reeve, & Reeve, 2009) with positive outcomes. Thus, research should examine additional schedule arrangements further to identify the most effective and most practical arrangements to administer DRO procedures.

**Signals and rules.** More than half of the studies included in this review did not provide a rule or signal to participants to communicate the contingencies associated with the DRO schedule. Skinner (1974) offered two different conditions under which behavior can be controlled: contingency-shaped behavior and rule-governed behavior. Individuals may be more likely to identify the contingencies of a DRO arrangement if a rule or signal is provided; thus, improving the likelihood of discrimination (Whitaker, 1996). Hammond and colleagues (2011) found that two participants benefitted from a signal during a fixed-momentary DRO arrangement, whereas two participants performed better when no signal was provided. In another study evaluating the inclusion of a signal, Watts, Wilder, Gregory, Leon, & Ditzian (2013) observed that the DRO contingency was more effective when a rule was used. Given the limited and mixed findings, more research evaluating the effects of the inclusion of signals or rules with DRO schedules is needed.

**Problem behavior.** As identified in this review, DRO is often used as a treatment option for stereotypic behaviors. Previous reviews suggest that DRO is frequently used to treat aggression and self-injurious behavior (SIB) (Poling & Ryan, 1982; Whitaker, 1996). This review extends the DRO literature by evaluating whether an assessment of behavior (i.e., FBA) was conducted prior to implementing DRO procedures. Although FBAs were conducted for 65% of the studies in this review, only half of those studies matched reinforcement during DRO procedures to the identified function of the target behaviors. In cases where the target behavior was identified to be nonsocially mediated, or automatically maintained, stimuli that had the potential to compete with the maintaining consequence were sometimes introduced with the DRO schedule to match stimulation produced via the target behavior. The cases that did identify socially mediated consequences to be maintaining the target behavior matched reinforcement in 14 of the 18 studies. Additional research is needed on function-based DRO interventions.
Applied nature of DRO. Only 15% of studies included in this review implemented DRO procedures in the home setting. In addition, only two parents were reported to implement procedures across all studies. This finding highlights a gap in the literature regarding the generalizability of DRO interventions to successfully decrease challenging behavior. It is important that research findings be generalized for individual participants in different settings with different implementers (Baer, Wolf, & Risley, 1968). Doyle, DeRosa, and Roane (2013) conducted a DRO procedure in a clinical setting to decrease aggression and property destruction for two siblings diagnosed with PDD, and results successfully generalized to the home with a parent implementer. Although this study produced positive outcomes, there is currently limited evidence supporting the use of DRO in a home setting. Given the complex nature of DRO procedures, as noted previously, more research should be done to determine whether DRO can be implemented effectively in a more natural setting and produce similar results to those observed in a more controlled environment to meet these requirements (Poling & Ryan, 1982).

Data Analysis

Only one of the included studies met all eight quality indicators provided by the CEC (Cook et al., 2014). One purpose of this review was to evaluate existing literature against the robust standard delineated by the CEC (Cook et al., 2014). Although eight studies produced seemingly desirable outcome with an effect size of .90 or higher in the PND analysis, the standards set by the CEC were not consistently represented; thus, it was not possible to classify these studies according to the standards published by the CEC (Cook et al., 2014). Based on the results of the quality indicator evaluation, more information regarding the intervention agent, treatment fidelity, and internal validity should be included in future research. When describing the intervention agent, researchers should ensure sufficient information is provided, such as their relationship to the participant, any previous training or experience that may affect performance, as well as descriptive factors (e.g., education level). In addition, measures of implementation fidelity should be described in detail to provide an indication that the described procedures were implemented with fidelity. Finally, researchers should ensure that an appropriate design is selected to provide sufficient evidence that any changes in the dependent variables are a result of exposure to the independent variable.

Practical Recommendations

Studies that combined multiple components within a treatment package (e.g., DRO + functional communication training) produced more meaningful
change across participants. As a result, it is recommended that practitioners consider utilizing DRO combined with other behavioral interventions that possess sufficient evidence. For more information on current evidence-based treatment options, the reader is directed to the evidence-based practice review conducted by Wong and colleagues (2014) as well as the NSP (National Autism Center, 2009). Practitioners should refer to the literature to ensure they are utilizing current, evidence-based treatment. Reports summarizing the literature can be beneficial resources to ensure such practice. Those who utilize DRO procedures alone or as part of a multicomponent intervention should evaluate the progress of any interventions using data-based decision-making.

**Limitations**

One limitation of the current review that should be considered was the exclusion of studies with participants other than those with an ASD diagnosis. DRO procedures have been applied to address concerns with individuals other than those diagnosed with ASD (Homer & Peterson, 1980; Poling & Ryan, 1982; Whitaker, 1996). The information presented in this review pertains specifically to the application of DRO procedures in the treatment of challenging behavior for individuals diagnosed with ASD. Because of this, the findings presented in this review should inform the reader within the parameters previously described.

This review may also be limited by the exclusion of studies that have not gone through peer review (e.g., dissertations). Excluding such studies may have limited the findings, as the CEC standards were published only recently, and unpublished dissertations may exist that adhere to the quality indicators outlined in the CEC standards (Cook et al., 2014). Furthermore, by excluding such studies from the current review, existing interventions contributing to a greater understanding of specific characteristics of DRO procedures may have been overlooked.

As Whitaker (1996) pointed out, there are some discrepancies in terminology pertaining to DRO research in the literature. Every study included in this review specified that a DRO contingency was used. Only including studies with such specific terminology may have limited the results of the search to exclude studies that described DRO procedures, but did not specifically label them as such. Finally, it is important to consider the potential for publication bias that may have prevented the publication of articles displaying negative results. Thus, although this review provides information regarding the effectiveness of each included study, publication bias should be considered, as studies reporting negative results are less likely to be submitted for publication.
Future Research

The findings discussed in this review highlight a need for more research on DRO procedures in several areas. Given the number of studies conducted that contain DRO within a treatment package, it would be beneficial to conduct component analyses to identify the components contributing to the effectiveness of such packages. In addition, DRO procedures should be compared with baseline conditions to determine the efficacy of DRO as a stand-alone intervention. Furthermore, research should be conducted to examine the effects of variable-interval schedules, as well as variable- and fixed-momentary interval DRO schedules, as much of the research has been conducted on fixed-interval schedules. Given the limited number of studies examining the effects of rules and signals accompanying DRO schedule arrangements, more research is needed to better understand how these cues affect DRO outcomes. Studies examining function-based DRO applications are currently limited. Given the positive outcomes of studies that have matched DRO reinforcement to the function maintaining the target behavior, further examination on this topic is warranted. The lack of research on the generalizability of DRO interventions limits the practical relevance of DRO procedures in applied settings, and as a result, more research on DRO procedures generalized to different settings and with different implementers should be conducted.

Finally, the stringent standards outlined by the CEC should be considered when conducting future research on DRO interventions. As it stands, there is a need for more research on DRO procedures to determine the efficacy of such procedures when used in isolation. The majority of studies included in the present review were published prior to the publication of the CEC evidence-based standards (80%, n = 36); thus, the quality indicators presented in this document were not readily accessible. To ensure that methodologically sound research is conducted to further evaluate the evidence base of DRO interventions, it is recommended that researchers employ the procedures outlined in the Standards for Evidence-Based Practices in Special Education (Cook et al., 2014).

Although the majority of studies included in this review met many of the quality indicators defined by the CEC, only one study met all quality indicators, thus limiting the quality of published studies on DRO procedures (Cook et al., 2014). Because of this, it is important that more studies adhering to the rigorous research methods described by the CEC be conducted to develop an evidence base for DRO as a behavior change intervention.

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