

# Tact instruction for children with autism spectrum disorder: A review

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## Abstract

Tacts facilitate social interaction, and a strong tact repertoire can lead to the development of other verbal operants. For children with autism spectrum disorder (ASD), the development of a tact repertoire can reduce stereotypical and repetitive language and increase social communication, as functional language may reduce the amount of stereotypical vocal behavior that children engage in. However, teaching tact repertoires to children with ASD that maintain and generalize is difficult. The current study reviewed tact interventions for children with ASD from 2000 to 2019 to provide an overview of current tact interventions, their effectiveness, and the inclusion of intervention components that may promote maintenance and generalization of learned tacts in children with ASD. Fifty-one studies were included in the review. Of the studies that met criteria for effect size calculations 87.18% of the interventions showed excellent or high effect. Although many of the studies focused more on stimulus control to answer specific research questions, some studies implemented intervention components and procedures that could promote acquisition and generalization of learned tacts in children with ASD. We discuss implications and the need to increase research regarding tact intervention components that can increase generalization in children with ASD.

## Keywords

Autism spectrum disorder children tact generalization

Skinner's radical approach to language emphasized the function (i.e., why we say what we say) rather than the topography (i.e., what we say) of language. The verbal behavior taxonomy involves an identification of the

variables (i.e., stimulus, reinforcement) that interact to produce a verbal response. He defined a pure tact as a verbal operant that is "evoked by a particular object or event or property of an object or event"

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(Skinner, 1957, p. 82), and is maintained by naturally occurring consequences delivered by a listener upon hearing the tact. An example is a child saying, "Puppy!" upon seeing a puppy and their mother saying, "That's right, it's a puppy!"

Tacts are said to be one of the most important verbal operants, as other operants highly depend on the strength of the tact (Sundberg, 2015, p. 4). It is hypothesized that a strong tact repertoire precedes more advanced mands and intraverbals. That is, the more children are able to label objects, events, and properties of events, the more verbal behavior they are likely to emit. Tacts also facilitate social interactions because they offer the listener specific information that is needed to engage in social communication. For example, two children pretend-playing will tact what they are doing in order to entice a peer to add to the play scene (e.g., Child A: "Baby is hungry," Child B: "Here is the bottle!").

For children with autism spectrum disorder (ASD), whose language development is atypical, teaching tacts may reduce the amount of stereotypical or repetitive language they engage in (Karmali et al., 2005). However, tact repertoires are especially difficult to teach to children with ASD due to characteristics associated with this disorder — social attention may not function as a reinforcer, restricted interests, and stimulus over selectivity (Chiang & Carter, 2008; Krantz & McClannahan, 1998).

### *Teaching tacts*

Of the elementary verbal operants, researchers and practitioners have tended not to prioritize teaching tacts because the reinforcement is not specified, as in a mand (e.g., saying "cookie" when you want a cookie; Tincani et al., 2020). Because it is more difficult to reinforce tacts naturally, the likelihood that children with ASD will tact outside of the clinical or research setting is highly unlikely if reinforced artificially (LeBlanc et al., 2009). That is, the motivation to tact stems from a desire to share an experience with a listener and is maintained by acknowledgement from that listener. When teaching tacts under conditions dissimilar to those naturally occurring, children with ASD are unlikely to tact under those conditions. This presents a unique challenge for researchers and practitioners as they must plan for and arrange environments to teach tacts that ensure they will occur under stimulus control that share similar properties to those that occur in the natural environment (Skinner, 1953).

A specific area of concern for researchers and practitioners lies with obtaining stimulus control over tact responses for a variety of antecedent stimuli. That is, children with ASD tend to produce language under the

precise antecedent and consequent conditions they are taught (LeBlanc et al., 2009, 2006; Partington et al., 1994). For example, if you teach a child to tact when sitting at a table and in the presence of a token board, they may only tact under similar conditions. For decades, researchers have experimentally evaluated whether the presentation of object only or object and verbal stimulus (e.g., "What is this?") alters the production of tacts. Partington et al. (1994) assessed whether the verbal stimulus "What is it?" was blocking the establishment of stimulus control over object or picture only tacts emitted by a 6-year-old girl with autism. A simultaneous treatment design with probes before and after treatment was used to determine whether transfer of control from a verbal stimulus to a non-verbal stimulus could be achieved. This study demonstrated that removal of verbal stimulus and differential reinforcement was effective in transferring control from a verbal discriminative stimulus to a non-verbal discriminative stimulus. In a subsequent study, Williams and Greer (1993) found that when students were taught to respond when presented with a verbal stimulus only (e.g., "What is this?"), they did not respond under the absence of this same stimulus. In contrast, the children who received training in the absence of a verbal stimulus and only the non-verbal stimulus were able to acquire tacts and maintained and generalized the skill.

A recent comparison of tact training procedures with and without supplemental questions demonstrated that acquisition of tacts under both conditions might be equally effective and necessary. Marchese et al. (2012) evaluated the effects of a verbal stimulus "What is this?" and non-verbal stimulus presentation on the rate of acquisition of tacts. Results demonstrated that the supplemental question did not seem to hinder or help in terms of stimulus control over responding. That is, children were able to learn tacts across both conditions. However, generalization was not tested under naturally occurring conditions.

One other major learning obstacle for children with ASD is a lack of skill generalization to new environments, situations, and people, without planned instruction (Schreibman et al., 2015). The contingencies of reinforcement that control the tact are directly associated with characteristic deficits of children with ASD (e.g., seeking social attention and social reinforcement). While researchers and practitioners have been successful at teaching tacts under decontextualized conditions, this approach has yet to demonstrate a generalized tact repertoire; even though producing generalized outcomes is a major tenant of behavioral interventions (see Baer et al., 1987). Programming for generalization can be an effective method for producing generalized outcomes (Stokes & Baer, 1977).

## Generalization of tacts

Though the body of literature on tact training has grown (Sautter & Leblanc, 2006), tact-training procedures have been said to focus minimally on generalization of tacts (LeBlanc et al., 2009). Over a decade ago, LeBlanc et al. (2009) published a chapter outlining recommendations for promoting generalization, specifically the authors recommended: (a) transferring stimulus control to teach tacts; (b) blending structured training sessions with natural teaching sessions; (c) testing whether tact repertoires transferred to settings outside of research settings; (d) selecting targets that are socially valid (e.g., common in the child's natural environment); and (e) using social reinforcement to teach tacts.

Using transfer of stimulus control procedure might involve identifying the student's verbal operant repertoire (e.g., mand, echoic, intraverbal) and aligning the prompting strategy to the student's repertoire. Once tacts are taught under a given prompt, they can be assessed under relevant intraverbal prompts (e.g., what do you see?) with multiple exemplars and non-exemplars to assure features of the stimuli are controlling the response (e.g., red car vs. blue car). Blending structured teaching to naturalistic situations is also an effective teaching technique for increasing generalization of trained tacts in structured settings to natural settings (LeBlanc et al., 2006). For example, in the natural language paradigm (NLP; Koegel et al., 1987), researchers teach tacts in a play-based context. The child receives contingent access to the item tacted after every correct modeled response (e.g., yellow ball). By teaching tacts in an environment that might mimic a more natural environment (e.g., play), a child may be more likely to tact under these conditions.

When selecting targets, the authors also advise that interventionists begin tact instruction by selecting targets that are 3-D, familiar to the child, and age appropriate. The idea is that this will increase the likelihood that children will tact items that they regularly see in their home, school, and community and receive a schedule of reinforcement in these settings that may promote maintenance. Lastly, researchers recommend that researchers and practitioners teach tacts under social reinforcement contingencies, as these are the conditions that maintain tact repertoires, in naturally occurring contexts (LeBlanc et al., 2009, 2006; Partington et al., 1994). That is, children do not typically receive artificial reinforcement for tacting an item or event outside of clinical or contrived arrangements (e.g., receiving a cookie for saying "Look, an elephant!"), but rather social reinforcement (e.g., "Oh wow, I see the elephant, too!"). A tact repertoire that is established under contingencies of social

reinforcement may be more likely to generalize to other settings, people, and scenarios, and maintain over time, as these contingencies will naturally occur outside of contrived teaching arrangements.

To the best of the authors' knowledge, the current tact intervention literature has not been reviewed systematically. Such a review would inform both researchers and practitioners on the maintenance and generalization effects and practices within tact training procedures. Although many resources are currently available on the internet (e.g., National Professional Development Center on Autism Spectrum Disorders) and as practitioner-intended book resources (e.g., Greer & Ross, 2008), practitioners refer to published research for replicable models of evidence-based interventions. Therefore, we reviewed the existing tact intervention literature for children with ASD published from 2000 to 2019 to provide an overview of current tact interventions practices, their effectiveness, and the extent to which researchers include intervention components that are hypothesized to lead maintenance of acquired tacts and generalized tact repertoires. Specifically, we asked the following research questions:

1. What are the procedures used to teach tacts and do they adhere to current recommendations?
2. What is the single case experimental design methodological rigor of tact studies?
3. What are the individual effects of tact studies?

## Method

### Primary search

Studies included in the review were located through a primary search using four online databases: PsycINFO, Education Resources Information Center (ERIC), PubMed, and Web of Science with the following Boolean search term:

$$AB \left( \text{autis} * \text{AND} \left( \text{tact OR label} * \text{OR name OR} \right) \right)$$

$$\left( \text{naming OR indicat} * \right)$$

The variants of the words naming, labeling, and indicating were added to identify potential tact instruction studies outside the field of applied behavior analysis. These specific search terms were selected by collecting non-behavior analytic definitions used for tacts in published articles that discuss verbal behavior (e.g., Forbes et al., 2020; Pennington et al., 2016). We also excluded academic terms; such as, sight word, sight word reading, letter and number identification; as we were interested in tact interventions that were

focused on language and social communication. We restricted the search to articles published in English peer-reviewed journals from January 1st, 2000 to December 31st, 2019. As such, theses and dissertations were excluded from the search. After removing duplicates, this primary search yielded 763 articles.

### Inclusion criteria

We applied the following inclusion criteria to the initial pool of 763 articles: 1) the study was of a data-based experimental design (e.g., group design, single-case experimental design); 2) the study included at least one child (i.e., ages 2 to 12) diagnosed with ASD; 3) the independent variable involved a tact intervention that was implemented to all participants with ASD; and 4) the dependent variable was a measure of acquisition (e.g., accuracy, frequency) that assessed only the learning objectives or tacts taught with the independent variable. For example, articles that assessed the emergence of tacts after listener or discrimination training (e.g., Fisher et al., 2019) or studies that assessed tacts not directly taught through the independent variable were not included for review (e.g., Fiorile & Greer, 2007). Forty-six studies met this inclusion criteria.

Next, we hand-searched published issues of *The Analysis of Verbal Behavior*, *Journal of Applied Behavior Analysis*, and *Behavior Analysis in Practice* from 2000 to 2019 to retrieve any studies that could have been left out during the primary database search. We selected these journals because they are considered premiere journals in the field of applied behavior analysis and they regularly publish research pertaining to verbal behavior interventions. We found no additional articles during this hand search.

Finally, we conducted an ancestral search by reviewing the reference section of the 46 studies. Five additional articles were identified through the ancestral search. A total of 51 studies were aggregated for coding for this review. The sequence of the search and inclusion process is presented in Figure 1.

### Coding

The 51 studies that were included in this review were each coded in two dimensions. First, the authors coded a basic summary of each study including author names; publication year; participants—the number of participants, age of the participants diagnosed with ASD, gender, and race or ethnicity—; the independent variable—type, setting, materials, how it was presented (e.g., the discriminative stimulus or  $S^D$ ), the fidelity data collected, and who implemented the intervention—; and the dependent variable.

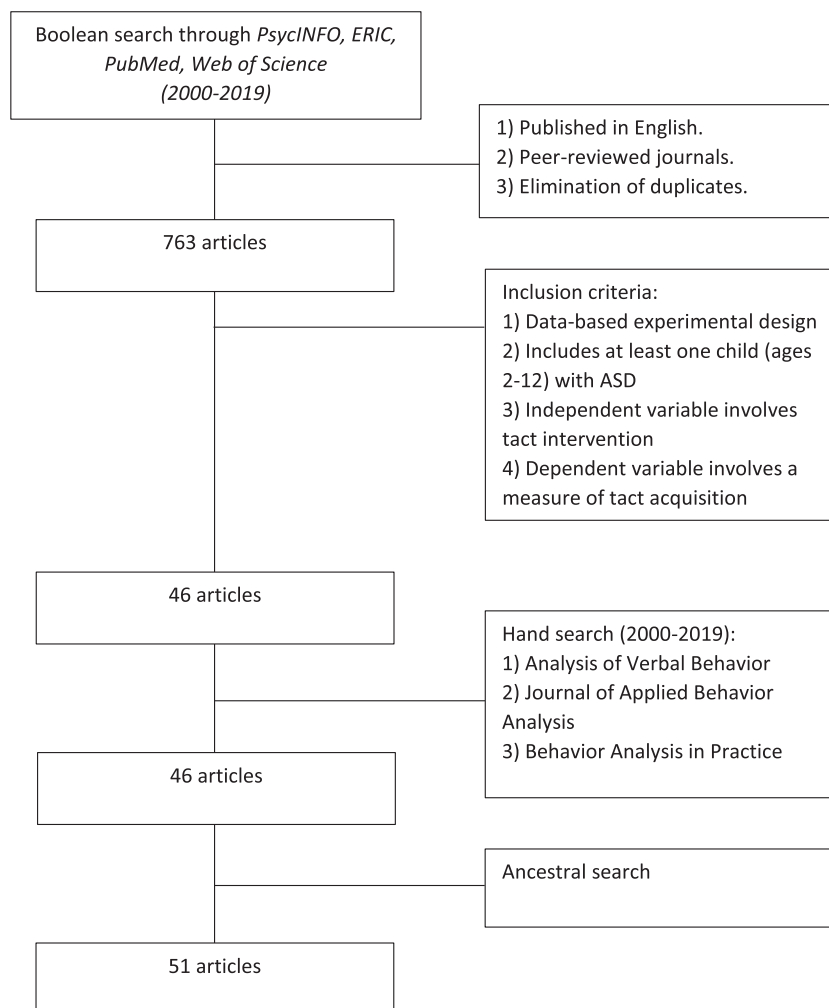
Second, the authors analyzed the tact instruction procedures and intervention implementation of each article specifically focusing on the elements presented in the research questions that may be important for generalized tact repertoires in children with ASD. The studies were coded as either yes, no, or not listed respective to whether the procedural strategies were reported in each study.

1. *Maintenance* was coded as a *yes* if the study included a maintenance phase.
2. *Generalization* was coded as a *yes* if the study included generalization.
3. *Target selection* was coded as a *yes* if the training targets used in the study were selected because they were commonly available items/activities/individuals or preferred items/activities specific to the participants in the study.
4. *Social reinforcement* was coded *yes* if the researchers only used social reinforcement. We defined social reinforcement as any verbal (e.g., praise statements such as “great work” or “nice job”) or non-verbal (e.g., hugs, clapping, tickling) demonstration of approval or positive attention by the adult delivering intervention (Cooper et al., 2020). Studies were also coded as a *yes* if a study used a primary reinforcement paired with social reinforcement, but the primary reinforcement was thinned, and eventually only social reinforcement was available to the participants.
5. *Multiple Discriminative Stimuli* was coded as *yes* if the learning objective (i.e., trained tacts) were elicited through a mixture of settings during instruction (e.g., table-top instruction and naturalistic instruction), a mixture of different verbal discriminative stimuli (e.g., “What is this?” and “What do you call this?”), or presenting an object or event discriminative stimuli without any verbal cues (i.e., a true tact; Skinner, 1957).

The first author and two graduate-level research assistants in special education participated in the coding. Training for the coding was conducted by the first author with sample articles not included in the current review. Each individual coded the articles according to the definitions and compared the results. The training session continued until all coders were within 100% agreement.

### Quality standards and effect size calculations

Coded studies were evaluated with research conduct and reporting standards to ensure they either met with standards or met with reservations to be eligible for effect size calculation. Single-case design studies



**Figure 1.** Flow chart of article search and inclusion process.

were evaluated using What Works Clearinghouse procedures (Kratochwill et al., 2013) and group design studies were evaluated using the Council for Exceptional Children procedures (Gersten et al., 2005). The quality standards were transferred to Qualtrics by the first and second authors and were coded by two graduate-level research assistants. Research assistants practiced on randomly selected studies and were trained till the all items were in 100% agreement with the authors. Single-case design studies that either met standards or met with reservations and group design studies that included essential quality indicators were gathered for effect size calculations.

Effect sizes for single-case design studies were calculated using Tau-U. There are different effect size metrics for single-case design studies, however Tau-U was selected as it is considered to be robust, has reliability with visual-analysis, and can control for baseline trend (Parker et al., 2011). The first author trained a

doctoral-level research assistant using randomly selected single-case design studies that met quality standards. Tau-u was calculated by extracting data points from presented graphs with *WebPlotDigitizer* and then entering the data in an online Tau-u calculator (<http://www.singlecaseresearch.org/calculators/tau-u>). All single-case design studies were evaluated for baseline trend and no studies required adjustments. For group design studies, the current review extracted the Cohen's d effect sizes reported by the study authors if they met with quality standards.

### *Inter-rater reliability*

All coding steps including the quality standards and the effect size calculations were assessed for inter-rater reliability (IRR). First, to assess IRR for the inclusion exclusion process, the third author, who did not participate in primary inclusion and exclusion, provided IRR on approximately 30% (n = 228) randomly

selected articles that we identified after the database search. The IRR was calculated by dividing the number of agreements by the number of total articles. The IRR for the inclusion and exclusion process was 96.46%. Second, to assess IRR for the primary coding of all articles included in the current review, the first author randomly selected approximately 31% of the articles ( $n=16$ ). A graduate-level research assistant who was trained with the primary coders but did not participate in the primary coding was recruited. The IRR for primary coding was calculated by dividing the number of agreements from the total number of coded items. The IRR for primary coding was 91.33% (range: 80-100%). Third, to assess IRR for quality standards evaluation the first author randomly selected another set of 16 articles (approximately 31%). A research assistant who trained with the quality standards assessors but did not participate in the primary assessment provided IRR. The IRR was calculated by dividing the number of agreements by the number of total articles. The IRR for quality standards was 86.67%. Finally, to assess IRR for the effect sizes, the first author double coded (i.e., the effect sizes were calculated by a trained graduate assistant and the first author) the effect sizes of all articles that met research quality standards. The Tau-u effect sizes were compared and were considered in-agreement if the Tau-u was equal to the one-hundredth decimal point (e.g., Tau-u for Leaf et al., 2014 was 0.964 by the research assistant and 0.961 by the first author, and, therefore, considered in agreement). All discrepancies during all stages of the IRR were discussed and re-evaluated by the first three authors until an agreement was reached.

## Results

Fifty-one studies met criteria for inclusion and were coded for this review. Table 1 shows the coded results for type of intervention, settings, materials, participant information, and interventionist for the studies included in the review. Of the 215 children with ASD included in the 51 studies, 81.86% ( $n=176$ ) were male participants. An additional 7.84% ( $n=4$ ) did not explicitly provide gender or sex information but referred to the participants with pseudo names (e.g., Giunta-Fede et al., 2016) or pronouns (e.g., Byrne et al., 2014) that could allow readers to infer this information. Of the 51 studies collected for review, 96.08% ( $n=49$ ) did not report the race or the ethnicity of the participants. It should also be noted that 11.76% ( $n=6$ ) were conducted outside of the US such as Southern Africa (Akande, 2000), Japan (Naoui et al., 2007), and Spain (Williams et al., 2006). Most studies' participants included only children diagnosed with ASD, but 17.65% ( $n=9$ ) included older individuals

with ASD (e.g., Bloh, 2008; Frampton et al., 2017), children with other developmental disabilities (e.g., social pragmatic communication disorder in Schebell et al., 2018; Asperger's syndrome in Williams et al., 2006), or typically developing children (e.g., Leaf et al., 2011; Sidener et al., 2010).

As for the interventionist, 52.94% ( $n=27$ ) did not report explicit information on who directly implemented the tact interventions to the participants. Studies used words such as "experimenter" (e.g., Sundberg et al., 2000), "instructor" (e.g., Kelly & Holloway, 2015), or "therapist" (e.g., Kodak & Clements, 2009) but did not explicitly provide information on whether they belonged to the research team. Thirty-three percent ( $n=17$ ) reported that an individual that was a part of the research team (e.g., authors, research assistants, or graduate students) implemented the intervention. Conversely, 13.73% ( $n=7$ ) reported practitioners or educators were trained by the research team to implement the intervention and among these, two articles (i.e., Conallen & Reed, 2016, 2017) reported the interventionists' experience as having at least 1 year experience working with individuals with ASD. No study reported the gender, age, and race or ethnicity of the interventionist. Procedural integrity or fidelity of intervention implementation was assessed in 54.9% ( $n=28$ ) of the 51 studies included in this review. Of the 54.9%, three studies did not provide explicit procedural integrity results although they mentioned assessing fidelity of implementation (e.g., Dixon et al., 2017; Lorah & Parnell, 2017). Among the studies that did not report procedural integrity, Scattone and Billhofer (2008) reported that the interventionists were trained to 80% mastery before implementation, and Simpson and Keen (2010) stated that interobserver agreement and fidelity was assumed because presentation and data collection was automated via a computer.

## Types of interventions

Although most studies investigated effectiveness of a specific tact intervention, 17 studies compared different instructional practices or prompting hierarchies within an intervention. For example, Majdalany et al. (2014) compared the results of three discrete trial teaching (DTT) methods (i.e., massed-trial instruction, distributed trial instruction, and task interspersal) and Marchese et al. (2012) compared the effectiveness of tact acquisition and maintenance between teaching by object-only (i.e., showing the object with no verbal cues) and teaching with the object and a question (e.g., "what is this?"). Other studies also investigated the effects of a tact instruction on other behaviors such as listener responding (e.g., Delfs et al., 2014).

**Table 1.** Results for type of intervention, settings, materials, participant information, and interventionist for the studies included in the review.

| Authors                             | Year         | Type of intervention                         | Setting <sup>a</sup>                      | Material/Stimuli               | Participant information |  | Interventionist <sup>b</sup>   |
|-------------------------------------|--------------|--|---|--------------------------------|-------------------------|--|--------------------------------|
|                                     |              |  |   |                                | Gender                  | Race/Ethnicity   |                                |
| Akande                              | 2000         | DTT  | Clinic, Table-top                         | Picture cards                  | m = 3                   | NR   | Research team                  |
| Akmanoglu                           | 2015         | Video Modeling                               | Clinic, Table-top                         | Videos                         | m = 3; f = 1            | NR   | Research team                  |
| Akmanoglu-<br>Uludag & Batu         | 2005         | Simultaneous<br>prompting                    | School, Table-top                         | Picture cards                  | m = 2                   | NR   | Research team                  |
| Barbera & Kubina                    | 2005         | Transfer<br>procedures                       | Home, Table-top                           | Picture cards                  | m = 1                   | NR   | Research team                  |
| Bloh                                | 2008         | Transfer<br>procedures                       | Home, Table-top                           | Picture cards                  | m = 4                   | NR   | Not explicit                   |
| Byrne et al.                        | 2014         | Stimulus-pairing<br>observation<br>procedure | School, Table-top                         | Picture cards                  | Not explicit            | NR   | Not explicit                   |
| Carbone et al.                      | 2006         | Total communica-<br>tion training            | Home, Table-top                           | Picture cards                  | f = 1                   | NR   | In-home teachers               |
| Cengher & Fienup<br>(Study 1)       | 2019         | Manipulating<br>pression<br>attention        | School, Table-top                         | Picture cards                  | m = 3                   | NR   | Research team                  |
| Cihon et al.                        | 2019         | Prompt fading                                | Clinic, Table-top                         | Picture cards                  | m = 22, f = 5           | NR   | Research team                  |
| Conallen & Reed                     | 2016         | Match-to-sample                              | Home, Table-top                           | Picture cards                  | m = 9, f = 1            | NR   | In-home ABA<br>therapists      |
| Conallen & Reed<br>(Study 1)        | 2017         | PECS   | Home, Table-top                           | Picture cards                  | m = 8, f = 2            | NR   | In-home ABA<br>therapists      |
| Dass et al.                         | 2018         | DTT package                                  | Clinic, Table-top                         | Object with<br>scents          | m = 1, f = 2            | NR   | Research team                  |
| Delfs et al.                        | 2014         | Listener and tact<br>training                | Clinic, Table-top                         | Picture cards                  | m = 4                   | NR   | Not explicit                   |
| Dixon et al.                        | 2017         | Observational<br>learning (PEAK)             | School, Table-top                         | Picture cards                  | m = 3                   | NR   | Not explicit                   |
| Dueñas, et al.                      | 2019         | Play-based<br>intervention                   | Clinic, Contrived<br>play area            | Objects                        | m = 2, f = 1            | NR   | Research team                  |
| Frampton et al.                     | 2016         | Matrix training                              | Clinic, Table-top                         | Object performing<br>an action | m = 3, f = 1            | NR   | Clinician                      |
| Frampton, et al.<br>Frampton et al. | 2017<br>2019 | DTT<br>Matrix training                       | Clinic, Table-top<br>Clinic, Table-top    | Picture cards<br>Matrix        | m = 7<br>m = 6          | NR<br>3 African<br>American, 1<br>Ethiopian,<br>1 Caucasian,<br>1 not reported | ABA therapists<br>Not explicit |
| Giunta-Fede et al.                  | 2016         | DTT  | Clinic, Table-top                         | Picture cards                  | Not explicit            | NR   | Not explicit                   |
| Greenberg et al.                    | 2014         | Intensive tact                               | School, Table-top                         | Picture cards                  | m = 2, f = 1            | NR   | ABA center<br>teacher          |
| Greer & Du                          | 2010         | Intensive tact                               | School, Non-<br>instructional<br>settings | Actual objects or<br>situation | m = 2, f = 1            | NR   | Not explicit                   |
| Grow et al.                         | 2016         | DTT  | Unknown, Table-<br>top                    | Picture cards &<br>actual toys | m = 3                   | NR   | Not explicit                   |
| Hanney et al.                       | 2019         | Stimuli<br>presentation                      | Clinic, Table-top                         | Object (toys) with<br>sounds   | Not explicit            | NR   | Research team                  |
| Jimenez-Gomez<br>et al.             | 2019         | Matrix training                              | Clinic, Floor mat<br>& table-top          | Object performing<br>an action | f = 2                   | NR   | Research team                  |
| Kelley et al.                       | 2007         | DTT  | School, Table-top                         | Actual item (food,<br>toys)    | m = 3                   | NR   | Not explicit                   |
| Kelly & Holloway                    | 2015         | Behavioral<br>momentum                       | School, Table-top                         | Picture cards                  | m = 1                   | NR   | Not explicit                   |
| Kodak &<br>Clements                 | 2009         | Transfer<br>procedures                       | Clinic, Table-top                         | Actual preferred<br>items      | m = 1, f = 2            | NR   | Not explicit                   |
| Leaf et al.                         | 2011         | "No-no"<br>prompting                         | School, Table-top                         | Picture cards                  | m = 1                   | NR   | Research team                  |

(continued)

Table 1. Continued.

| Authors                          | Year | Type of intervention                | Setting <sup>a</sup>               | Material/Stimuli                    | Participant information |                | Interventionist <sup>b</sup> |
|----------------------------------|------|-------------------------------------|------------------------------------|-------------------------------------|-------------------------|----------------|------------------------------|
|                                  |      |                                     |                                    |                                     | Gender                  | Race/Ethnicity |                              |
| Leaf et al.                      | 2014 | DTT (Prompt procedures)             | N/A, Table-top                     | Picture cards                       | m = 4                   | NR             | Research team                |
| Leaf et al.                      | 2016 | Prompt procedures                   | Clinic, Table-top                  | Picture cards                       | m = 2                   | NR             | Research team                |
| Leaf et al.                      | 2017 | DTT (Instructive feedback in group) | Clinic, Table-top                  | Picture cards                       | m = 2, f = 1            | NR             | Not explicit                 |
| Lorah & Parnell                  | 2017 | Prompt procedures                   | School, Circle-time                | Object                              | m = 8, f = 1            | NR             | Research team                |
| Lydon et al.                     | 2009 | Intensive tact instruction          | School, Non-instructional settings | Picture cards                       | Not explicit            | NR             | Not explicit                 |
| Majdalany et al.                 | 2014 | 3 DTT methods                       | Clinic, Table-top                  | Cards in shapes of countries        | m = 1, f = 1            | NR             | Not explicit                 |
| Majdalany et al.                 | 2016 | DTT                                 | Clinic/Home, Table-top             | Cards in shapes of countries        | m = 5                   | NR             | Not explicit                 |
| Marchese et al.                  | 2012 | Stimuli presentation                | Clinic, Table-top                  | Object                              | m = 3                   | NR             | Not explicit                 |
| McHugh et al.                    | 2011 | Emotion recognition training        | Home, Table-top                    | Videos                              | m = 3, f = 1            | NR             | Instructional team           |
| Miguel & Kobari-Wright (Study 1) | 2013 | DTT                                 | School, Table-top                  | Categorized picture cards           | m = 2                   | NR             | Not explicit                 |
| Naoi et al.                      | 2007 | Tacts as reporting                  | Clinic, Table-top                  | Video & picture cards               | m = 3                   | NR             | Not explicit                 |
| Pistoljevic & Greer              | 2006 | Intensive tact                      | School, Table-top                  | Picture cards                       | m = 2                   | NR             | Not explicit                 |
| Ryan & Charragain                | 2010 | Emotion recognition training        | N/A, Table-top                     | Emotions recognition test           | m = 27, f = 3           | NR             | Not explicit                 |
| Scattone & Billhofer             | 2008 | DTT                                 | N/A, Table-top                     | Object                              | m = 1                   | NR             | Not explicit                 |
| Schebell et al.                  | 2018 | Stimuli presentation                | School, Table-top                  | iPad containing pictures and videos | m = 1                   | Caucasian      | Research team                |
| Schnell et al.                   | 2018 | Multiple exemplar training          | School, Table-top                  | Picture cards                       | m = 2, f = 1            | NR             | Not explicit                 |
| Shepley et al.                   | 2016 | Stimuli presentation                | School, Table-top                  | iPad containing pictures and videos | m = 2, f = 1            | NR             | Research team                |
| Sidener et al.                   | 2010 | DTT                                 | Home/School, Table-top             | Object                              | m = 1                   | NR             | Not explicit                 |
| Simpson & Keen                   | 2010 | Interactive whiteboard presentation | School, Table-top                  | Interactive whiteboard              | m = 3                   | NR             | Research team                |
| Sprinkle & Miguel                | 2012 | Listener/speaker training           | Home/School, Table-top             | Picture cards                       | Not explicit            | NR             | Not explicit                 |
| Sundberg et al.                  | 2000 | Prompt procedures                   | School, Table-top                  | Objects                             | m = 2                   | NR             | Not explicit                 |
| Valentino & Shillingsburg        | 2011 | Sign exposure                       | School, Table-top                  | Objects and activities              | m = 1                   | NR             | Not explicit                 |
| Williams et al.                  | 2006 | Stimuli presentation                | School, Table-top                  | Picture cards                       | m = 3, f = 1            | NR             | Not explicit                 |

Note: M = male, F = female, NR = Not Reported.

<sup>a</sup>Refers to the location and the setting of the intervention. Clinic = clinic, center, therapy room, or research lab, School = preschool, private or public classroom, Home = participants' homes, N/A = not reported or unclear.

<sup>b</sup>Refers to the individual(s) that directly implemented the intervention to the participants.



Many studies investigated interventions that were based on or that have similarities with DTT instruction. However, 27.45% or 14 studies directly referenced DTT as their independent variable. Among those studies, seven specifically compared methods within DTT as opposed to investigating the effectiveness of DTT methods for tact instruction. Some studies compared differential reinforcement (e.g., Majdalany et al., 2016), stimuli presentation (e.g., Akande, 2000), and feedback procedures (e.g., Grow et al., 2016; Leaf et al., 2014) to understand factors that may additionally increase effectiveness of tact instructions presented through DTT. Other studies used DTT to investigate setting effects (i.e., establishing operations; Sidener et al., 2010), and system effects such as different data collection (e.g., Giunta-Fede et al., 2016) and probes (e.g., Frampton et al., 2017).

Intervention methods that were used by more than one study included in the current review were variations of multiple-exemplar instruction ( $n=4$ ; e.g., Byrne et al., 2014; McHugh et al., 2011); intensive tact instruction ( $n=4$ ; e.g., Greenberg et al., 2014; Pistoljevic & Greer, 2006); and matrix training ( $n=3$ , e.g., Frampton et al., 2019). Some other interventions that were used by single studies included comparing different prompting methods (e.g., standard versus intraverbal prompts; Sundberg et al., 2000); comparing different stimulus presentations (e.g., isolated versus compound stimuli; Hanney et al., 2019); using mixed verbal operant instruction (e.g., tact versus tact with echoic; Kodak and Clements, 2009); video modeling (e.g., Akmanoglu, 2015); total communication training (Carbone et al., 2006); PECS (e.g., Conallen & Reed, 2017); observational learning based on PEAK training methods (e.g., Dixon et al., 2017); behavioral momentum (Kelly & Holloway, 2015); and sign exposure (Valentino & Shillingsburg, 2011).

### Settings and materials

**Settings.** Of the 51 studies included in the review, 43.14% ( $n=22$ ) conducted their intervention in the participant's school such as the classroom (e.g., Valentino & Shillingsburg, 2011) or a separate quiet room (Schnell et al., 2018); 37.25% ( $n=19$ ) conducted their intervention in the participant's ASD treatment center (e.g., Majdalany et al., 2014), clinic (e.g., Hanney et al., 2019), or a research laboratory (e.g., Naoi et al., 2007); and 17.65% ( $n=9$ ) conducted their intervention in the participant's homes (e.g., Carbone et al., 2006). Setting descriptions from four studies were not sufficient to identify the exact location (e.g., Scattone & Billhofer, 2008) and three studies were conducted in multiple locations such as Majdalany

et al.'s (2016) where they conducted their intervention in either a participant's home or a therapy room.

Approximately 90% ( $n=46$ ) of the studies used a table-top setting where the interventionist was either seated side-by-side or in front of the participant to teach tacts to children with ASD. Alternatively, 9.8% ( $n=5$ ) taught tacts away from the table and used natural or contrived-naturalistic settings. Dueñas et al. (2019) taught tacts in a contrived play setting using play-based instruction; and Lorah and Parnell (2017) taught tacts using time-delay and physical prompts during carpet-circle reading-time in a preschool classroom. Greer and Du (2010), and Lydon et al. (2009) used intensive tact procedures to teach tacts in non-instructional settings such as the play area, lunch area, or hallways between classrooms. And Simpson and Keen (2010) used an interactive white board commonly used in classrooms to teach and assess tacts.

**Materials.** The most often used materials were two-dimensional picture or photo cards. Specifically, 62.74% ( $n=32$ ) of the studies used pictures of photos of objects, animals, actions, or people to teach tacts to children with ASD. However, 11.76% ( $n=6$ ) used videos and videos with pictures to teach target tacts. The videos included human enactments of emotions and facial expressions (e.g., Akmanoglu, 2015); puppet enactments of emotion (e.g., McHugh et al., 2011); actions (Schebell et al., 2018); and animation or cartoons (e.g., Naoi et al., 2007; Simpson & Keen, 2010). Lorah and Parnell's (2017) study that involved a teacher-led reading-circle in a preschool classroom used a common story book and taught tact responding to characters depicted in the book. This study was coded as using an actual object. And 25.49% ( $n=13$ ) used actual objects or in-vivo human acting to present tact objectives. These included toys (e.g., Dueñas et al., 2019), toys moved by interventionists to enact actions (e.g., Frampton et al., 2016; Jimenez-Gomez et al., 2019); preferred items (Kodak & Clements, 2009); and situations such as weather events (e.g., Greer & Du, 2010). Dass et al. (2018) selected objects that have distinct scents to teach tacting olfactory stimuli, and similarly Hanney et al. (2019) used toys that made sounds to teach auditory stimuli to children with ASD.

### Considerations for maintenance and generalization

Table 2 shows the coding results pertaining to specific elements that may promote maintenance and generalization of tacts in children with ASD, and the extent to which they were included for the studies in this review.

**Maintenance.** Maintenance sessions were included in 41.18% ( $n=21$ ) of the 51 studies. Of these, 15.69%

**Table 2** Results for Inclusion of Elements that Promote Maintenance and Generalization of Tacts.

| Authors                          | Year | Maintenance | Generalization | Target Selection | Social Reinforcement | Multiple Discriminative Stimuli |
|----------------------------------|------|-------------|----------------|------------------|----------------------|---------------------------------|
| Akande                           | 2000 | N           | N              | N                | N                    | N                               |
| Akmanoglu                        | 2015 | Y           | Y              | Y                | Y                    | N                               |
| Akmanoglu-Uludag & Batu          | 2005 | Y           | Y              | Y                | Y                    | N                               |
| Barbera & Kubina                 | 2005 | N           | N              | N                | Y                    | N                               |
| Bloh                             | 2008 | N           | N              | Y                | N                    | N                               |
| Byrne et al.                     | 2014 | N           | N              | N                | N                    | N                               |
| Carbone et al.                   | 2006 | N           | N              | N                | Y                    | N                               |
| Cengher & Fienup (Study 1)       | 2019 | Y           | N              | N                | N                    | N                               |
| Cihon et al.                     | 2019 | N           | Y              | Y                | Y                    | N                               |
| Conallen & Reed                  | 2016 | Y           | Y              | N                | Y                    | N                               |
| Conallen & Reed (Study 1)        | 2017 | N           | Y              | Y                | N                    | N                               |
| Dass et al.                      | 2018 | Y           | N              | Y                | N                    | N                               |
| Delfs et al.                     | 2014 | N           | N              | N                | N                    | N                               |
| Dixon et al.                     | 2017 | N           | N              | Y                | Y                    | N                               |
| Dueñas, et al.                   | 2019 | Y           | N              | Y                | Y                    | Y                               |
| Frampton et al.                  | 2016 | N           | N              | N                | N                    | N                               |
| Frampton, et al.                 | 2017 | N           | N              | N                | N                    | N                               |
| Frampton et al.                  | 2019 | Y           | Y              | N                | N                    | N                               |
| Giunta-Fede et al.               | 2016 | Y           | Y              | N                | N                    | N                               |
| Greenberg et al.                 | 2014 | N           | N              | N                | Y                    | Y                               |
| Greer & Du                       | 2010 | N           | N              | N                | N                    | Y                               |
| Grow et al.                      | 2016 | N           | Y              | N                | N                    | Y                               |
| Hanney et al.                    | 2019 | N           | N              | Y                | N                    | N                               |
| Jimenez-Gomez et al.             | 2019 | N           | Y              | N                | N                    | N                               |
| Kelley et al.                    | 2007 | N           | Y              | Y                | N                    | N                               |
| Kelly & Holloway                 | 2015 | N           | N              | N                | N                    | Y                               |
| Kodak & Clements                 | 2009 | N           | N              | Y                | N                    | Y                               |
| Leaf et al.                      | 2011 | Y           | Y              | Y                | N                    | N                               |
| Leaf et al.                      | 2014 | Y           | N              | Y                | N                    | N                               |
| Leaf et al.                      | 2016 | Y           | N              | N                | Y                    | N                               |
| Leaf et al.                      | 2017 | Y           | N              | Y                | Y                    | Y                               |
| Lorah & Parnell                  | 2017 | Y           | N              | Y                | Y                    | Y                               |
| Lydon et al.                     | 2009 | N           | N              | N                | N                    | Y                               |
| Majdalany et al.                 | 2014 | Y           | N              | N                | Y                    | N                               |
| Majdalany et al.                 | 2016 | N           | N              | N                | N                    | N                               |
| Marchese et al.                  | 2012 | Y           | N              | Y                | N                    | Y                               |
| McHugh et al.                    | 2011 | Y           | Y              | Y                | N                    | N                               |
| Miguel & Kobari-Wright (Study 1) | 2013 | N           | N              | N                | Y                    | N                               |
| Naoi et al.                      | 2007 | N           | Y              | Y                | Y                    | Y                               |
| Pistoljevic & Greer              | 2006 | N           | N              | N                | Y                    | Y                               |
| Ryan & Charragain                | 2010 | Y           | N              | Y                | N                    | Y                               |
| Scattone & Billhofer             | 2008 | Y           | N              | N                | N                    | N                               |
| Schebell et al.                  | 2018 | Y           | Y              | N                | N                    | N                               |
| Schnell et al.                   | 2018 | N           | Y              | Y                | N                    | N                               |
| Shepley et al.                   | 2016 | Y           | Y              | N                | N                    | N                               |
| Sidener et al.                   | 2010 | N           | N              | Y                | N                    | N                               |
| Simpson & Keen                   | 2010 | Y           | Y              | Y                | N                    | N                               |
| Sprinkle & Miguel                | 2012 | N           | N              | N                | N                    | N                               |
| Sundberg et al.                  | 2000 | N           | N              | N                | Y                    | N                               |
| Valentino & Shillingsburg        | 2011 | N           | N              | Y                | Y                    | Y                               |
| Williams et al.                  | 2006 | N           | N              | N                | N                    | Y                               |

Note. Y = included, N = not included or not reported.

( $n = 8$ ) either started the maintenance session immediately after interventions or did not specify when their maintenance session started – although in some studies the duration could be deduced in the line graphs (e.g., Marchese et al., 2012). In contrast, 25.49% ( $n = 13$ ) conducted maintenance sessions with some time delay after interventions and presented the results in graphed data. Specifically, Marchese et al.'s (2012) research question involved acquisition and maintenance of learned tacts and presented detailed graphs of the maintenance sessions separately. Some studies could only provide partial maintenance results. For example, Ryan and Charragain (2010) conducted a group study and were only able to gather follow-up measures for 25 of the 30 participants originally enrolled. Although the studies did not include maintenance sessions, Lydon et al. (2009) conducted post-treatment probes and Naoi et al. (2007) re-administered one generalization probe one month after the first generalization assessment.

**Generalization probes.** Generalization probes were included in 33.33% ( $n = 17$ ) of the 51 articles. Stimulus generalization was evaluated for novel stimuli within similar categories such as a different individual showing a certain facial expression (e.g., Conallen & Reed, 2016; a different picture of the same learning target such as a whole-body image of a relative instead of a close-up portrait (e.g., Akmanoglu-Uludag & Batu, 2005); novel settings outside of the learning environment (e.g., Grow et al., 2016); or novel individuals (e.g., McHugh et al., 2011). One study assessed response generalization. Kelley et al. (2007) tested whether children responded across different verbal operants. That is, whether participants could mand for a ball after being taught to tact ball.

In addition to the 17 studies that directly programmed for and tested generalization, 13.73% ( $n = 7$ ) included probes or trials during or after the intervention to assess for generalization. These studies were not coded as generalization sessions as they did not specify those as generalization procedures in their manuscript. For example, Dass et al. (2018) included category probes while teaching olfactory stimuli. In their category probes, the interventionists asked for “the other [stinky] one” to assess for generalization (Dass et al., 2018, p. 544). Similarly, Kelly and Holloway (2015) included a “skill application test” to assess for untrained stimuli and Frampton et al. (2016) included a post-test with a recombinative generalization matrix.

**Target selection.** Studies that selected tact targets that were commonly available, preferred, or age-appropriate consisted of 45.09% ( $n = 23$ ) of the

included studies. Target selection rationale was diverse among studies. Some studies used age-appropriate items such as stimuli from age appropriate books or magazines (e.g., Bloh, 2008); characters from age-appropriate pop culture (e.g., cartoon characters; Leaf et al., 2016); previously unlearned stimuli that were deemed age-appropriate (e.g., Sidener et al., 2010; Valentino & Shillingsburg, 2011); or objectives that were included in the general education curriculum (e.g., relative's names; Akmanoglu-Uludag & Batu, 2005). Some studies used highly preferred items based on previous observations and parent identification (e.g., Kodak & Clements, 2009) or observations during free play and preference assessments (e.g., Kelley et al., 2007).

Among the remainder of the studies, 13.73% ( $n = 7$ ) chose targets that would ensure experimental control. For example, three studies chose targets that were non-preferred items or items that the participants did not engage with (e.g., Grow et al., 2016; Scattone & Billhofer, 2008; Sundberg et al., 2000); Majdalany et al. (2017) chose targets that the participants were unlikely to encounter outside of the intervention; and Cengher and Fienup (2019) chose to teach colors in languages that the participants did not understand. Frampton et al. (2016) chose nouns (i.e., animal figures) and verbs (i.e., actions) that participants were able to tact in isolation (i.e., “what is it?”) in order to assess whether participants could tact them together (i.e., answering “dog is reading” to “what is happening?”). Other studies chose learning targets that were recommended by clinicians (e.g., Delfs et al., 2014), targets that were used in previous or original studies (e.g., Greenberg et al., 2014), or basic vocabulary such as household items or animal names (e.g., Barbera & Kubina, 2005). However, 9.8% ( $n = 5$ ) did not give any rationale for the targets selected for the participants to learn.

**Social reinforcement.** For reinforcement, 33.33% ( $n = 17$ ) either paired social interaction (e.g., verbal praise, hugs) with tangible reinforcers (e.g., edibles, toys) that was later faded out completely or only used social interaction as reinforcers. Giunta-Fede et al. (2016) did mention that they faded out the token reinforcement that was paired with the verbal praises but did not mention if it was completely faded out. Most of the 17 studies used social interaction to reinforce tacting but two studies paired social interaction and tangible reinforcers and later faded out the tangible reinforcer. Akmanoglu (2015) paired preferred edibles with verbal praise and later faded out the edibles after a participant had a session with 100% accurate answers during the intervention phase. And Marchese et al.

(2012) paired an unrelated preferred item with verbal praise in their comparison of tact procedures.

Another 35.29% ( $n=18$ ) used both tangible reinforcers and social interaction as reinforcers but did not fade out the tangible reinforcers. Two studies used only a preferred item as their reinforcer (e.g., Grow et al., 2016; Lydon et al., 2009). Some studies used reinforcers to increase attending to the intervention session rather than using them to reinforce accurate responding. For example, Marchese et al. (2012) used a preferred item on a variable ratio schedule as a putative reinforcer with the verbal praise and McHugh et al. (2011) used both the preferred item and the social praises to reinforce attending whilst having no contingencies for tact responses. Three studies did not mention any reinforcers or reinforcement schedules.

**Multiple discriminative stimuli.** In 29.41% ( $n=15$ ) of the studies, the learning objective (i.e., trained tacts) was probed through a mixture of settings during instruction, a mixture of different verbal  $S^D$ s, for example, an object or event  $S^D$  without any verbal cues. Eight of the 15 studies required the participants to produce true tacts (see Skinner, 1957). Other studies provided different verbal cues. For example, Dueñas et al. (2019) presented items and asked a variety of verbal questions such as “What is it?” and “What do you call it?”, as well as modeling saying the tact to elicit the tact objective from the participant. Other studies first presented the participant with the item but built in a time delay so a verbal cue such as “What is it?” would follow if the participant does not produce the tact (e.g., Kodak & Clements, 2009; Naoi et al., 2007).

Some studies specifically investigated presentations of different  $S^D$ s and their effects on tact learning. Marchese et al. (2012) specifically conducted a study where they compared the effectiveness of tact instruction by comparing an object only  $S^D$  with the object plus verbal cue  $S^D$ . And Schebell et al. (2018) also looked at the effects of different  $S^D$ s by comparing tact responding between simple pictures and videos of actions.

Although many studies did not elicit tacts with different  $S^D$ s, they also asked different questions for different tact responses or different verbal operants. For example, Dass et al. (2018) taught children with ASD how to tact olfactory stimuli but they asked, “What is it?” with “How does it smell?”. Frampton et al. (2017) required participants to answer to “What is it?” but also required the participants to “Touch [object]” as a listener response. Similarly, Jimenez-Gomez et al. (2019) also required participants to “Show me [object]” as a listener response as well as asking the participants “What is it doing?” to teach children with ASD to tact actions.

## Effect sizes

Within the criteria of the current review, 56.86% ( $n=29$ ) studies met minimum research design quality standards. These 27 single-case design and two group design studies were examined for effect size calculation. Of the 27 single-case design studies, we could not identify extractable graphs for Tau-U calculation for two studies. Conallen and Reed (2016) did not include a line graph that could be used to calculate Tau-U effect size. And Kodak and Clements’ (2016) study included a line graph but the effect size could not be calculated for just the tact intervention as their study also looked at mand acquisition. As such, we calculated effect sizes for 25 single-case and two group design studies. For studies that conducted a comparison (e.g., Hanney et al., 2019; sound-only condition compared to an object-with-sound-compound condition), we calculated the effect sizes for all conditions and reported them separately. Table 3 shows whether a study included in this review has either met, met with reservations, or has not met quality standards for research; their effects sizes; and the total number of AB comparisons within each study for single-case design studies.

Of the 37 interventions included in the 25 single-case studies, 85.19% ( $n=23$ ) showed extremely high effect (i.e.,  $\text{Tau-U} \geq .80$ ); 24.32% ( $n=9$ ) showed high effect (i.e.,  $.60 \leq \text{Tau-U} < .80$ ); 13.51% ( $n=5$ ) showed moderate effect (i.e.,  $.20 \leq \text{Tau-U} < .60$ ); and no studies showed low effect (i.e.,  $\text{Tau-U} < .20$ ; Vannest & Ninci, 2015). Figure 2 depicts the box plot of the Tau-U effect sizes and a scatter plot of the effect sizes for the single-case design studies. For group studies, the study by Cihon et al. (2019) showed moderate effect size for percentage of correct responding ( $d=.56$ ) and the study by Ryan and Charragain (2010) showed extremely high effect size ( $d=1.43$ ; Cohen, 1988). Cihon et al. (2019) also reported the effect sizes for other dependent measures such as sessions to mastery ( $d=.824$ ), generalization ( $d=.133$ ), and percentage of independent correct responses ( $d=1.355$ ).

## Discussion

Tacting (or labeling, indicating) is important for children as it facilitates social interaction and can assist the development of other language skills such as requesting and engaging in conversations (Pistoljevic & Greer, 2006; Skinner, 1957; Valentino et al., 2015). However, tacting is particularly difficult to teach to children with ASD because social reinforcement may be ineffective, stimulus control may be inflexible, and stimulus and response generalization may be difficult to achieve

**Table 3** Results for Research Quality Standards, Effect Size, Number of A-B Comparisons, and Procedural Integrity.

| Number Label for Figure 2 | Authors                    | Year | Type               | Quality Standards       | Effect Size  | Number of A-B Comparisons | Procedural Integrity <sup>a</sup>  |
|---------------------------|----------------------------|------|--------------------|-------------------------|--|---------------------------|--|
| 1                         | Akande                     | 2000 | Single-case design | Does not meet           | Tau-U = 0.911  | 12                        | NR   |
|                           | Akmanoglu                  | 2015 | Single-case design | Meets with reservations |  |                           | 20% of baseline and intervention;<br>100%.   |
|                           | Akmanoglu-Uludag & Batu    | 2005 | Single-case design | Does not meet           |  |                           | 20% of baseline and intervention;<br>100%.   |
| 2                         | Barbera & Kubina           | 2005 | Single-case design | Meets                   | Tau-U = 0.92   | 3                         | NR   |
| 3                         | Bloh                       | 2008 | Single-case design | Meets with reservations | Tau-U = 0.629 (e-t)  | 24                        | NR   |
| 4                         |                            |      |                    |                         |  |                           |  |
| 5                         | Byrne et al.               | 2014 | Single-case design | Meets with reservations | Tau-U = 0.531  | 3                         | 35% of all sessions;<br>P1 99.9%, P2 99.5%,<br>P3 99.9%  |
| 6                         | Carbone et al.             | 2006 | Single-case design | Does not meet           | Tau-U = 1 (NPA)<br>Tau-U = 0.973 (PA)<br>Cohen's <i>d</i> = .56 (primary DV) | 6                         | NR   |
|                           | Cengher & Fienup (Study 1) | 2019 | Single-case design | Meets                   |  |                           | NR   |
|                           | Cihon et al.               | 2019 | Group design       | Meets with reservations |  |                           | 25%, 25%, and 27% of all sessions;<br>99.7%, 99.5%, and<br>99.7%   |
| 8                         | Conallen & Reed            | 2016 | Single-case design | Meets with reservations | No graph   | 3                         | 20% of sessions;<br>No score reported  |
|                           | Conallen & Reed (Study 1)  | 2017 | Single-case design | Does not meet           |  |                           | NR   |
|                           | Dass et al.                | 2018 | Single-case design | Meets                   |  |                           | Tau-U = 0.692  |
| 9                         | Delfs et al.               | 2014 | Single-case design | Meets with reservations | Tau-U = 0.816  | 11                        | NR   |
| 10                        | Dixon et al.               | 2017 | Single-case design | Meets                   | Tau-U = 0.988  | 5                         | Mentions fidelity data was collected;<br>No details reported   |
| 11                        | Dueñas, et al.             | 2019 | Single-case design | Meets                   | Tau-U = 0.756  | 9                         | 33% of sessions;<br>Baseline 95%, inter-<br>vention 96%  |
| 12                        | Frampton et al.            | 2016 | Single-case design | Meets                   | Tau-U = 0.971  | 7                         | 50%, 36%, 65%, 50%,<br>22% assessed per<br>participant;<br>P1 100%, P2 100%, P3<br>99.8%, P4 99.8%,<br>P5 99%                          |
|                           | Frampton, et al.           | 2017 | Single-case design | Does not meet           |  |                           | 30% across partici-<br>pants;<br>99%   |
| 13                        | Frampton et al.            | 2019 | Single-case design | Meets                   | Tau-U = 0.943  | 6                         | 44.68%, 32%, 0%, 20%,<br>25%, 41.67% per<br>participant;<br>P1 99.89%, P2 100%,<br>P3 not collected,<br>P4 100%, P5 100%,<br>P6 99.72% |
| 14                        | Giunta-Fede et al.         | 2016 | Single-case design | Meets                   | Tau-U = 0.899 (CM)   | 9                         | 100% of DTT ses-<br>sions;<br>P1 99%, P2 99%, P3<br>99%  |
|                           | Greenberg et al.           | 2014 | Single-case design | Does not meet           |  |                           | NR   |
|                           | Greer & Du                 | 2010 | Single-case design | Does not meet           |  |                           | NR   |
|                           | Grow et al.                | 2016 | Single-case design | Does not meet           |  |                           | NR   |

(continued)

Table 3 Continued.

| Number Label for Figure 2 | Authors                          | Year         | Type                                     | Quality Standards                        | Effect Size   | Number of A-B Comparisons | Procedural Integrity <sup>a</sup>   |
|---------------------------|----------------------------------|--------------|--|--|---|---------------------------|---|
| 15<br>16                  | Hanney et al.                    | 2019         | Single-case design                       | Meets                                    | Tau-U = 0.48 (isolated)<br>Tau-U = 0.707 (compound)                   | 4                         | 40% of all tact-training trials;<br>exceeded 98%  |
|                           | Jimenez-Gomez et al.             | 2019         | Single-case design                       | Does not meet                            |   |                           | NR  |
| 17                        | Kelley et al.                    | 2007         | Single-case design                       | Meets with reservations                  | Tau-U = 0.925   | 7                         | NR  |
| 18                        | Kelly & Holloway                 | 2015         | Single-case design                       | Meets with reservations                  | Tau-U = 0.812   | 9                         | NR  |
|                           | Kodak & Clements                 | 2009         | Single-case design                       | Meets with reservations                  | Cannot calculate  |                           | NR  |
| 19                        | Leaf et al.                      | 2011         | Single-case design                       | Meets                                    | Tau-U = 0.908   | 7                         | 41.9% of all intervention sessions;<br>97.9%  |
| 20<br>21                  | Leaf et al.                      | 2014         | Single-case design                       | Meets                                    | Tau-U = 0.961 (EC)<br>Tau-U = 0.826 (MTL)                             | 12                        | EC 37% and MTL 34% of sessions;<br>EC 99.1% MTL 98.1% SE 37% and MA 36% of sessions;<br>99% |
|                           | Leaf et al.                      | 2016         | Single-case design                       | Does not meet                            |   |                           | 29% of probes and 23% of teaching;<br>99%   |
|                           | Leaf et al.                      | 2017         | Single-case design                       | Does not meet                            |   |                           | 100% collected;<br>No scores given<br>NR  |
|                           | Lorah & Parnell                  | 2017         | Single-case design                       | Does not meet                            |   |                           | NR  |
| 22                        | Lydon et al.<br>Majdalany et al. | 2009<br>2014 | Single-case design<br>Single-case design | Does not meet<br>Meets with reservations | Tau-U = 0.915 (massed)  | 18                        | minimum 30% per participant;<br>99%   |
| 23                        |                                  |              |  |  | Tau-U = 0.889 (distributed)   |                           |   |
| 24                        |                                  |              |  |  | Tau-U = 0.837 (interspersed)  |                           |   |
| 25                        | Majdalany et al.                 | 2016         | Single-case design                       | Meets                                    | Tau-U = 0.911 (0 s)   | 9                         | 50% per participant;<br>100%  |
| 26<br>27<br>28            | Marchese et al.                  | 2012         | Single-case design                       | Meets                                    | Tau-U = 0.908 (6 s)<br>Tau-U = 0.847 (12 s)<br>Tau-U = 0.956 (object) | 8                         | 50% baseline, 27% training, 33% maintenance-evaluation sessions;<br>100%, 96%, 98%          |
| 29                        |                                  |              |  |  | Tau-U = 0.957 (object + question)                                     |                           |   |
| 30                        | McHugh et al.                    | 2011         | Single-case design                       | Meets with reservations                  | Tau-U = 1   | 12                        | NR  |
|                           | Miguel & Kobari-Wright (Study I) | 2013         | Single-case design                       | Does not meet                            |   |                           | 82% of sessions;<br>PI 100%, P2 99%   |
|                           | Naoi et al.                      | 2007         | Single-case design                       | Does not meet                            |   |                           | NR  |
|                           | Pistoljevic & Greer              | 2006         | Single-case design                       | Does not meet                            |   |                           | NR  |
|                           | Ryan & Charragain                | 2010         | Group design                             | Meets with reservations                  | Cohen's <i>d</i> = 1.42   |                           | NR  |
|                           | Scattone & Billhofer             | 2008         | Single-case design                       | No graph                                 |   |                           | NR  |
| 31                        | Schebell et al.                  | 2018         | Single-case design                       | Meets                                    |   | 6                         |   |

(continued)

**Table 3** Continued.

| Number Label for Figure 2 | Authors                   | Year | Type               | Quality Standards       | Effect Size              | Number of A-B Comparisons | Procedural Integrity <sup>a</sup>          |
|---------------------------|---------------------------|------|--------------------|-------------------------|--------------------------|---------------------------|--|
|                           |                           |      |                    |                         | Tau-U = 0.493 (pictures) |                           | at least 30% of sessions; 100%             |
| 32                        |                           |      |                    |                         | Tau-U = 0.457 (videos)   |                           |  |
| 33                        | Schnell et al.            | 2018 | Single-case design | Meets                   | Tau-U = 0.699 (SMET)     | 9                         | 33% of sessions; P1 100%, P2 100%, P3 99%  |
| 34                        |                           |      |                    |                         | Tau-U = 0.708 (CMET)     |                           |  |
| 35                        |                           |      |                    |                         | Tau-U = 0.626 (IF)       |                           |  |
| 36                        | Shepley et al.            | 2016 | Single-case design | Meets with reservations | Tau-U = 0.775            | 6                         | minimum 20% for each condition; 99.4%      |
|                           | Sidener et al.            | 2010 | Single-case design | Does not meet           |                          |                           | 48% of sessions; 98%                       |
|                           | Simpson & Keen            | 2010 | Single-case design | Does not meet           |                          |                           | Data collection was automated via computer |
|                           | Sprinkle & Miguel         | 2012 | Single-case design | Does not meet           |                          |                           | 33% across participants; 96.7%             |
|                           | Sundberg et al.           | 2000 | Single-case design | Does not meet           |                          |                           | NR   |
| 37                        | Valentino & Shillingsburg | 2011 | Single-case design | Meets with reservations | Tau-U = 0.501            | 3                         | 53% of sessions; 99%                       |
|                           | Williams et al.           | 2006 | Single-case design | No graph                |                          |                           | NR   |

Note: NR = Not Reported; P = Participant (e.g., P1 = Participant 1, P2 = Participant 2).

<sup>a</sup>Procedural Integrity is presented by the ratio of procedural integrity data collected; followed by the average score reported.

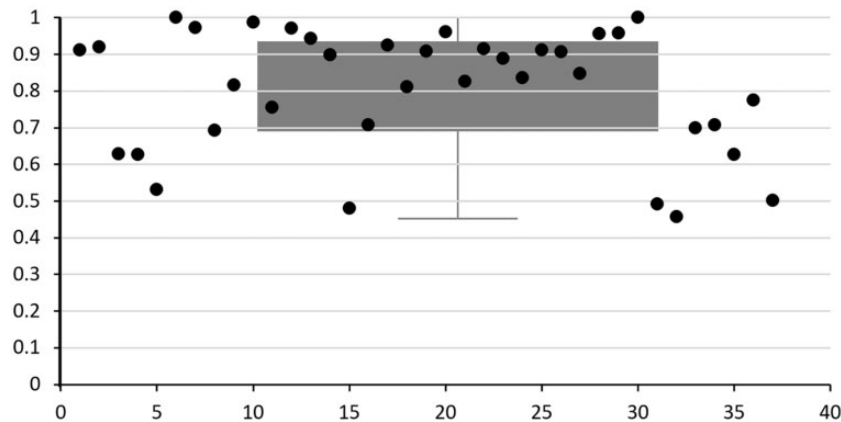
(Chiang & Carter, 2008; Krantz & McClannahan, 1998). The current study reviewed 51 tact studies published between 2000 to 2019 for children with ASD. We highlight the following directions for future research based on this review: procedures for teaching tacts in the natural environment, programming and testing for generalization and maintenance, and the need to evaluate individual components that lead to an established tact repertoire in the natural environment.

### *Tact interventions for children with ASD*

The majority of the tact interventions included in the current review yielded high effect sizes (see Table 3). One reason may be that only 13.72% ( $n = 7$ ) of the studies trained practitioners in the field to deliver the interventions. However, another reason may be because many of the studies employed DTT or similar methods in clinical or pseudo-naturalistic settings where reinforcement was readily available and, in most cases, where the tact was evoked with a verbal antecedent (e.g., “What is it?”). Research has repeatedly shown that DTT is effective when teaching children with ASD (Steinbrenner et al., 2020; Wong et al.,

2015). Children with ASD benefit from systematic interventions with consistent and explicit instruction (National Research Council, 2001). And using a DTT approach for tact interventions has shown to produce increased language in children with ASD in those contexts (Reichow, 2012). However, teaching tacts to children with ASD under strict stimulus control and contrived settings can result in rote responding (LeBlanc et al., 2009; Partington et al., 1994). That is, children with ASD may only tact under similar environmental conditions (e.g., faced with the instructor seated in a chair) and antecedents (e.g., instructor holds up the picture card used in the intervention and asks, “What is it?”).

As such, researchers have made the following recommendations for teaching tacts to children with ASD: implementing in naturalistic settings, using actual objects or using various examples, varying verbal antecedents or not using verbal antecedents, choosing objectives that are meaningful and likely to be used in the child’s natural environment, and conditioning social reinforcement (Goldstein, 2002; LeBlanc et al., 2009; Partington et al., 1994; Schreibman et al., 2015). In addition, the results of the current review show that



**Figure 2.** Box and scatter plot of Tau-U effect sizes for single-case design studies.

The figure shows a box and whiskers plot and a scatter plot of the Tau-U effect sizes of all single-case design studies included in this review. The y-axis represents Tau-U effect sizes from 0 to 1 and the x-axis represent the numbered order of which the studies are displayed on the scatter plot. The numbered order of the studies can be found in Table 2.

the majority of studies did not report participant descriptions that may influence language development and learning such as race, ethnicity, mother tongue, and socioeconomic status.

Moreover, our findings suggest that the research questions posed by some studies included in this review have placed an emphasis on achieving stimulus control and, therefore, developed tact procedures that focus solely on this outcome. In one example, Majdalany et al. (2016) investigated the effects of reinforcement delay on tact acquisition to demonstrate that timely reinforcement during tact training led to quicker acquisition of tacts in children with ASD. Researchers need to control external factors such as the possibility of learning a target word outside the intervention when the primary objective of a tact intervention is answering specific research questions. For example, Cengher and Fienup (2019) selected words in foreign languages; and Scattone and Billhofer (2008) chose targets that were not preferred by their participants to increase the strength of internal validity. Hence, less of a priority is placed on developing and testing tact procedures that lead to children with ASD tacting in their natural environment.

### *Procedures that promote generalization and maintenance*

In order for children with ASD to maintain acquired tact repertoires, the learned tacts need to transfer to natural environments where naturally occurring social consequences are available (Skinner, 1957). The results of the current review reveal the need for experimental evaluation of procedures that lead to maintenance and generalization of tact repertoires in the natural

environment for children with ASD. An end goal for future tact studies, therefore, may be assessing whether children with ASD display the learned tact on the onset of an object or event when they are with a peer or a caretaker (e.g., “It’s raining!”) after the intervention concludes. The natural environment is also likely to contain spontaneous and/or unexpected variables that differ from the setting and variables in which a child with ASD learned the tact objective. Therefore, procedures that plan for and teach tact repertoires with those conditions in mind, may be beneficial.

*Natural environment.* Tact interventions that occur in natural environments may increase the likelihood children will emit acquired tacts during similar activities even after the intervention has ended. For example, Lorah and Parnell’s (2017) intervention was implemented during a pre-school story time where the interventionists were seated behind the participants while a teacher read a story book to the entire preschool classroom. While integrating tact instruction into the participant’s natural environment may be beneficial, some children with ASD who have attention or behavioral difficulties may find this intervention. But a contrived natural setting may help researchers include DTT elements that are effective in teaching children with ASD whilst also simulating a natural setting for optimal maintenance and generalization. A few studies included in the review demonstrated this approach. For example, Dueñas et al. (2019) contrived naturalistic play to teach tacts, and Valentino and Shillingsburg (2011) conducted their intervention in a tabletop setting but used naturally simulated play within that setting. Interventions that teach tacts using embedded DTT procedures but situate the assessment component



outside intervention settings using common objects or events (e.g., toys in the play area) such as Lydon et al.'s (2009) study may increase the chance of a maintained tact repertoire in a child's natural environment.

**Natural consequences.** Because tacts are maintained by social interaction, a strong tact repertoire may result in the emergence of other verbal operants such as mands (i.e., requests) and intraverbals (i.e., conversations; Sundberg, 2015). As such, researchers have provided several recommendations for planning tact interventions for children with ASD that ensure acquired tacts will maintain and generalize in the natural environment (see LeBlanc et al., 2009; and also, Partington et al., 1994). Although tacts are maintained by social reinforcement in the natural setting, it is difficult to teach children with ASD with only social reinforcement (e.g., verbal praise) because it may not be a conditioned reinforcer for many children with ASD (Zwaigenbaum et al., 2005). Thus, many interventions included in the review used preferred items, edibles, or tangibles and conditioned reinforcers such as tokens for independent correct responses. However, in the natural environment, reinforcement may be limited to the naturally occurring social reinforcement from the listener. If primary reinforcers are used, pairing them with social reinforcement in the beginning of a tact intervention while fading out the primary reinforcement (e.g., Akmanoglu, 2015) may increase the likelihood that social attention and praise will function as a reinforcer in the natural environment (LeBlanc et al., 2009). Another approach may be using social reinforcement such as verbal praise or interaction (e.g., hugs) for correct responding whilst also using putative reinforcers (e.g., tokens) for attending throughout the intervention. For example, Akmanoglu-Uludag and Batu (2005) provided preferred items and attention after the training session for attentiveness and Kelley et al. (2007) provided access to preferred toys after the intervention session.

**Common objects and multiple exemplars.** Teaching a child with ASD with an object common to their environment (e.g., an actual dog or a toy dog) rather than a picture (e.g., a picture of a dog) may increase the likelihood that the child will emit the tact, "Dog!" when they see one outside the intervention. But the majority of studies in this review involved tact procedures using picture cards or variations of two-dimensional stimuli (e.g., pictures, photos, videos) to teach tacts. One possible reason is practical advantages that two-dimensional stimuli offer such as easy access and efficient preparations.

Researchers have stated the importance of using a variety of stimuli and presentation to enhance transfer

of tacts from the pictures to a real event or object (see Schnell et al., 2018). Thus, some studies included in this review used multiple-exemplar training when they used pictures (e.g., McHugh et al., 2011) and other studies presented two-dimensional pictures or videos but included post-intervention generalization probes that used live-action stimuli (e.g., Akmanoglu, 2015; Schebell et al., 2018). Embedding multiple examples or different types of stimuli (e.g., pictures, videos, and live-action modeling) may increase the possibility of stimulus generalization for children with ASD (Schnell et al., 2018).

**Varied discriminative stimuli.** In addition to multiple examples, using a variety of verbal cues or discriminative stimuli (e.g., object only, object and question, "What is it?" or varied verbal cues "What is in the box?" "What do you see?") may also ensure that acquired tacts transfer to settings dissimilar to training and may result in reduced rote-responding. Studies included in the current review presented tact stimuli without a verbal cue (e.g., Greenberg et al., 2014; Pistoljevic & Greer, 2006). Other studies used variations of verbal cues such as interjecting "who is this?" and "what is his name?" (e.g., Leaf et al., 2017) or "what is it?" and "what do you call it?" (e.g., Dueñas et al., 2019). However, some children with ASD may not initially respond or display anxiety because they may not understand the novel response requirements. Studies included in this review include methods that could possibly provide support for this population. For example, McHugh et al. (2011) introduced a verbal cue with immediate fading and Kodak and Clements (2009) used a time-delay to first teach the child of the response requirement and gradually faded the verbal  $S^D$ .

### **Assessment of individual components in tact-training procedures**

The current review reveals that there is a growing body of literature demonstrating effective procedures for teaching tacts. However, variation exists on the specific procedures used to teach tacts to children with ASD and little is known about the effects of individual components that lead to tact repertoires in the natural environment. The current review calculated effect sizes based on baseline and intervention conditions; however, the effect size of generalization and maintenance conditions is unknown. Compared to the abundance of evidence-based interventions for individuals with ASD (Steinbrenner et al., 2020), there is insufficient evidence within the tact intervention literature on how individual components such as using objects versus picture cards, using verbal  $S^D$ s versus using just the object, affect tact acquisition. The current

review yielded a few studies that specifically asked research questions about the effects of individual components. One example is Hanney et al. (2019) who compared auditory stimuli presented without visual cues (e.g., dog barking) with compound stimuli that included auditory and visual cues (e.g., a toy dog that emits barking noises) and found that compound stimuli has a higher effect size (i.e., Tau-U = 0.71) than using just the auditory stimuli (Tau-U = 0.48).

Furthermore, there is even less research about how individual components affect the strength of generalization and maintenance of acquired tacts in children with ASD. Marchese et al. (2012) compared the effectiveness of acquired tacts with an object with tacts that were taught with a verbal  $S^D$  and object presentation. Marchese et al.'s (2012) study showed that the effect sizes of the two comparisons were similar (i.e., Tau-U was 0.956 for object and 0.957 for verbal  $S^D$  + object). Although the two interventions had similarly high effects, we do not know if the effects would be stronger for one of the methods in the long term or whether one or the other would yield more robust generalization effects. Of the 53 studies included in the review, only half of the studies conducted maintenance trials and fewer studies evaluated generalization of tacts across stimuli, persons, setting, and response modalities. Because children with ASD are less likely to display learned tacts outside the intervention (LeBlanc et al., 2009), there is a need for extensive research on how different tact interventions affect long-term outcomes in the child's verbal repertoire.

### Limitations

There are some limitations to the current review. First, the search words we used to identify tact instructions available outside ABA literature may have limited the scope of the review and therefore caution should be taken when speaking of the state of the tact literature for children with ASD. Future studies should attempt a more inclusive search to inform ABA practices and to potentially reach broader audiences such as teachers serving children with ASD.

Second, we limited the review to interventions for young children and school age children with ASD. Mand or tact instruction studies primarily focus on children because of considerations to their developmental age (i.e., after echoic vocalization, mands and tacts are developmentally appropriate for early language learners). However, researchers estimate that 30% of individuals with ASD would remain non- or minimally verbal after elementary school (Tager-Flusberg & Kasari, 2013). Future studies could discuss how tact instruction should differ for different groups or whether the recommendations for children with

ASD presented in this review can be applied to a diverse population.

Third, although we reviewed studies for methodological rigor as a prerequisite to calculating effect size and to ensure that the studies met single case design standards with reservations, we did not conduct visual analysis. This information would allow us to compare effect size metrics with visual analysis and evaluate whether the metrics correspond with the visual analysis. This is especially important given that SCED relies heavily on visual analysis to determine effectiveness and there is no gold standard effect size metric for SCED studies.

Finally, we did not expand our literature search to dissertations and theses, therefore the conclusions of this review may be biased towards published studies that tend to report positive results (Gage et al., 2017).

### Conclusion

An established tact repertoire can reduce stereotypical or repetitive language in children with ASD (Karmali et al., 2005), increase opportunities for social interaction by offering the listener information to engage in communication (LeBlanc et al., 2009), and assist in the development of other verbal operants (Pistoljevic & Greer, 2006; Valentino et al., 2015). The current review provides an overview of current tact intervention procedures and highlights important areas of future research, what are the intervention components that lead to tact acquisition, maintenance of tact repertoires and generalization to natural environments. The majority of tact studies showed high to moderate effects and many studies showed innovative ways to teach tacts to children with ASD. However, there may be a need for more research that investigate individual components that can increase sustained and generalized tact repertoires in children with ASD.

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