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REVIEW

Systematic Review of Procedures and Outcomes of Choice-Based Interventions with Children

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Abstract In behavior-analytic clinical work and research, opportunities for choice can be arranged as an independent variable, and response allocation among choice options can be measured as a dependent variable (i.e., engaging in one response given two or more concurrently available options). Choice-based interventions provide behavior analysts with tools to promote their clients' rights to autonomy and self-determination by incorporating client preference. The purpose of the current article is to systematically review the literature published from 2003 to 2020 on choice-based interventions with children. We reviewed 32 articles (38 experiments) identified through ERIC, PsycINFO, and MEDLINE/PubMed, and we summarized the participant and study characteristics arranged into two categories by procedure: (1) differential reinforcement with asymmetrical-choice options; and (2) building choice opportunities into daily contexts. We provide suggestions for clinical applications of choice to intervention procedures and future research. The reviewed literature demonstrates how practitioners working with children can use choice-based interventions to incorporate consumer choice into clinical practice while effectively addressing versatile clinical goals across populations and settings.

Keywords Choice · Concurrent schedules · Concurrent operants · Differential reinforcement

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Making choices is a significant part of daily living and having the opportunity to make choices contributes to the quality of life (Shogren et al., 2004; Wehmeyer & Schalock, 2001). In behavioral clinical work and research, opportunities to make choices can be arranged as an independent variable, and response allocation among choice options can be measured as a dependent variable. As an independent variable, the provision of choice options (i.e., *concurrent schedules* or *concurrent operants*), and the ways in which options are arranged, can affect behavior in socially significant ways. In fact, all operant behavior can be conceptualized in the context of available concurrent operants (Catania, 2012), and there is a robust literature base showing that humans (and other organisms) allocate responding among choice options according to the relative reinforcement parameters (i.e., Matching Law; Borrero et al., 2010; Davison & McCarthy, 2017; Reed & Kaplan, 2011). Choice behavior as a dependent variable is often defined as engaging in one response when there are two or more concurrently available response options (Catania, 2012;

Fisher & Mazur, 1997). Measuring response allocation of behavior (i.e., choice) can provide useful information related to preference, sensitivity to reinforcement parameters, and function of behavior.

Procedures employing concurrent-operant arrangements have become increasingly popular in clinical (e.g., Briggs et al., 2019; Cooper et al., 1999; Carter, 2001; Peck et al., 1996) and educational settings (e.g., Dibley & Lim, 1999; Kern et al., 2001; Seybert et al., 1996). Such choice-based interventions arrange environmental variables so individuals can choose among concurrently available contingencies to increase or decrease clinically relevant behavior. Choice-based interventions are of interest to behavior analysts due to the versatility of the procedures and their efficacy in a wide range of clinical goals, populations, and settings (Peterson et al., 2020). Furthermore, behavior analysts have an obligation to incorporate client preference and choice into their interventions and to promote their clients' rights to autonomy and self-determination (Behavior Analyst Certification Board, 2020; Peterson et al., 2020).

Cannella et al. (2005) reviewed the literature on choice from 1996 to 2002, focusing on individuals of all ages with severe and profound disabilities. Since then, investigations of choice-based interventions have increased in number, expanded in type, and included different participant populations. These expansions warrant an updated review of the state of the literature. Thus, we systematically reviewed the published literature on choice-based interventions with children between 2003 and 2020. Unlike the review by Cannella et al., which restricted the population for the review to individuals with severe to profound developmental disabilities, we did not restrict the target population by diagnosis. The objectives of this review were to (1) describe the overall state of the literature on clinical applications of choice with children; (2) quantify the characteristics of the experimental arrangements, participants, and procedures; and (3) characterize the outcomes of choice-based interventions across two procedural categories.

Method

Search and Coding Procedure

We conducted this review according to the guidelines for the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Page et al., 2021). We conducted a literature search using three search engines (ERIC, PsycINFO, and MEDLINE/PubMed) using the search terms "behavior analysis; choice; concurrent choice; concurrent operant*; concurrent schedule*." The search results were filtered to include peer-reviewed articles available in English between 2003 and 2018; a separate search using the same procedures was completed for 2019 and 2020, approximately 1 year apart. Articles published online as an early release at the time of the search were included. We screened the titles and abstracts of the search results. We included articles that met the following criteria: human participants under 18, at least one socially significant dependent variable, and the inclusion of concurrent operants (i.e., "two or more topographically distinct responses") as part of the independent variable.

Although two previous reviews on choice have included the preference assessment literature (Cannella et al., 2005; Lancioni et al., 1996), the research in this area has expanded significantly over the last 16 years and has been reviewed thoroughly elsewhere (see Kang et al., 2013; Leaf et al., 2019; Rush et al., 2010; Virués-Ortega et al., 2014). Thus, articles focused on preference assessments were excluded. Likewise, we excluded articles describing choice-based assessments that were not followed by a choice-based intervention (e.g., Finkel et al., 2003; Gardner et al., 2009; Hood et al., 2019). We also excluded descriptive experiments. For articles that included multiple experiments, each experiment that met the inclusion criteria was scored individually. Raters scored each experiment on the indicators described in the following sections.

Participants and Setting Characteristics

Participant information included the number, age, and reported diagnoses. The settings were scored as school, home, clinic, or job, and the activity categories were academic, vocational/domestic, and leisure/social.

Design, Independent and Dependent Variables, and Intervention Categories

Raters recorded the experimental design of each experiment, which were exclusively single-subject

designs, including reversal designs, multiple baseline designs, and multielement designs. Some experiments included multiple design components (e.g., a multielement evaluation embedded within a reversal design), in which case the combination was recorded.

Based on a review of the categories used by Cannella et al. (2005) and Lancioni et al. (1996) and an initial review of the abstracts of the identified experiments, we adopted a scoring system for categorizing experiments by their independent-variable condition(s). In their previous review, Cannella et al. (2005) arranged studies into four categories: building choice opportunities into daily contexts, the effects of choice-making on behavior parameters, preference assessments, and accuracy/efficiency of preference-assessment formats. Half of the 30 studies reviewed by Cannella et al. were on preference assessments; as noted previously, we excluded experiments on preference assessments. We retained Cannella's category label for *building choice opportunities into daily contexts*. In place of the category used by Cannella et al., "effects of choice-making," we created a category for *differential reinforcement with concurrent asymmetrical-choice options,* which has been used in previous literature (Crowley et al., 2020; Fisher & Mazur, 1997; Fisher et al., 2019; McDowell, 1989). The purpose of this change was to use a more descriptive label that more clearly differentiates between the two intervention categories and create a label that encompassed an arrangement that appeared with frequency in our review of abstracts. Thus, we arranged the experiments into two categories: (1) differential reinforcement with asymmetrical-choice options; and (2) building choice opportunities into daily contexts. The category *of differential reinforcement with asymmetrical-choice options* was defined as interventions arranging reinforcement schedules for two or more response options (e.g., challenging behavior and an appropriate communication response) with programmed differences in the reinforcer dimensions across the options (e.g., relative density or rate, magnitude, immediacy, and quality of reinforcement, the response effort required to satisfy a schedule requirement). The category of *building choice opportunities into daily contexts* was defined as inserting concurrent-choice opportunities into naturally occurring situations and daily routines (e.g., daily living and self-care activities, academic tasks) by providing opportunities to choose activities, activity features, or the consequences that will follow an activity (e.g., choice of a reinforcer).

The dependent variables in each experiment were categorized according to the definitions displayed in Table 1; the categories were mutually exclusive. The raters also coded the specific topography of the dependent variable (e.g., challenging behavior measured as aggression) and recorded a description of the study purpose, independent variable(s), and findings in approximately two to four sentences each. Using a procedure based on Cannella et al. (2005), we coded the findings as positive, mixed, or negative. Findings were coded as *positive* when the behavior changed in the desired direction in at least one choice condition for all participants. We incorporated the caveat of "at least one condition" to account for experiments that conducted parametric analyses or evaluated multiple conditions (e.g., Athens & Vollmer, [2010], systematically adjusted the reinforcement parameters for challenging and alternative behavior across multiple conditions). Findings were coded as *mixed* when a positive effect in at least one choice condition was observed for some, but not all, participants. Finally, findings were coded as *negative* when the intervention did not result in a positive effect for any participants or had countertherapeutic effects on behavior for one or more participants.

Function-Based Arrangements

For experiments involving the treatment of challenging behavior, the rater recorded whether a functional behavior assessment was included and, if so, the type(s) of assessment described. For all experiments with challenging behavior as a dependent variable, the rater then coded whether the intervention was function-based (e.g., consequences arranged as the duration of a break for escape-maintained behavior).

Interrater Agreement

A secondary rater independently scored 16 experiments (42.1%). The responses for nine categories with discrete coding variables were compared as a measure of interrater agreement. Each indicator was scored as an agreement or disagreement, and a percentage was calculated by dividing the number of agreements by agreements + disagreements and multiplying by 100. An agreement was defined

Table 1 Dependent variable category definitions

Term	Definition	Examples
Challenging behavior	Behavior for which the goal is to decrease or eliminate.	Aggression, property destruction
Functional communication response	A verbal, but not necessarily vocal, communication response selected as an alternative behavior to replace challenging behavior.	Mand for attention
Adherence/ engagement	A measure of completion or engagement with instructions or demands with the goal to increase engagement.	Percentage of time spent on-task when working on an academic worksheet
Skill acquisition	A particular response or set of responses relating to academic, vocational, or social skills. In general, the goal is to increase "correct" responding or establish a response topography not previously at strength in the learner's repertoire.	Independent tact responses with unmastered targets
Impulsive choice; self-control choice	Selection response or response allocation that results in smaller, sooner (impulsive choice) or larger, later reinforcers (self-control choice). The goal is generally to increase self-control choices.	Selection of 1 min of immediate access to a reinforcer; Selection of 5 min of access after a delay
Response allocation	A measure of responding among multiple options; selection responses that are not socially significant in their own right.	Percentage of time spent on the side of the room with available adult attention

as an exact match between raters' recorded codes. The mean agreement score was 94.1% (range: 73%–100%). Indicators that did not include discrete codes (e.g., description of the outcomes) were reviewed manually for correspondence; any discrepancies were resolved by the author who had not previously scored the article.

Results

The ERIC, PsycINFO, and MEDLINE/PubMed searches yielded 1,343 items (see Fig. 1). After removing duplicates, 1,073 articles remained. One author screened each article for the inclusion criteria (a portion of which went through an independent screening by a different author). Additional articles were identified from the reference lists and screened, which included three additional articles. In the end, there were 32 articles consisting of 38 experiments included.

Article Characteristics

Thirteen journals were represented in the included articles, with the *Journal of Applied Behavior Analysis* containing the largest portion of included articles (46.9%), followed by *Behavior Analysis in Practice* (9.4%). There were two articles each (6.3%) from *Education and Treatment of Children*, *Journal of Behavioral Education*, and *Journal of the Experimental Analysis of Behavior.*

Table 2 displays a summary of the independent variable categories. Twenty-five (65.8%) of the 38 included experiments fell into the category of differential reinforcement with asymmetrical-choice options and 13 (34.2%) in the category of building choice opportunities in daily contexts. The table also displays the count and percentage of experiments that included each dependent variable category; most experiments included more than one dependent variable. Summaries of each experiment arranged by procedural category appear in Tables 3 and 4, which include the age range, diagnoses, and the number of participants, dependent variables, setting, category of activities, and a summary of

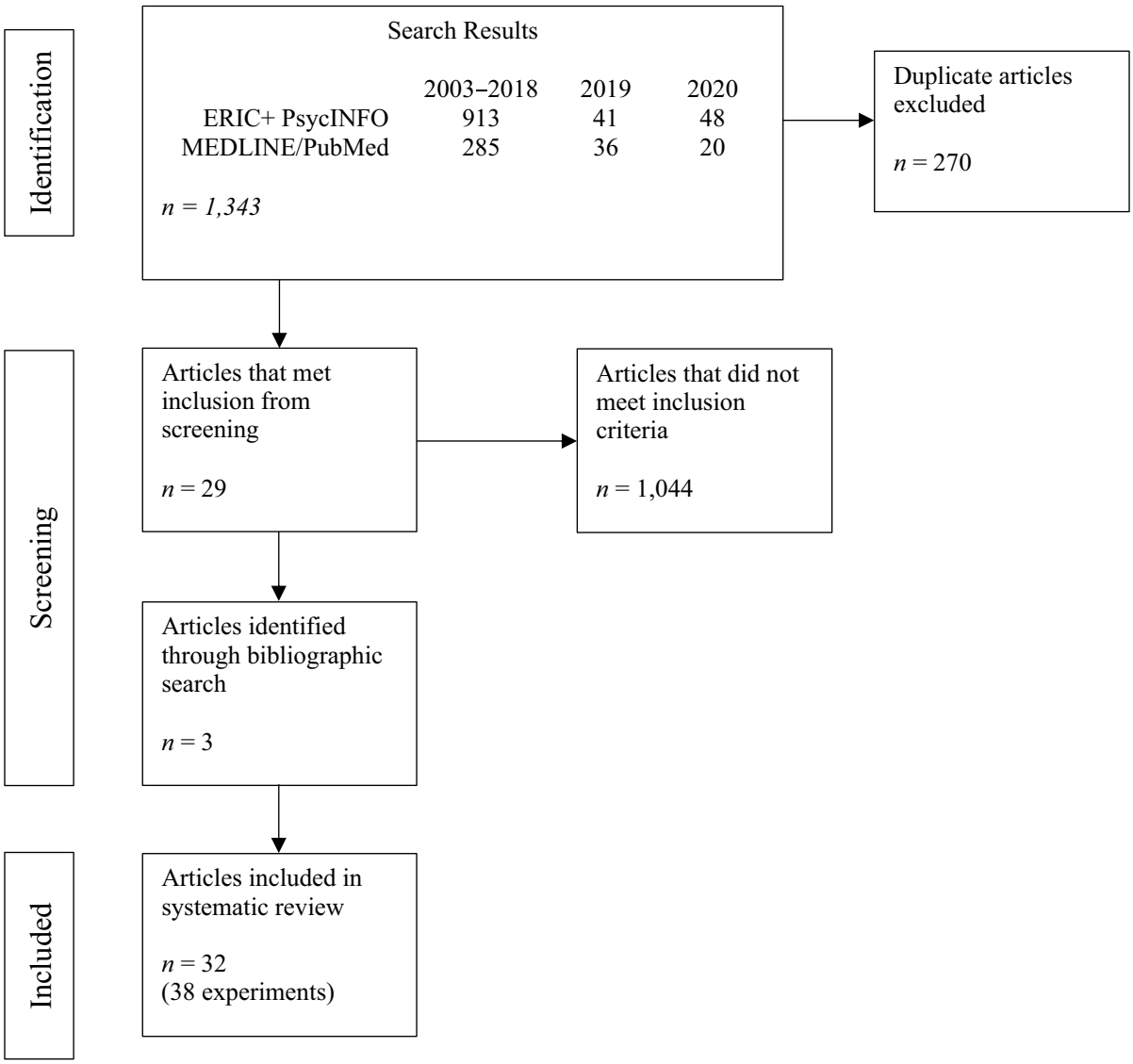

Fig. 1 Summary of the search and inclusion procedures

the purpose and outcomes. In the sections below, we organize these two independent variable categories into two to three thematic subheadings based on procedural characteristics.

Differential Reinforcement with Asymmetrical-Choice Options

One category of choice-based intervention involves employing differential reinforcement procedures and arranging concurrent schedules with asymmetrical-choice conditions (Fisher & Mazur, 1997; McDowell, 1989). These interventions arrange reinforcement schedules for two or more response options (e.g., challenging behavior and an appropriate communication response). Using concurrently available reinforcement schedules with identical reinforcement is generally ineffective for shifting response allocation (Briggs et al., 2019; Hoch et al., 2002; Piazza et al., 1997). However, extensive research on the Matching Law and choice has consistently demonstrated that responding is allocated according to the

Table 2 Summary of independent and dependent variable categories

Independent Variable Category		*n*	%
Differential Reinforcement with Asymmetrical-Choice Options		**25**	**65.8**
	Dependent Variable(s)		
	Challenging behavior	15	56
	Alternative communication response	10	40
	Adherence/engagement	20	80
	Skill acquisition	1	4
	Subcategory		
	Challenging behavior	15	60
	Adherence and task completion	8	32
	Reinforcement of self-control choices	2	8
Building Choice Opportunities in Daily Contexts		**13**	**34.2**
	Dependent Variable(s)		
	Challenging behavior	4	30.8
	Alternative communication response	0	0
	Adherence/engagement	8	61.5
	Skill acquisition	5	38.5
	Subcategory		
	Choice of activity or features	5	38.5
	Choice of consequence	8	61.5

Summary of independent and dependent variable categories identified across each experiment in the reviewed literature. Most experiments measured more than one dependent variable. Thus, the summation of percentages is greater than 100

parameters among available options, such as the relative density or rate, magnitude, immediacy, and quality of reinforcement, as well as the response effort required to satisfy a schedule requirement (Borrero et al., 2010; Davison & McCarthy, 2017; Hoch et al., 2002; Horner & Day, 1991; Mace et al., 1996; Neef et al., 1992; Peck et al., 1996). Practitioners can influence a client's behavior by arranging asymmetrical-choice options such that the more desirable response option (i.e., appropriate behavior) results in consequences that are more *favorable* in some way than the alternatives (e.g., higher magnitude or density of reinforcement).

Several experiments included in this review used mathematical analyses of data from concurrent-operant arrangements with varying parameters of reinforcement to quantify the extent to which participants allocated responding in accordance with the available reinforcement contingencies using the generalized matching equation (Borrero et al., 2010; Martens et al., 2016; Reed & Martens, 2008, Experiments 1 and 2). As expected, the results of the quantitative analyses showed that the relative response rates in these experiments correspond to the relative reinforcement rate. However, some minor deviations in matching were observed (i.e., unsurprisingly, human behavior does not always align perfectly with the expected allocation derived from mathematical models).

Twenty-five experiments arranged differential reinforcement with concurrent asymmetrical-choice options with the goal of shifting response allocation to one or more defined, desirable alternatives (see Table 3). The discussion of these articles will be arranged according to three subcategories based on the primary purpose of the choice-based intervention: (1) decreasing challenging behavior; (2) increasing adherence and task completion; and (3) increasing self-control choice.

Challenging Behavior

Fifteen experiments arranged differential reinforcement with concurrent asymmetrical-choice options to target the reduction of challenging behavior (Athens

Table 3 Differential reinforcement with asymmetrical-choice options

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Athens & Vollmer (2010) Exp 1	2	4–7	ASD, ADHD	CB; alternative response; adherence/engagement	clinic; academic	Purpose: Evaluate the impact of asymmetrical-choice options varying the duration of access to reinforcement on allocation of responding between CB and appropriate behavior (i.e., mands or compliance) without EXT for CB. Results: CB and appropriate alternative behavior were generally sensitive to the relative duration of reinforcement available for each option for both participants.
Athens & Vollmer (2010) Exp 2	2	6–7	ASD, ADHD	CB; alternative response	clinic; academic	Purpose: Determine the effects of varying the quality of reinforcement on allocation of responding between CB and appropriate behavior (i.e., compliance with demands or a PECS exchange) without EXT for CB. Results: CB and appropriate alternative behavior were generally sensitive to the quality of reinforcement available for each option for both participants.
Athens & Vollmer (2010) Exp 3	2	8–9	ASD, ADHD	CB; alternative response	clinic; academic	Purpose: Evaluate effects of varying the delay to reinforcement on allocation of responding between CB and appropriate behavior (i.e., mands or PECS exchange) without EXT for CB. Results: CB and appropriate alternative behavior were generally sensitive to the immediacy of reinforcement available for each option for both participants.
Athens & Vollmer (2010) Exp 4	2	10–12	ASD	CB; alternative response	clinic; academic	Purpose: Evaluate effects of varying the duration, quality, and delay to reinforcement on allocation of responding between CB and mands without EXT for CB. Results: CB and appropriate alternative behavior were sensitive to the combination of duration, quality, and delay to reinforcement available for each option for both participants.
Bernstein et al. (2009)	3	3	DD	alternative response; skill acquisition	home; leisure	Purpose: Assess the allocation of responding between mands and play responses when a denser reinforcement schedule is programmed for mands. Results: Participants engaged in more mands than play when both responses were reinforced according to an FR-1 schedule. When mands were put on an FR-10 schedule, play increased for all 3 participants; mands decreased for 2 participants and increased for 1 participant.

Table 3 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Borrero et al. (2010)	3	8–14	DD, ID, ASD	CB; alternative response	clinic, school; leisure/ social	Purpose: Evaluate allocation of responding across asymmetrical-choice options with several reinforcement schedules for two response options (CB and mands) and analyzed outcomes using the generalized matching equation. Results: Response rates were correlated with the relative reinforcer rates for each response option; a slight bias in responding occurred for all participants.
Briggs et al. (2019)	4	4–16	DD, ID	CB; adherence/ engagement	clinic, school; academic	Purpose: Evaluate the effects of varying quality and magnitude of reinforcement without EXT on CB and compliance. Results: CB decreased and compliance increased for 2 participants when manipulating quality and for the other 2 participants when altering both magnitude and quality. Treatment outcomes maintained for 3 of 4 participants during schedule thinning with the combination of magnitude and quality.
Crowley et al. (2020)	7	2–8	ASD; avoidant/restrictive food intake disorder	adherence/ engagement	clinic; domestic/ vocational	Purpose: Arrange asymmetrical choices to decrease change-resistant behavior with target foods and increase consumption of alternative foods. Results: Resistance-to-change behavior decreased for all participants. Alternative food consumption increased for 2 participants in the asymmetrical-choice condition and for 5 participants following exposure to a single-choice condition with one food presentation at a time. Results generalized to nontargeted foods.
Davis et al. (2018)	1	7	ADHD, ODD, & Disruptive mood dysregulated disorder	CB; alternative response; adherence/ engagement	clinic; academic	Purpose: Determine how varying the duration and quality of breaks in an asymmetrical-choice intervention impacts allocation of responding between CB and a break mand without the use of EXT. Demand fading was used to systematically increase the work requirement to earn access to the break mand. Results: CB decreased and break mands increased; break mands occurred at rates that would likely be unsustainable in a naturalistic setting until the demand-fading component was added.
Falcomata et al. (2010)	9	5–8	Not specified; referred for ADHD evaluation	adherence/ engagement; impulsive/ self-control choice	clinic; academic	Purpose: Evaluate the effects of varying delay, quality, and effort on selection of the self-control response and task engagement. Results: For the 6 participants who engaged in impulsive choices during baseline, an increase in self-control responding was observed for all participants in one or more conditions.

Table 3 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Fisher et al. (2019) Exp 1	2	5	ASD	CB; adherence/ engagement	clinic; domestic/ vocational	Purpose: Assess tolerance for change across three choice conditions: free choice, guided choice, (conceptualized as escape EXT), and asymmetrical choice (a high-preferred reinforcer delivered with desired behavior). Results: At first, only the guided-choice condition resulted in clinically relevant increases in tolerance. After multiple exposures to the guided-choice condition, tolerance increased and CB decreased in the asymmetrical- and free-choice conditions as well.
Fisher et al. (2019) Exp 2	2	4–7	ASD	CB; adherence/ engagement	clinic; domestic/ vocational	Purpose: Assessed tolerance for change across three choice conditions: free choice, single choice, (conceptualized as escape EXT), and asymmetrical choice (a high-preferred reinforcer delivered with desired behavior). Results: Tolerance was low in the initial exposure to the free- and asymmetrical-choice conditions. It increased for both participants in the single-choice condition in the subsequent asymmetrical-choice condition for one of the two participants.
Kelley et al. (2011)	2	6	PDD, FAS, ODD, SID, ADHD	Adherence/ engagement	clinic; academic	Purpose: Determine whether arranging either reinforcement or work completion following two concurrently available response options increased compliance with the directive "pick one" and allocation toward the option associated with reinforcement. Results: Choice making increased for both participants. Allocation toward the choice option associated with reinforcement increased relative to allocation toward the choice option that was associated with additional work completion.
Martens et al. (2016)	2	4	Not specified; receiving special education services	CB; adherence/ engagement	school; academic, leisure/ social	Purpose: Determine how varying the rate of reinforcement (attention) impacts allocation of responding between on-task and CB (i.e., off-task). Outcomes were analyzed using the generalized matching equation. EXT of CB was not used. Results: Allocation and relative response rate of on- and off-task behavior correlated with the relative reinforcement rate for both participants. Some undermatching, bias toward on-task behavior, and low sensitivity were observed.

Table 3 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Passage et al. (2012)	1	16	ID, spastic cerebral palsy, cortical blindness	adherence/ engagement; impulsive/ self-control choice	clinic; academic	Purpose: Determine the effects of access to qualitatively different reinforcers on self-control choice when the high-preferred reinforcers are available for selecting option to complete a task with a progressively increasing duration of delay. Results: Selection of the self-control response and duration of task engagement increased.
Peck Peterson et al. (2005)	2	4–9	DD, ID, tuberous sclerosis	CB; alternative response	school; academic	Purpose: Evaluate the manipulation of break duration and quality in an asymmetrical-choice intervention without EXT on allocation of responding among CB, break mands, and work mands. Results: CB decreased for both participants. Participants engaged in frequent break mands following FCT. In the asymmetrical-choice phase when higher-quality breaks were provided for task completion, work was selected more frequently than break mands.
Peterson et al. (2009)	7	7–12	ASD, DD, ID, Down syndrome, galactosemia	CB; alternative response	school, home; academic	Purpose: Assess the effects of varying the quality and duration of a break in an asymmetrical-choice arrangement on allocation of responding among CB, break mands, and work mands without the use of EXT. Results: CB decreased for all three participants. Participants allocated more responding to work or break mands depending on which choice-option was consequated with the high-quality break.
Peterson et al. (2017)	2	7–8	DD, ID, Down syndrome	CB; adherence/ engagement; alternative response	school; academic	Purpose: Probe relapse of CB and persistence of alternative behavior during an intervention using differential reinforcement with 2- and 3-choice asymmetrical-choice options. Results: Responding during the probes was idiosyncratic; relapse occurred more in the 2-choice probes. Persistence of appropriate alternative behavior was achieved with 1 participant after extended exposure to the intervention, but not for the other.

Table 3 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Quigley et al. (2013)	1	9	ASD	CB; response allocation adherence/ engagement	school	Purpose: Clarify results from an inconclusive FA to assess the function of passive noncompliance. Increase task engagement and decrease passive noncompliance using a choice-based intervention. Results: Avoidance of task demands was identified as the function of passive noncompliance. Time spent working and accurate assignment completion increased during the intervention with arranged for differential reinforcement with asymmetrical-choice options.
Reed & Martens (2008) Exp 1	3	8–9	TD	adherence/ engagement	school; academic	Purpose: Determine how variations in density of reinforcement for each choice option impacted allocation of responding between 2 equivalent tasks. Outcomes were analyzed using the generalized matching equation. Results: Task engagement was proportionally allocated to the option with the highest reinforcement rate for 2 of 3 participants.
Reed & Martens (2008) Exp 2	3	8–9	TD	adherence/ engagement	school; academic	Purpose: Determine the effects of varying density of reinforcement and response effort (i.e., difficulty of math problems) on responding between two available workstations with math worksheets. Outcomes were analyzed using the generalized matching equation. Results: Response allocation was biased toward the easier math problem for all participants.
Rivas et al. (2014) Exp 1	3	2–3	Pediatric feeding disorder	adherence/ engagement	clinic, home; domestic/ vocational	Purpose: Assess an asymmetrical-choice procedure in which participants could choose to take 1 bite independently or 1 or more caregiver-delivered bites (the magnitude of required bites varied across phases). Results: Self-fed bites increased for 2 participants in the 1:2 or 1:3 ratio conditions. Clinically significant increases were not observed for the third participant.
Rivas et al. (2014) Exp 2	1	2	Pediatric feeding disorder	adherence/ engagement	home; domestic/ vocational	Purpose: Assess an asymmetrical-choice procedure in which the participant could choose to take 1 bite independently or 1 or more caregiver-delivered bites (low-preferred food item; the required number of bites varied). Results: Self-fed bites of food increased under the condition of a 1:4 ratio.

Table 3 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Rogalski et al. (2020)	3	5–13	ASD	CB; adherence/ engagement	school	Purpose: Determine the effects of a concurrent-schedule arrangement in which the magnitude of escape is differentiated following escape-maintained CB and compliance. Results: CB decreased for all participants when the magnitude of escape was greater following compliance relative to CB.
Vaz et al. (2011)	1	6	TD; referred for food selectivity	adherence/ engagement	clinic; domestic/ vocational	Purpose: Determine the effects of an asymmetrical-choice procedure in which the participant was presented the choice between 1 independent bite or 5 therapist-assisted bites of an avoidance food. Results: Independent bites increased during the choice condition; replicated across 3 target food items.

A summary of participant demographics, dependent variables, settings, activities, purpose, and results for experiments that implemented differential reinforcement with asymmetrical-choice options

The following abbreviations are used: attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), challenging behavior (CB), developmental delay (DD), emotional and behavioral disorders (EBD), extinction (EXT), fetal alcohol syndrome (FAS), fixed ratio (FR), functional communication training (FCT), intellectual disability (ID), obsessive compulsive disorder (OCD), oppositional defiance disorder (ODD), pervasive developmental disorder (PDD), posttraumatic stress disorder (PTSD), progressive ratio (PR), and sensory integration disorder (SID), traumatic brain injury (TBI), typically developing (TD)

& Vollmer, 2010, Experiments 1–4; Borrero et al., 2010; Briggs et al., 2019; Davis et al., 2018; Fisher et al., 2019, Experiments 1 & 2; Martens et al., 2016; Peck Peterson et al., 2005; Peterson et al., 2009, 2017; Rogalski et al., 2020; Quigley et al., 2013). All of these experiments also measured and reinforced at least one appropriate alternative response, such as a communication response or task engagement. Participants in these experiments ranged from 4–16 years old, and almost all had reported diagnoses such as autism spectrum disorders (ASD), attention deficit hyperactivity disorder (ADHD), or intellectual disabilities. Most of these experiments took place in a clinic or school setting and included academic activities.

Most (80.0%; 12 of 15) of the experiments aimed at reducing challenging behavior included a functional analysis of challenging behavior. Fisher et al. (2019; Experiments 1 & 2) did not report a functional assessment; however, the target behavior was presumed to be maintained, at least in part, by automatic reinforcement of avoiding contact with new routines. Quigley et al. (2013) described an intervention following an inconclusive functional analysis during which the participant engaged in only passive noncompliance during the assessment. These exceptions notwithstanding, most experiments in this category programmed choice options informed by the hypothesized function of challenging behavior. For example, Peterson et al. (2009) arranged independent schedules of reinforcement for challenging behavior and two alternative responses (i.e., break mands and work mands) for participants with escape-maintained challenging behavior. To create asymmetrical-choice options, they varied the quality (i.e., access to preferred tangibles) and duration of the breaks for the three responses. Challenging behavior always resulted in low-quality reinforcers in the form of a 10-s break with no adult attention and access to only low-preferred tangible items. Depending on the phase, break mands and work mands resulted in either high- or medium-quality breaks. High-quality breaks were 60 s in duration and included access to high-preferred adult attention and tangible items. Medium-quality breaks were 30 s in duration with neutral adult attention and access to medium-preferred tangible items. Using a reversal design, the high- and medium-quality breaks alternated between the two mand types. Across all phases, response allocation was highest for the response option that produced high-quality breaks. Challenging behavior rarely occurred despite the absence of programmed extinction.

In another example, Quigley et al. (2013) conducted a choice assessment and treatment with a 9-year-old boy who engaged in passive noncompliance during academic tasks in a functional analysis. A choice assessment was conducted to guide treatment after the inconclusive analysis. The results suggested that avoiding academic tasks was the likely function of the challenging behavior and that attention and access to items were preferred over academic tasks. These results guided an intervention using differential reinforcement with asymmetrical-choice options. The child was given a choice to select an academic task (combined with demand fading) and earn a high-quality break or choose to mand for a break resulting in a low-quality break. Once the participant consistently chose the work choice, the work requirement was slowly increased. The intervention increased work completion, and the researchers successfully increased the work requirement. The effectiveness of this approach for developing a treatment for passive challenging behavior is notable and may offer an alternative to functional-assessment procedures in cases in which behavior is not amenable to standard methods (e.g., passive behavior that cannot be easily measured or reinforced during a functional analysis).

Like Peterson et al. (2009) and Quigley et al. (2013), several experiments demonstrated a decrease in challenging behavior with the use of asymmetrical-choice options without the use of extinction for challenging behavior (Athens & Vollmer, 2010, Experiments 1–4; Borrero et al., 2010 in some conditions; Briggs et al., 2019; Davis et al., 2018; Martens et al., 2016; Peck Peterson et al., 2005; Peterson et al., 2017; Quigley et al., 2013; Rogalski et al., 2020), although some of these experiments observed adequate suppression under only some experimental conditions or had idiosyncratic results across participants. Because extinction can be difficult to implement in some situations due to logistical and ethical factors (Athens & Vollmer, 2010), future research should further assess the conditions under which interventions arranging asymmetrical-choice options result in clinically significant reductions in challenging behavior in the absence of extinction. It may be notable that several of the experiments and conditions that suppressed challenging behavior to a clinically relevant degree

Table 4 Building choice opportunities in daily contexts

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Bicard et al. (2012)	21	10–11	None specified (2 qualify for special education)	CB	school; academic	Purpose: Evaluate the effects of teacher versus student seat selection on student CB. Results: CB was lower in the no-choice condition (assigned seats) compared to the choice condition.
Elliot & Dillenburger (2016)	3	4	ASD	skill acquisition	home; academic	Purpose: Compare the effects of participant choice and no-choice (i.e., experimenter choice) of reinforcers on skill acquisition in a discrete-trial training procedure. Results: No differences in skill acquisition were observed between choice and no-choice conditions for 2 participants. Accuracy of responding increased slightly and less non-responding was observed for 1 participant in the choice-of-consequence condition.
Gureghian et al. (2020)	3	5–9	ASD	skill acquisition	school; academic	Purpose: Replicate and extend Peterson et al. (2016) by comparing choice-making opportunities presented before or after task completion with novel targets using natural teaching schedules of reinforcement. Results: Acquisition was more efficient in the consequence-of-choice condition for 2 participants; there was no difference in efficiency for the third participant.
Koegel et al. (2010)	4	4–7	ASD	CB; adherence/ engagement	school; academic	Purpose: Assess the effects of choice of materials and setting on latency to engage and task completion. Results: The latency to engagement in academic tasks decreased and rates of task completion increased under the choice conditions. CB also decreased for all participants.

Table 4 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
May (2019)	3	5	DD, ID, EBD	adherence/ engagement	school; academic	Purpose: Determine whether antecedent choice for activity and escape + differential attention or escape + differential physical proximity of experimenter impacted on-task behavior. Results: On-task behavior increased in the differential attention condition for all 3 participants. On-task behavior did not change in the escape + differential-physical-proximity condition.
Northgrave et al. (2019)	2	5–9	ASD	skill acquisition	home; academic	Purpose: Evaluate efficiency of providing participant versus experimenter choice of reinforcers after task completion. Results: Faster skill acquisition was observed in the experimenter-choice condition for both participants.
Peterson et al. (2016)	4	6–11	ASD	adherence/ engagement	clinic; academic	Purpose: Compare opportunity for choice-of-consequence occurring before or after task completion and persistence with increasing task requirements using PR schedules. Results: For 2 participants, task completion was higher in the pre-task choice condition and 2 participants did not show differentiated behavior across the conditions. Three participants preferred the pre-trial choice and one preferred the post-trial choice condition.

Table 4 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Sran & Borrero (2010)	4	4	TD	adherence/ engagement	school; academic	Purpose: Evaluate effects of 4 conditions on work completion; a baseline condition with no programmed consequences for completing academic work, a no-choice condition with tokens exchangeable for a single reinforcer, a single-choice condition with tokens exchangeable for 5 of the same reinforcer, and a varied-choice condition with tokens exchangeable for a choice of 5 different reinforcers. They also evaluated participant preference for the conditions. Results: All 3 reinforcement conditions increased work completion for 2 participants compared to the no-reinforcement baseline. For 1 participant, the no-choice condition produced lower rates of responding than the other 2. All 3 participants preferred the varied-choice condition.
Stayer Smeltzer et al. (2009)	3	6–8	ASD, DD, ID, Fragile X	CB; adherence/ engagement	school; academic	Purpose: Evaluate the effects of choice of task sequence on CB and on-task behavior. Results: On-task behavior increased, duration to complete tasks decreased, and CB decreased in the student-choice condition compared to the experimenter-choice condition for 2 of 3 participants.
Sullivan & Roane (2018)	2	12–15	Smith-Magenis Syndrome; ASD	CB; adherence/ engagement	clinic; social	Purpose: Compare the effects of DRO with participant- or experimenter-choice as the reinforcer on CB and work engagement. Results: Both participants engaged in lower levels of CB and higher levels of work in the DRO with the choice-of-consequence condition.

Table 4 (continued)

Author(s)	*n*	Age	Diagnoses	DVs	Setting; Activity	Purpose and Results
Tiger et al. (2010)	3	3–7	ASD	adherence/ engagement; skill acquisition	clinic; leisure/ social	Purpose: Compare effects of choice- and no-choice conditions using PR schedule versus FR schedule reinforcer assessments on task engagement. Results: In the FR assessment, no differences were observed between choice and no-choice condition. In the PR assessment, 2 of 3 participants showed higher rates of task completion in the choice condition compared to the no-choice condition.
Toussaint et al. (2016)	3	3	ASD	skill acquisition	clinic; academic	Purpose: Evaluate the effects of choice-of-consequence on skill acquisition and to assess preference for choice versus no-choice conditions. Results: 2 of the 3 participants mastered targets more quickly in the choice condition. For the 3rd participant, there was no difference between conditions. All showed preference for the choice condition.
Ulke-Kurkcuoglu & Kircaali-Iftar (2010)	4	5–8	ASD	adherence/ engagement	clinic; academic	Purpose: Compare the effects of activity choice, material choice, and no-choice on on-task behavior. Results: On-task behavior increased for all participants in both the activity-choice condition and the materials-choice condition relative to the no-choice condition.

A summary of participant demographics, dependent variables, settings, activities, purpose, and results for experiments that included choice options built into daily contexts (i.e., choice of activity or materials and choice of consequence)

The following abbreviations are used: attention deficit hyperactivity disorder (ADHD), autism spectrum disorder (ASD), challenging behavior (CB), developmental delay (DD), emotional and behavioral disorders (EBD), extinction (EXT), fetal alcohol syndrome (FAS), fixed ratio (FR), functional communication training (FCT), intellectual disability (ID), obsessive compulsive disorder (OCD), oppositional defiance disorder (ODD), pervasive developmental disorder (PDD), posttraumatic stress disorder (PTSD), progressive ratio (PR), and sensory integration disorder (SID), traumatic brain injury (TBI), typically developing (TD)

manipulated more than one parameter of reinforcement simultaneously (e.g., quality and duration; Athens & Vollmer, 2010, Experiment 4; Briggs et al., 2019; Peterson et al., 2009; Peck Peterson et al., 2005); however, none of the reviewed experiments directly compared the effects of manipulating one or more parameters, which would be a worthwhile evaluation for informing practice guidelines in this area.

Another underexplored research question relates to the role of extinction and learning history. Undoubtedly, an individual's learning history is a relevant variable that can influence outcomes in behavioral interventions, and past exposure to extinction could possibly affect the outcomes of differential reinforcement with asymmetrical-choice options. For instance, Fisher et al. (2019) showed increased tolerance (defined as engaging an alternative response without "contrary" or challenging behavior) in the choice conditions for three of four participants. However, this increase was only observed after the participants experienced a condition that the authors conceptualized as escape extinction (i.e., by requiring selection of the alternative response and contact with the programmed contingencies). These results suggest that even the temporary use of extinction may have a lasting effect on response allocation in choice-based interventions. Overall, there may be clinical benefits to understanding the role of histories of extinction in choice-based interventions and identifying the conditions necessary for effective interventions when extinction is not a feasible component.

All experiments using asymmetrical choice as an intervention for challenging behavior presented two concurrently available response options except Peck Peterson et al. (2005), Peterson et al. (2009), Peterson et al. (2017), and Quigley et al. (2013), all of which programmed three concurrent asymmetrical-response options. In these experiments, the options included challenging behavior, break mands, and academic responses. These experiments demonstrate that arranging three asymmetrical-choice options is a potential solution to unmanageable frequencies of functional communication responses, which is common in functional communication training when the choice options are challenging behavior and a single alternative response (often a communication response). These experiments with three choice options showed the highest allocation to academic responses while avoiding the issue of frequent break mands, as long as the highest-quality reinforcement was programmed for working (Peck Peterson et al., 2005; Peterson et al., 2009; Quigley et al., 2013).

Furthermore, two participants in the study by Peterson et al. (2017) experienced both two- and three-choice differential reinforcement with asymmetrical-choice options with interspersed relapse probes. During these probes, the consequences for all response options were equated such that all resulted in high-quality reinforcement, thus evaluating the persistence or relapse (i.e., reemergence of a previously reinforced response) of challenging and appropriate behavior. Relapse of challenging behavior was more likely in the two-choice condition (mands occurred during the three-choice probes), and response persistence of work during the relapse probes increased for one participant with prolonged exposure to the intervention. A different potential solution to high-rate mands is exemplified in the study by Davis et al. (2018). The participants in this study engaged in high-rate break mands in a two-choice arrangement. The researchers incorporated demand fading in which the break mand only became available after completing the work requirement, which progressively increased over time. Additional research should identify the conditions under which two- or three-choice interventions are more efficacious.

Future evaluations of differential reinforcement with asymmetrical-choice options should consider variables such as the propensity for challenging behavior to relapse and desirable alternative choice options to persist. Overall, the reviewed experiments show that differential reinforcement with asymmetrical-choice options may be an effective alternative to more standard differential reinforcement arrangements (e.g., differential reinforcement of alternative or incompatible behavior; DRA or DRI, respectively) when extinction is not possible or feasible (e.g., automatically maintained behavior, logistical or regulatory barriers), extinction could have undesirable side effects (e.g., extinction bursts, emotional responding), or there is a concern that clients will overselect a single alternative behavior (e.g., adding additional response options to mitigate high rates of mands for attention or breaks from academic tasks). However, we identified no experiments that were designed to directly compare clinical outcomes using typical DRA with extinction procedures with those using asymmetrical-choice options. Furthermore, future

research could evaluate asymmetrical-choice options with other differential reinforcement procedures (e.g., differential reinforcement of other behavior in which a higher magnitude of reinforcement is available for meeting the omission interval; Call et al., 2011).

Adherence and Task Completion

Eight experiments used differential reinforcement with asymmetrical-choice options to target behavior related to adherence with demands and task completion (Bernstein et al., 2009; Crowley et al., 2020; Kelley et al., 2011; Reed & Martens, 2008, Experiments 1 & 2; Rivas et al., 2014, Experiments 1 & 2; Vaz et al., 2011). One study evaluated the effects of altering the relative reinforcement schedules on mands and play behavior with individuals aged 3 years old with ASD or other developmental disabilities (Bernstein et al., 2009). The participants engaged in a higher rate of mands compared to play behavior when the reinforcement schedules were equated for both responses options. When the researchers decreased the density of reinforcement for mands from an FR 1 to an FR 10 (play remained on an FR 1), the participants engaged in higher rates of play behavior and two of the three participants engaged in lower rates of mands. Two experiments addressed academic task completion with typically developing children between the ages of 8 and 9 years (Reed & Martens, 2008, Experiments 1 & 2) and found that task engagement with math problems was proportionally allocated to the option with the highest reinforcement rate for two of three participants. When task difficulty was varied, there was a bias toward the easier math problems. Another study by Kelley et al. (2011) with academic tasks found allocation toward the choice option associated with reinforcement increased relative to allocation toward the choice option associated with additional work completion with two 6-year-old participants.

Four experiments in this subcategory employed interventions with children aged 2–8 years with pediatric feeding disorders or food selectivity. Vaz et al. (2011) implemented a differential reinforcement procedure with asymmetrical-choice options to increase self-fed bites for one participant referred to a pediatric feeding program to treat food selectivity. During the intervention phase, the participant could choose to self-feed one bite of the target food or for the therapist to deliver the target food plus five bites of a nonpreferred ("avoidance") food. The authors framed the choice condition as manipulating both response effort (number of bites) and quality (target foods were more preferred than avoidance foods). Independent bites increased in the phases with the asymmetrical-choice arrangement, and this outcome was replicated across three target foods. In two similar experiments, Rivas et al. (2014, Experiments 1 & 2) arranged a choice condition in which participants could choose to take one independent bite of food or the alternative of one or more caregiver-delivered bites of the same food (the magnitude of required bites varied across phases). Two of the three participants engaged in more self-fed bites during the intervention conditions (Experiment 1). The third participant increased self-fed bites when they implemented a modified version of the procedure in which the alternative option was multiple caregiver-delivered bites of a nonpreferred food item (Experiment 2).

Crowley et al. (2020) conducted a similar study; however, rather than manipulating magnitude, participants could earn access to a preferred food item following a choice to eat an alternative (low-probability) food rather than a change-resistant food (i.e., food items that the participant frequently ingests; also known as a high-probability food). For two participants, alternative food consumption increased during the asymmetrical-choice condition, during which the therapist provided access to a preferred food following a choice for the alternative food. For the other five participants, response allocation shifted toward the alternative choice following a single-choice condition in which the therapist guided the alternative choice. It is interesting that after the shift in response allocation was achieved, the alternative food choices were maintained and generalized to other food items, even when they returned to the concurrent-choice conditions. The authors pointed out that one potential benefit of this arrangement compared to the previous experiments is that arranging asymmetrical-choice options using preferred food consequences is more analogous to natural mealtime environments during which children often have a choice among multiple types of food.

Although most experiments using differential reinforcement with asymmetrical-choice options were designed to decrease challenging behavior, the results of the experiments reviewed in this subcategory

demonstrate promising outcomes across a variety of behavioral targets and intervention goals, including task engagement and adherence and feeding-related goals.

Self-Control Choices

Two experiments evaluated interventions with a concurrent-operant arrangement to increase self-control choices (i.e., self-control training procedures; Falcomata et al., 2010; Passage et al., 2012). In these experiments, researchers varied consequences for concurrently available choice options to shift choice allocation from one option leading to a smaller sooner reinforcer (i.e., the impulsive choice) to an option in which task engagement led to a larger, more delayed reinforcer (i.e., the self-control choice). In a two- or three-choice arrangement, researchers presented a socially significant task during the delay following a self-control choice. Participants in these experiments included individuals aged 5–16 years.

Passage et al. (2012) used progressive delay procedures with a matching-to-sample task with one participant diagnosed with an intellectual disability, spastic cerebral palsy, and cortical blindness. They demonstrated that task engagement increased when a high-preferred reinforcer was available for selecting the self-control-choice option to complete a task with a progressively increasing delay duration (i.e., progressive delay procedure).

In a two-choice arrangement, Falcomata et al. (2010) evaluated self-control responding with academic tasks (e.g., math and spelling worksheets) for children who were referred for symptoms potentially related to an ADHD diagnosis. They varied reinforcer and response dimensions (delay, quality, and effort), and the effects were idiosyncratic across participants. However, all showed increased task completion under at least one of the arranged conditions. The authors pointed out that using similar procedures could provide a framework for completing individualized assessments for intervention planning to increase self-control.

Both experiments in this subcategory measured allocation across self-control responses, impulsive responses, and task engagement as dependent variables. The participants in these experiments shifted response allocation from impulsive choice in baseline to self-control choice following the introduction of the self-control training intervention and increased task engagement during the delay periods. Overall, these experiments show the feasibility of reinforcing self-control choices with larger, higher-quality reinforcement relative to smaller, lower-quality reinforcement following impulsive choices to increase self-control and task engagement. Furthermore, future research should evaluate the extent to which self-control training procedures result in pervasive patterns of self-control choice in naturalistic contexts, including complex situations that call for decision making when outcomes are substantially delayed (e.g., days, months, or years), probabilistic, cumulative, or even life-altering (e.g., health, economic, and relational consequences).

Summary of Outcomes and Implications for Practice

The left panel of Fig. 2 displays the outcomes of the experiments that used asymmetrical choice. Twenty-three (92.0%) experiments showed positive results, outcomes of two experiments (8.0%) were mixed, and no experiments in this category showed negative results. These outcomes suggest that differential reinforcement with asymmetrical-choice options is a robust approach for decreasing challenging behavior and increasing alternative communication and adherence/task engagement.

Practitioners can develop these arrangements by selecting two or more responses and adjusting the reinforcement parameters to be more "favorable" for the more desirable response(s) (e.g., communication responses, work completion, food acceptance) compared to the undesirable response(s) (e.g., challenging behavior, food refusal). It should be noted that when planning interventions to decrease challenging behavior, use of asymmetrical choices may be a good fit when working with children for whom the use of extinction is undesirable or not possible.

For the most part, the reviewed experiments with behavior-deceleration goals have shown success when a functional behavior assessment (most often a functional analysis) was conducted prior to the intervention, and the choice options were, at least in part, based on the identified function of the behavior. Practitioners should conduct functional behavior assessments to identify function-based reinforcers for these interventions.

Furthermore, it may be necessary to evaluate multiple reinforcement manipulations, as individuals display different sensitivities to reinforcement parameters (Kunnavatana et al., 2018). Practitioners can evaluate the effects of varied parameters of reinforcement provided for alternative behavior choices and measure the response allocation across the differentiated choice options (e.g., with arbitrary responses or clinically relevant behavior). In such cases when extinction is not possible or desirable, practitioners may consider starting with the approach of manipulating multiple reinforcement parameters simultaneously (e.g., duration, quality, and immediacy; Athens & Vollmer, 2010) or including multiple reinforcers, such as arranging both positive and negative reinforcers (e.g., Peterson et al., 2017; Quigley et al., 2013). For instance, when working to address escape-maintained behavior, practitioners might include the following as consequences for appropriate behavior: (1) longer break duration; (2) include positive reinforcers (e.g., breaks and tangible and/or attention); and (3) arrange for higher quality or more preferred break activities. Furthermore, when high rates of an alternative response (e.g., functional communication responses) are a concern, arranging for three choice options with or without demand fading may help mitigate this limitation (Davis et al., 2018). Probes like those arranged by Peterson et al. (2017) can be used to assess the effects of two- versus three-choice arrangements and aid in data-based decisions about fading out choice options and the likelihood of relapse and persistence of response options.

The reviewed experiments also demonstrated that differential reinforcement with concurrent asymmetrical-choice options could be used for behavior-acceleration goals for behavioral targets such as task engagement and adherence and feeding-related goals using arrangements similar to those described above. Although additional research is warranted for its use in interventions to increase self-control choice, practitioners interested in increasing self-control choice may be able to accomplish this by layering additional reinforcement on that option. However, given the small number of experiments, additional research is likely needed before this type of self-control training procedure is adopted as common practice.

Building Choice Opportunities in Daily Contexts

Another way to implement choice in behavior-change procedures is to build choice-making opportunities into naturally occurring situations and daily routines (e.g., daily living and self-care activities, academic tasks). Thirteen experiments provided participants with opportunities to choose activities, activity features, or consequences to follow an activity (e.g., choice of a reinforcer; see Table 4).

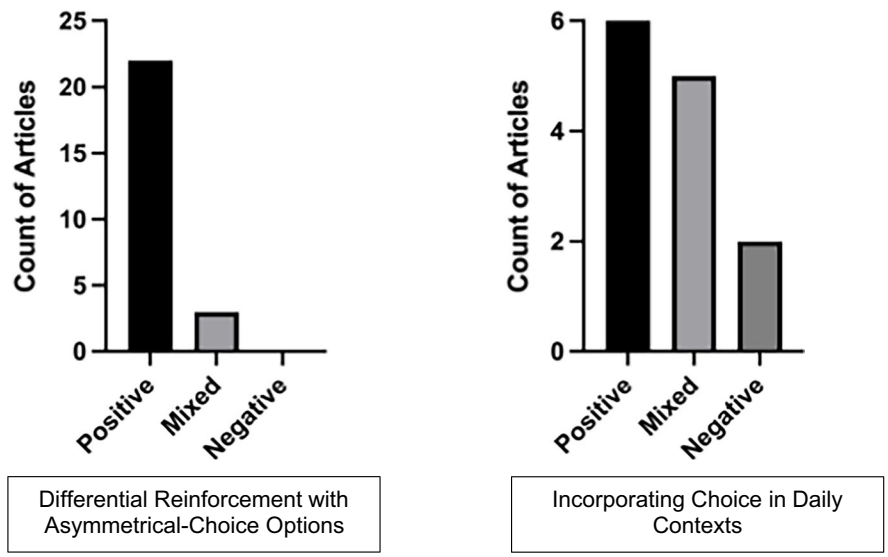

Fig. 2 Outcomes. *Note.* Count of articles on differential reinforcement with asymmetrical-choice options (left) and incorporating choice in daily contexts (right) coded as positive, mixed, and negative outcomes. Note the difference in scale for the y-axes

Choice of Activity or Features

One option for incorporating choice into daily contexts is to present opportunities to select among two or more available activities (e.g., type of tasks or the order of activities) or options for varying activity features. Following the selection, the participant experiences the selected event or is given access to the selected materials. For the experiments identified in this subcategory, the choice options were related to activity type, order, or the materials to be used (e.g., crayons or markers to complete a worksheet).

Five experiments evaluated the choice of activity or materials interventions (Bicard et al., 2012; Koegel et al., 2010; May, 2019; Stayer Smeltzer et al., 2009; Ulke-Kurkcuoglu & Kircaali-Iftar, 2010). One experiment included choice options related to the hypothesized function of challenging behavior (i.e., escape, attention, and physical proximity; May, 2019). Experiments included participants with and without disabilities ranging from 4 to 11 years old. Four out of the five experiments in this subcategory measured task engagement or completion as a dependent variable (Koegel et al., 2010; May, 2019; Stayer Smeltzer et al., 2009; Ulke-Kurkcuoglu & Kircaali-Iftar, 2010), and three measured challenging behavior (Bicard et al., 2012; Koegel et al., 2010; Stayer Smeltzer et al., 2009). The settings in these experiments included schools and clinics.

Several experiments compared conditions of participant choice with experimenter choice. For example, Stayer Smeltzer et al. (2009) provided three participants with choice options prior to completing specific tasks. They compared two conditions in a multielement design to assess the effects of participant choice of task order on task engagement and challenging behavior. Participants were instructed to complete the tasks in any order in the student-selected choice condition. To isolate choice as the independent variable, the selections in the experimenter-choice condition were yoked to participant choices from the student-selected choice condition. Following the alternating-treatments phase, both conditions were concurrently available to assess participant preference. Response allocation across the concurrent schedules revealed that all participants preferred the student-selected choice condition over the experimenter-choice condition. Challenging behavior decreased, on-task behavior increased, and duration to complete tasks decreased for two of three participants in the student-selected choice condition relative to the experimenter-choice condition.

In another experiment evaluating the effects of opportunities to choose, Ulke-Kurkcuoglu and Kircaali-Iftar (2010) used a reversal design to compare the effects of choice of activity with choice of materials on on-task behavior for four students with ASD. After a baseline condition in which no choice opportunity was provided, students had the opportunity to choose either the activity (with the materials selected by the teacher) or the materials (with a teacher-selected activity). The material- and activity-choice conditions resulted in higher levels of on-task behavior compared to the baseline phase. This suggests that participant behavior may benefit from choice opportunities that can be arranged in various ways.

Across the five experiments in this subcategory, there were positive results of incorporating choice opportunities for most participants with increased task or leisure engagement or decreased challenging behavior. However, providing a choice of activity or materials is not a one-size-fits-all solution in all contexts. Bicard et al. (2012) evaluated the effects of student versus teacher choice of classroom seating arrangements on disruptive behavior (i.e., talking without permission and touching peers). They found that disruptive behavior was higher in the student-choice condition. This outcome may be unsurprising to many, given the nature of the choice evaluated; students likely chose to sit near someone with whom they preferred to socialize. However, findings like this highlight the need for practitioners to make individualized data-based decisions and evaluate the effects of choice opportunities on behavior as they relate to contextual variables and intervention goals. Overall, the outcomes observed in the experiments on the choice of activity or features suggest that providing choice options, such as instructional tasks or materials, can be a low-cost and straightforward tool for increasing task engagement and decreasing challenging behavior.

Choice of Consequence

Other experiments incorporated choice-making opportunities into routines by providing options for

participants to select the consequences for a specified response (e.g., completing an academic task). Eight experiments included a choice-of-consequence intervention (Elliot & Dillenburger, 2016; Gureghian et al., 2020; Northgrave et al., 2019; Peterson et al., 2016; Sran & Borrero, 2010; Sullivan & Roane, 2018; Tiger et al., 2010; Toussaint et al., 2016). Participants ranged from 3 to 15 years old. Most experiments included younger children (3–7 years old) with ASD; Sullivan and Roane (2018) included a slightly older population aged 12–15, and Sran and Borrero (2010) included typically developing children 4 years of age. These experiments employed choice-of-consequence interventions across various settings, including schools, clinics, and homes. All experiments in this subcategory measured task engagement or completion or skill acquisition as a dependent variable, and one also measured challenging behavior (Sullivan & Roane, 2018).

All eight experiments in this subcategory evaluated opportunities to choose reinforcers during skill-acquisition tasks. For example, Toussaint et al. (2016) compared conditions during which participants had a choice between multiple edible reinforcers following correct responses during discrete-trial training (choice condition), a yoked (no-choice) condition during which the experimenter presented the item chosen in the previous choice condition, and a baseline (control) condition that included no consequence for responding. Two of three participants reached the mastery criterion faster in the choice condition relative to the no-choice condition. To evaluate preference, researchers used a concurrent-chains arrangement and presented participants with stimuli associated with each condition (choice, no-choice, and control) concurrently. After selection, participants experienced that condition. All three participants showed a preference for the choice condition. Similar results were demonstrated by Sullivan and Roane (2018). They used a differential reinforcement of other behavior (DRO) procedure and compared a condition in which the participant gained access to their choice of activity or an experimenter-selected activity. Both participants engaged in lower levels of challenging behavior and higher levels of work in the DRO with the choice-of-consequence condition.

Two experiments investigated the effects of incorporating reinforcer choice into routines and manipulating the timing of the presentation of the choice opportunities. Peterson et al. (2016) compared the effects of participant-selected reinforcers before or after learning trials on task completion of mastered targets. After a baseline with no reinforcement for task completion, participants experienced alternating conditions during which they were either provided a choice of reinforcers immediately before work completion (pretrial) or immediately after work completion (posttrial). After each trial, the number of responses required before the reinforcer was provided increased using a progressive-ratio (PR) schedule, and preference for the conditions was evaluated using a concurrent-chains arrangement. Two participants completed tasks more often when reinforcer choice occurred pretrial rather than posttrial, and three of the four participants preferred the pretrial choice of consequence condition. Gureghian et al. (2020) sought to replicate and extend Peterson et al. (2016) by evaluating efficiency and effectiveness using unmastered targets. They used a token economy with fixed-ratio (FR) delivery and exchange schedules, which differed from Peterson et al. (2016). New skills were mastered more quickly for two of the three participants when the choice of reinforcer was provided posttrial. Preference for the condition was not evaluated in this experiment.

Overall, the results of choice-of-consequence manipulations were idiosyncratic across experiments and participants within the same experiments. Effective arrangements of choice opportunities for consequences were characterized by increased skill acquisition and task engagement (e.g., Toussaint et al., 2016). Some experiments found no difference in responding between choice and no-choice conditions for some participants (e.g., Elliot & Dillenburger, 2016; Tiger et al., 2010), and one experiment found that skill acquisition was more efficient in the experimenter-choice condition (Northgrave et al., 2019). Tiger et al. observed higher rates of task completion in the choice-of-consequence condition for two of the three participants in the assessment using PR schedules, but they observed no difference in the assessment condition using FR schedules; this highlights the point that contextual variables (e.g., reinforcement schedule, response effort) can interact in meaningful ways during choice-based interventions. In addition, presenting the choice opportunity before the task was more effective for two participants in Peterson et al. (2016), and presenting the choice opportunity following task

completion was more effective for two participants in Gureghian et al. (2020). However, there were also participants for whom no difference in responding was observed. Procedural differences such as the use of mastered versus unmastered targets and PR versus FR schedules for task requirements may account for the differences in results (the latter of which is consistent with the results of Tiger et al., 2010).

The differences in overall results between experiments could be related to a range of variables such as participant characteristics or procedural variations (e.g., task difficulty or differences in the length of trials across conditions). Future research should continue to investigate the conditions under which incorporating choice into routines with choice-of-consequence arrangements has positive therapeutic effects. It is also possible that there are individual-level variables that are relevant. Until future research can provide more concrete, practical guidelines, practitioners should consider probes or other abbreviated assessments to inform the best intervention on an individual basis. Likewise, given the idiosyncratic results, future research should evaluate preference for choice conditions compared with no-choice conditions. It should be noted that participants preferred the choice condition over the experimenter-choice condition in the two experiments that evaluated preference (Sran & Borerro, 2010; Toussaint et al., 2016). Preference for conditions is an important variable for treatment decisions, especially when efficacy is not affected by the choice arrangements, or the difference is not clinically relevant.

Summary of Outcomes and Implications for Clinical Practice

The right panel of Fig. 2 shows the outcome scoring for the experiments in this category. Of 13 experiments, the outcomes for 6 (46.2%) were rated as positive, 5 were mixed (38.5%), and 2 were negative (15.4%). Upon further inspection, it appears that the choice of activity or features (in general, choice of antecedents) was more effective than choice of consequences because four of the five experiments produced positive results. In contrast, of the eight experiments that presented a choice of consequences, only two (25.0%) were positive, five (62.5%) were mixed, and one was negative (12.5%).

The reviewed experiments show several examples of how practitioners can consider incorporating choice in routines both on the antecedent side (e.g., choice of activities or aspects of activities including order, features, materials, location, timing, duration) and on the consequence side (e.g., choice for reinforcers). Many of these approaches could be incorporated into daily schedules without much time or effort for the practitioner. The outcomes were somewhat idiosyncratic across and within experiments, highlighting the importance of taking data on the effects of choice related to individualized contexts and goals. Although some experiments did show positive behavioral effects of these choice opportunities (e.g., improved acquisition or task engagement), providing opportunities to choose can have additional benefits for clients such as (1) respecting autonomy and self-determination; (2) providing small, low-stakes choice-making opportunities may help clients develop their choice-making repertoire in ways that may benefit them when larger or choices with greater impact can be made; and (3) providing choice when there is a preference for having the opportunity to do so.

Practitioners should look for ways to incorporate these choice opportunities throughout the day and collect data on preference (e.g., using concurrent-chain assessments) for choice opportunities and how they affect performance or progress on goals. The value of providing choices should not be discounted. Even if the provision of choice options does not improve specific behavioral targets (e.g., adherence), it may be worth the continued effort. If providing choice disrupts other behavioral goals, practitioners could consider the cost-benefit analysis in the given context. For example, if providing choice opportunities disrupts academic tasks to a large extent, the practitioner could arrange other choice variations (e.g., offering antecedent choice options rather than consequence options) or program choice opportunities outside of academic periods. In other cases, the level of disruption may be outweighed by the other benefits of providing choice-making opportunities.

Discussion

We reviewed 32 articles (38 experiments) from 2003 to 2020 on the use of choice-based interventions for socially significant behavior. The reviewed

experiments demonstrate diverse ways to incorporate choice into clinical practice. This review extends previous reviews in several ways. First, we updated the previous reviews on applied applications of choice (Lancioni et al., 1996; Cannella et al., 2005) by examining 38 experiments published since Cannella et al. (2005). Second, we explored procedures implemented with a larger population subset by including experiments conducted with children regardless of their diagnosis or setting. Lancioni et al. (1996) and Cannella et al. (2005) called for further research evaluating the effectiveness of choice-based interventions both during and postintervention, and the experiments in the current review suggest that the subsequent research in this area aimed to answer their call.

Using a coding system similar to Cannella et al. (2005), we coded the outcomes of the reviewed intervention experiments as positive, mixed, and negative. A high proportion of the intervention experiments employing differential reinforcement with asymmetrical-choice options were coded as positive (92.0%), and none were coded as negative. The outcomes for experiments in the subcategory of incorporating choice into daily contexts were less uniform (only 46.2% were positive). Based on further inspection of the data, it appears that the experiments that presented a choice of activity or feature (i.e., an antecedent choice) were more likely to have positive outcomes (80.0%) compared to those presenting choice as a consequence (25.0% positive). Based on these data, researchers should continue investigating the conditions under which incorporating choice into daily activities results in clinical improvements.

It should be noted that these outcome data should be interpreted with caution based on several limitations. First, the binary nature of the scoring system assumed that for each participant, the intervention was either effective or ineffective in changing the dependent variable(s). Furthermore, the outcome coding did not consider the magnitude or social significance of the behavior change. It is possible that the degree to which behavior changed was clinically insignificant in some experiments for which a positive effect was concluded. Second, publication bias due to researchers potentially being more likely to publish positive results or for journals to be more likely to accept them means that the outcome measures from these experiments may not reflect a real-world success rate. One way to address this limitation through future research would be to employ consecutive controlled case series (Hagopian, 2020). Despite the relatively mixed outcomes supporting the use of choice in daily contexts based on the goals and outcomes of the reviewed experiments, we argue that it remains important to take opportunities to incorporate choice into many aspects of their consumers' lives. Consumers of behavior analytic services may benefit from incorporating choice into daily routines, even when it does not serve to accomplish a clinical behavior-change goal.

Choice-based interventions were used across a variety of settings (e.g., home, school, clinic) with a broad range of treatment goals and dependent variables, including task engagement (73.7%), challenging behavior (50.0%), alternative communication responses (26.3%), skill acquisition (15.8%), and self-control choice (5.3%). Most of the reviewed experiments measured more than one dependent variable (57.9%). Academic-related treatment goals were the most common activity type, and leisure/occupational goals were the least common. Individuals with ASD were the most common diagnostic group across all categories. There were only four articles on choice-based interventions that were excluded because their participant population was comprised of adults rather than children; thus, there is an opportunity for future research to build on the existing choice literature with adult populations (e.g., Tasky et al., 2008; Wilson et al., 2006; Watanabe & Sturmey, 2003; Dixon & Falcomata, 2004). Future research would also benefit from identifying and reporting additional participant demographic data beyond age and diagnoses. Detailed demographic profiles were lacking overall, consistent with recently reported trends in the literature in applied behavior analysis (Jones et al., 2020). In future publications, we recommend that choice researchers include additional demographic information on their participants, including ethnicity, race, gender, and socioeconomic status. Including this information may illuminate relations between these variables and our treatment procedures (e.g., social validity, efficacy, culturally adapted procedures) and ensure our research is inclusive of all individuals who may benefit from research.

One of the positive themes we observed in the reviewed experiments was the practice of arranging for multiple layers of choice by providing

opportunities for participants to demonstrate their preference for intervention conditions. Concurrent and concurrent-chain schedules are convenient methods to assess preference and are not limited to use with individuals with verbal repertoires (Hanley, 2010). Practitioners should consider preference data along with efficacy data and prioritize honoring participant preference, particularly when the data on efficacy show that multiple conditions are similarly effective or when the positive effects of a particular condition relative to another are minimal. For example, Northgrave et al. (2019) found that the experimenter-choice condition resulted in more efficient skill acquisition, but it was more efficient by only four to seven sessions. Similar results were found for one participant in an experiment conducted by Gureghian et al. (2020) that compared an antecedent versus consequence reinforcer choice interventions. In many cases, these minor differences in acquisition rate would likely not be considered socially significant, especially if the learner preferred one learning environment over the other. Although extenuating circumstances should be considered, we support implementation of preferred conditions when possible. Providing choices often and within many aspects of day-to-day experiences is especially important to consider when working with children or individuals with disabilities, because it provides increased autonomy and control over the environment, which has been historically overlooked across many settings (Peterson et al., 2020).

We hope this review demonstrates the versatility of clinical applications using concurrent-operant arrangements, including an array of choice-based interventions. Throughout this review, we highlighted potential areas for future investigation, and we hope to see researchers extend choice-based interventions to additional settings and clinical goals. We will end with two recommendations for future directions based on our review.

First, we suggest that researchers use common labels and key terms for choice interventions to help organize this area of research. We found substantial variation in the terms used to describe the various treatment procedures despite there being commonalities in the approaches across published experiments. For instance, we adopted the description of *asymmetrical-choice options* for the procedures using differential reinforcement in concurrent-operant arrangements because it is a term that appears early in the literature base (e.g., McDowell, 1989; Fisher & Mazur, 1997) and is an accurate description of the conditions, which consist of purposefully programming differences in the reinforcement parameters across response options. Although several of the reviewed experiments also used this label directly (e.g., Fisher et al., 2019; Crowley et al., 2020; Borrero et al., 2010), we observed multiple labels for procedures with common features including *choice-making* (e.g., Peck Peterson et al., 2009), *DRA without extinction* (e.g., Athens & Vollmer, 2010; Briggs et al., 2019), and *FCT with concurrent operants* (e.g., Davis et al., 2018). Having some continuity in the verbal behavior around choice-based interventions may help systematize the literature moving forward and may even facilitate advancements in choice-based technologies through better communication in the research community. Consistency of language may also be beneficial for practitioners who wish to incorporate choice into their clinical practice and maintain contact with emerging research in this area.

Our second recommendation is to explore the extent to which choice-based interventions result in durable and persistent behavior change, especially when choice behavior encounters disruptors (e.g., treatment integrity errors, changes in context, schedule-thinning, and intervention fading; Wacker et al., 2011). One of the reviewed experiments (Peterson et al., 2017) addressed the questions of the durability of changes in choice behavior by embedding relapse probes in an asymmetrical-choice arrangement. A fair amount of research on the relapse of challenging behavior in DRA interventions has emerged in recent years (e.g., Greer et al., 2020), and future research could compare relapse and persistence of behavior change using differential reinforcement with asymmetrical-choice options and more "traditional" differential reinforcement arrangement with and without extinction. Along these lines, Brown et al. (2020) conducted a reverse-translation study evaluating relapse of target behavior following DRA with and without extinction with symmetrical consequences. Levels of resurgence were similar across conditions. However, outcomes related to relapse following asymmetrical consequences remain unknown. As the prevalence of choice-based interventions increases in research and applied practice, it will become increasingly important to understand the extent to which

treatment outcomes generalize and persist following the cessation of direct treatment. Additional research in the areas mentioned above may facilitate the development of generalizable practice guidelines for considering choice-based interventions for various intervention objectives (see Geiger et al., 2010, for an example of guidelines for escape-maintained behavior).

In conclusion, we suggest that practitioners will find value in choice-making as a framework for addressing clinical issues for several reasons. First, conceptualizing behavior in the context of concurrent operants is a useful framework for applied behavior analysts because clinical interventions aim to influence clients' behavior (i.e., choice). Second, socially significant behavior functions similarly to behavior in the laboratory, and the findings and functional relations identified in basic research can be translated in predictable ways to clinical interventions (e.g., Matching Law; Fisher & Mazur, 1997). Third, many individuals prefer to have choices, and having the opportunity to choose can function as a reinforcer (Ackerlund Brandt et al., 2015; Stayer Smeltzer, 2009; Tiger et al., 2006). Fourth, choice-making interventions may be particularly valuable in applied contexts due to their relative ease of implementation, a structure that fits in with existing routines in those settings, and the potential to avoid the use of extinction when treating challenging behavior. The experiments in this review demonstrate a wide range of examples of how choice can be incorporated into daily life. Most important, ensuring that consumers of behavior-analytic interventions have ample opportunities to make choices supports individual rights to autonomy and dignity (see Peterson et al., 2020 for an extended discussion on this topic).

Data Availability Additional data on the coding of these articles can be requested by contacting the corresponding author.

Code Availability Not applicable.

Declarations

Ethics Approval Not applicable.

Consent to Participate Not applicable.

Consent for Publication Not applicable.

Conflicts of Interest/Competing Interests The authors declare no conflicts of interest.

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