Considering Visual Stimuli as an Active Ingredient in Vocabulary Interventions with Children on the Autism Spectrum: Evidence from a Scoping Review

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Abstract

Purpose: Children with ASD demonstrate different visual processing profiles than typically developing children (Walton & Ingersoll, 2013; DiCriscio & Troiani, 2018). Evidence suggests that children with ASD may demonstrate overselectivity (i.e. overgeneralizing labels to other objects), weak central coherence (i.e. heightened local over global focus), and difficulty inhibiting distractor information, all which negatively impact word learning. These theories, as well as other evidence, suggest that children with ASD may perform best with iconic visual stimuli, especially children with severe language impairment and severe ASD. Iconic stimuli are those that most closely represent the referent and may often include objects and color photographs, with less iconic stimuli representing the referent more loosely, including line-drawings and clip-art. Language interventions targeting word learning use visual stimuli to teach word labels. However, children's performance with various stimuli during these interventions has not been closely explored. Therefore, this scoping review was conducted to answer the following questions (1) Does visual stimuli selection in language intervention impact outcomes in children with ASD? If so, how; (2) Does the relationship between stimuli selection and language outcomes vary by the child's pre-treatment language skills and/or ASD severity; and (3) Does intervention mode have an effect on type of stimuli selected?

Methods: A scoping review protocol was developed based on previously reported frameworks for conducting scoping reviews (Arksey & O'Malley, 2005; Peters et al., 2015). This protocol followed a 5-stage process including: (1) identifying the research question, (2) identifying relevant studies, (3) study selection, (4) charting the data, and (5) collating, summarizing and reporting the results. Relevant studies were identified through databases searches using the pre-determined search strategy. Initial searching resulted in 794 identified studies. After screening, eligibility checks and ancestral searches were complete, 18 studies were selected for inclusion in this study. To answer the study questions, each study was coded across the following parameters: (1) author(s), (2) year of publication, (3) study design, (4) # of participants, (5) participant language level, (6) participant age range, (7) ASD severity, (8) intervention type, (9) target of intervention (10) response mode of communication, (11) visual stimuli used, (12) number of words taught, (13) number of words learned, (14) number of sessions, and (15) rate of learning.

Results: In the included studies, different types of visual stimuli were used, with 7 studies including line-drawings, 7 including photographs and 7 including objects. The average rate of learning was highest for those that included photographs, with the next highest for those that used line-drawings, with the lowest rate of learning from those that use objects. When split up by participant language ability, results showed that (1) children who are nonverbal had the highest rate of learning with objects (*M = 1.6*), (2) children who are minimally verbal had the highest rate of learning with photographs (*M = 1.43*), (3) children who have emerging verbal skills had the highest rate of learning with line-drawings (*M =2.13*). Only one study included children with average verbal abilities, which demonstrated a rate of learning of 4.17 with both line-drawings and photographs. Additionally, 11 included studies used clinician directed interventions, 7 used hybrid interventions and no studies used client-centered interventions. The hybrid interventions were all receptive, while the clinician directed interventions included both expressive and receptive labeling. Clinician directed interventions that targeted receptive labeling and used line-drawings or photographs lead to the highest average rate of learning across the studies (line-drawings *M = 2.24*; photographs *M = 2.2*). Receptive interventions had a higher rate of learning overall as compared to expressive interventions. Clinician directed interventions that targeted

expressive labeling and used photographs lead to the highest rates of learning across the expressive studies (*M = 1.56*). Finally, interventions were sorted by technology vs. no-technology. Consistent with previous findings, interventions that included technology showed higher rates of learning than those that did not use technology. However, for those that did include technology, line-drawings (Clinician directed *M = 4.17*; Hybrid *M = 0.81*) were associated with higher rates of learning than the other stimulus types, followed by photographs and then objects.

Conclusions: The results of this review demonstrate the significance of visual stimuli selection during word learning interventions, especially for children with ASD and varying degrees of language impairment. Results suggest that the visual stimulus that promotes the highest rate of learning changes as language abilities increase. Specifically, children who are nonverbal may perform best with objects, children who have minimal verbal skills may perform best with photographs and children with emerging verbal skills may perform best with line-drawings. Additionally, other interventions factors, such as use of technology and target of intervention (expressive or receptive labeling) may impact stimuli selection and rate of learning, such that interventions that include technology lead to higher rates of learning as do interventions that target receptive labeling. Other significant take-aways from this review include identification of the need for standardized reporting of visual stimuli types, child characteristics (i.e. language, ASD severity) and intervention outcomes to better allow for replication and comparison between studies. Future studies should continue investigating visual stimuli as an active ingredient during word learning interventions with children with ASD.

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Chapter I: Introduction

Children with ASD represent a heterogenous group of individuals who demonstrate a wide range of skills and abilities across multiple domains (e.g. language, cognition, motor skills, visuospatial skills, behavior; Tager-Flusberg, 2016). More specifically, language skills across domains (i.e. pragmatics, syntax, semantics, morphology, phonology) vary drastically amongst these individuals (Pickles, Anderson & Lord, 2014). One of the most striking differences observed amongst children with ASD is the variability in language skills (Ellis-Weismer & Kover 2015). Children with ASD have language skills that range from nonverbal to typical language profiles (See Boucher, 2012 for a review). For children with ASD and language impairment, language intervention is especially critical to provide a communication system that serves as a bridge to all other learning (Koegel, 2000).

Visual stimuli (or symbols) are commonly used with children with ASD and limited verbal expression to facilitate both receptive and expressive communication. While the use of visual stimuli (i.e. objects, photographs, line-drawings) during language intervention is common practice with children with ASD, mixed evidence exists for guiding visual stimuli selection based on stimuli characteristics (e.g. color, shape, iconicity). Consequently, there are no consistent stimuli selection guidelines for children with ASD. Furthermore, children with ASD demonstrate differences to their typically developing peers in visual processing that may impact picture or symbol learning (Walton & Ingersoll, 2013; DiCriscio & Troiani, 2018). While visual processing and visual stimuli have been investigated with children with ASD, visual stimuli have not been considered as a factor in language intervention research. Therefore, further investigation into visual stimulus selection as it relates to outcomes during vocabulary interventions is warranted. Due to the potentially important nature of visual processing differences in ASD, the next sections will provide an introductory overview of vocabulary profiles of children with ASD, an outline of known vocabulary intervention types, visual processing in children with ASD, as well as an overview of characteristics used to describe various types of visual stimuli.

1.1 Vocabulary skills in ASD

Children with ASD represent a heterogeneous group of individuals with a wide range of language abilities (Lord, Risi, & Pickles, 2004). Around 25% of children with ASD have average language skills (Kjelgaard & Tager-Flusberg, 2001), most preschool-aged children with ASD are preverbal and will eventually learn to use spoken language, and about 25–30% will be nonverbal, or only minimally verbal by the time they enter kindergarten (Anderson et al., 2007). For all children with ASD, learning vocabulary (both receptive and expressive) poses a special challenge due to core deficits in triadic attention skills (e.g. attention following, requesting; Sigman & Kasari, 1995). It is believed that due to this deficit in establishing joint attention, children with ASD are likely to have a mismatch between their own attentional focus and the referential focus of the adult, which can lead to incorrect word-object pairings (McDuffie et al., 2005). Additionally, imitation and joint attention skills (Smith et al., 2007) as well as participation in routine contexts (Rollins, 1999) appear to be positively related to vocabulary development in children with ASD.

1.1.1 Vocabulary acquisition profiles through development

Language development in early ASD generally follows a similar developmental pathway as in other children (Tager-Flusberg et al., 2005), in that they start by acquiring preverbal communication, followed by first words, word combinations, sentences and complex language (Tager-Flusberg et al., 2009). However, children with ASD have smaller expressive vocabularies than typically developing children of the same age (Stone & Yoder, 2001; Kover et al., 2013). Weismer and Kover (2015) found that better receptive or expressive abilities at 2½ years was predictive of greater language growth throughout the preschool period. However, children whose early language skills were more limited did not demonstrate significant growth. Additionally, language abilities shift across development, at the individual-child level. For example, some children who are preverbal at 2 ½ years develop high levels of language proficiency by 5 ½ years and most preverbal toddlers achieve some degree of spoken language (Weismer & Kover, 2015). As this variability suggests, it is unknown how many children with ASD will remain minimally verbal by the time they reach school age (Tager-Flusberg & Kasari, 2013).

1.1.2. Do outcomes vary by language ability?

When developing vocabulary skills, it appears that children with ASD who also have no to minimal (0-20) expressive words, tend to demonstrate slower learning than do children who have emerging language skills (>20 words), with children who have average language skills showing the fastest rate of learning (Smith et al., 2007). This leads to the question: when outcomes of vocabulary interventions are compared, does a child's language ability impact the rate of learning and number of words learned? Additionally, is language ability associated with what type of visual stimuli is used?

1.2 Vocabulary interventions for children with ASD

As previously stated, children with ASD require direct intervention to teach word labels and establish expressive communication (Koegel, 2000). Speech-language interventions can be described on a continuum of naturalness of the intervention, with the most natural interventions being client centered and the least natural interventions being clinician directed interventions.

Anything that falls in-between would be considered a hybrid intervention (Paul, 2014). Various vocabulary interventions will be discussed under each of the intervention types (i.e. client-centered, clinician directed & hybrid). If known, target populations for each intervention type will be provided.

1.2.1 Client-centered Interventions

A client-centered intervention is an intervention that follows the child's lead, utilizes the child's interest and focus of attention as a means to provide meaningful input and focuses on spontaneity and natural contexts (Fey, 1986). The most common client-centered intervention is facilitative play. Facilitative play is when the clinician sets up the environment to encourage the child to generate spontaneous responses in a natural context during a play activity (Owens, 2013). Examples of strategies used during client-centered approaches include self-talk, parallel-talk, expansions, extensions and recasts. These are strategies that involve modeling talk related what the child is engaging with that is just above the child's current level of expression (Smith, 2001). There have been only a few studies documenting the efficacy of the child-centered approach specifically for treating individuals with autism, with the primary benefit of child-centered interventions being the likelihood that a child would demonstrate generalization of learned behaviors (Elliot et al., 1991). Visual stimuli used during child-centered interventions are usually naturally occurring objects, including toys and books, in which are of high interest to the child, as opposed to 2D stimuli, such as photographs and line-drawings.

1.2.2 Clinician directed interventions

Clinician directed interventions tend to follow a drill-like format, where the clinician controls all aspects of the intervention (i.e., materials to be used, nature of responses expected from the child, type and frequency of reinforcement, and structure and order of activities; Koul et al., 2001). Drill activities are when the clinician provides a prompt to be repeated and reinforces correct responses with verbal praise and/or primary reinforcers (e.g. preferred toy or snack). Other common examples of clinician directed interventions include discrete trial training (DTT), and modeling, including simultaneous communication.

DTT is an applied behavior analytic procedure that involves 5 steps (cue, prompt, response, consequence & intertrial interval) and is implemented in a one-on-one manner in a distraction free setting (Smith, 2001). It is thought that since children with ASD have difficulty with learning language in natural interactions that this more unnatural behavioral approach to learning words would be effective.

Modeling is similar to drill activities in that is involves a highly structured format with extrinsic reinforcers and formal context but does not require the child to immediately imitate or respond (Koul et al., 2001). Modeling is commonly used during simultaneous communication, or sign language plus verbal communication, to provide a model (or input) of both forms of communication for a specific label at the same time (Remington & Clarke, 1983).

Behavioral techniques, such as shaping and fading of prompts, are commonly used during clinician directed interventions. These techniques are used to scaffold support for the child to be successful, while reducing prompts and reinforcing closer approximations on a predetermined schedule (Koul et al., 2001).

Clinician directed interventions may include a variety of visual stimuli types, including photographs, line-drawings or objects, depending on the target objective set by the clinician (e.g. matching objects to pictures, receptively identifying line-drawings when presented with a verbal label). It is expected that the stimuli selected would be functional for the individual and could be selected based on language level. For example, a clinician working with a child with ASD who is nonverbal may select objects or photographs as stimuli due to their high level of iconicity (see section 4.2.1 below).

1.2.3 Hybrid Interventions

Hybrid interventions are those that fall somewhere in between clinician directed and client-centered and typically aim to combine the two intervention styles to make a superior intervention technique (Fey, 1986). Hybrid interventions all have three main characteristics: (1) small number of goals targeted, (2) clinician selects therapy activities and materials, and (3) clinician produces utterance behaviors that are contingent to the client's communication but also model and accentuate the target forms (Paul, 2014). Examples of hybrid interventions for vocabulary include incidental teaching, the Picture Exchange Communication System (PECS; Frost & Bondy, 1994), as well as some responsive vocabulary computer/tablet programs.

Incidental teaching uses operant techniques including prompts and extrinsic reinforcers in the natural environment to facilitate communication (Hart & Risley, 1975). This method is considered hybrid because the clinician controls the items that are in the environment as well as strategic responses to the child, but the child determines the topic and timing of teaching (Koul et al., 2001). Only a few studies have successfully taught children with autism receptive labels using incidental teaching (McGee et al, 1983). It is expected that when using incidental teaching to teach word labels, clinicians would most likely select naturally occurring objects in the environment that the child is highly engaged with and most likely to interact with on a regular basis.

PECS uses basic behavioral principles and techniques (e.g. shaping, differential reinforcement, time delay prompts) to teach children functional communication about preferred items using picture symbols as the communicative referent (Frost & Bondy, 1994). PECS follows a specific protocol that the clinician follows as the child progresses through each phase of learning the system, but the clinician uses highly reinforcing items to entice the child to initiate a communication exchange. It has been shown that children who successfully learn PECS may also develop some spoken language (Bondy & Frost, 1994). Traditional PECS symbols are line-drawings; however, clinicians often teach children with ASD to match the line-drawn symbol to its object referent. Additionally, some clinicians may modify the traditional PECS symbols to use photographs of actual items that the child is requesting to increase the iconicity of the symbol.

Other, more unique or innovative interventions that utilize a hybrid approach to teach vocabulary through the use of computer games or apps. These include virtual vocabulary tutors (Massaro & Bossler, 2006; Simpson, 2015; Lorah & Karnes, 2016) that follow a prescribed lesson based that responds based on the child's performance and selections. However, there is only weak empirical support for the efficacy of hybrid approaches on language acquisition for individuals with autism (Koul et al, 2001). Due to the nature of technology-based interventions, it is expected that visual stimuli could only include two dimensional stimuli, such as photographs and line-drawings.

1.2.4 Technology in interventions

As just mentioned, recently technology has been incorporated in vocabulary interventions for children with autism and may be an effective mode due to the lack of social interaction required to participate with a device (Bossler & Massaro, 2003). Technologies include computer programs, robots, and mobile technologies (i.e. tablets and phones), for example. Mobile technologies may be utilized as (1) a therapeutic tool to aid in teaching a new skill or (2) as a dedicated AAC device (Paul, 2014). When used as an AAC device, the incorporation of technology is simply a mode of communication and the intervention may follow any of the previously mentioned styles. On the other hand, when a device is used as a therapeutic tool, the intervention and learning is occurring through the device (e.g. game or interactive activity).

Additionally, when used as a therapeutic tool, technologies most likely follow a hybrid or clinician directed approach. In a hybrid technology intervention, the program would have preset activities and targets to choose from but would be set up in a way to encourage communication and would allow the child to make choices. A clinician directed technology intervention would have preset activities and targets that the child has to follow, with no contingent feedback or choices given. While little is still known about which children may do best with technology-based interventions, Moore & Calvert (2000) found that children with ASD were more attentive and motivated when engaged in computer instruction than clinician instruction. As previously stated, due to the nature of technology interventions, they most likely exclude three dimensional stimuli, such as objects but are likely to include two dimensional stimuli, such as photographs and line-drawings.

1.2.5 Mode of Communication

During vocabulary interventions, the mode of communication is dependent on multiple factors (e.g. child's communication system, language level, focus of intervention) and may vary. One of the most important distinctions is whether the vocabulary intervention is focused on expressive or receptive labeling. In receptive labeling, the child would be asked to select the correct item out of a designated array by pointing, touching or giving the item. The receptive labeling tasks may be matching an object-object, object-picture, picture-object or picture-picture, with matching different items being the most challenging. During an expressive labeling task, the child would be asked to expressively label an item through verbal, sign, or AAC modes. The mode of expression varies based on the child's communication system or system that is being targeted with the child. It is expected that, as in typical development, children with ASD would first acquire receptive labeling skills before expressive labeling skills. However, children with ASD show a smaller difference between their expressive and receptive language skills (McDaniel et al., 2018), so the difference in difficulty between receptive and expressive labeling tasks may not be as large as it would for a typically developing child.

1.2.6 Does intervention type have an effect on visual stimuli selection?

It is evident that there are many variables to include consider when selecting type of intervention (i.e. style, target, mode of communication, technology). When considering the importance of visual stimuli selection, could these intervention variables impact the type of stimuli used to teach vocabulary? For example, client centered interventions may be the most likely type of intervention to include objects as visual stimuli, while both hybrid and clinician directed interventions may allow the clinician to select any of the stimuli types (i.e. photographs, line-drawing, objects). Furthermore, the use of technology in an intervention most likely rules out the use of three-dimensional objects. Additionally, receptive interventions may be more likely to include multiple types of visual stimuli at the same time, while expressive interventions may not.

1.3 Visual Processing and ASD

Not only do children with ASD vary in language skills, they also vary in visual processing skills. This could have implications for how stimuli selection affects the success of vocabulary interventions. Visual processing refers to the activities that take place when viewing an image that involve how visual information is interpreted by the brain (Van der Hallen et al., 2013). As previously mentioned, children with ASD demonstrate differences in visual processing that may cause them to perceive images differently than their typically developing peers (Walton & Ingersoll, 2013; DiCriscio & Troiani, 2018). These visual processing differences have been described by theorists and include overselectivity, weak central coherence, difficulty inhibiting distractor information and changing visual processing profiles. While these theories are broadly known, evidence for each of the visual processing theories is mixed, with contradictory evidence between studies. See below for detailed descriptions of each visual processing theory.

1.3.1. Overselectivity

The phenomenon of *stimulus overselectivity* was first coined fifty years ago by Lovaas et al., (1971), referring to abnormal stimulus control in children with ASD, where children overselect a limited number of stimuli from those available in their environment (Lovaas et al., 1979) or are overly selective to a portion of a stimulus complex (Lovas et al., 1971). For example, a child might overgeneralize the label of "ball" to all round objects (e.g. plate, cup, clock) or the label of "fork" to all utensils, based on one particular feature of the item (i.e. roundness, long metal object). Some postulate that overselectivity may be caused by sensory overload, but this has been largely overruled (Lovaas & Schriebman, 1971). Others suggest that overselectivity is due to a bias, or lack of guided focus to extract stimulus features with regard to relevance (Hermelin, 1976). Similarly, Happé & Frith (2006) describe overselectivity as a bias toward local and not global information, despite relevancy of the object to the stimulus.

Typically developing children may demonstrate overselectivity until age three, when children develop the ability to reliably respond to simultaneous multiple cues (Reed et al., 2013), suggesting that overselectivity may be impacted by mental age. Similarly, children with ASD perform commensurately with typically developing peers when intellectual level, receptive vocabulary and nonverbal reasoning are taken into consideration (Dube et al., 2016). Dube and colleagues (2016) also found that overselectivity may occur with some stimuli and not others, indicating that increased complexity of the stimulus results in an increased probability of stimulus overselectivity. These findings suggest that children with ASD, especially those with intellectual disability and language impairment, are more likely to demonstrate stimulus overselectivity, which could negatively impact their ability to learn and generalize word labels. Consequently, consideration should be taken for visual stimulus complexity in the selection of materials for use in word learning interventions. Specifically, children with intellectual disability and/or language impairment may perform better with visually simpler stimuli.

1.3.2 Weak Central Coherence

Similar to stimulus overselectivity, *weak central coherence theory* was first posited by Frith (1989) describing the processing of local detailed information, while leaving out more global, contextual and semantic information. For example, a child might focus on the flag on the picture of a mailbox without considering the rest of the object. The key difference between stimulus overselectivity and weak central coherence is that the latter implies a superior ability to process local, or detailed, information, while the former does not. More recently, Happé & Firth (2006) suggest that children with autism do not demonstrate a deficit, but instead a bias that gives them a superior ability to process local information. Like overselectivity, weak central coherence theory implies that a child may, detrimentally, over-focus on an irrelevant dimension when learning a label, causing the child significant difficulty generalizing labels onto real items or pictures in the natural environment. To reduce the likelihood of focusing on distracting details, visual stimuli that are simple and have fewer unnecessary elements may be preferred for children with ASD.

In contrast, other studies found that that children with ASD represent a mixed group of both local and global processors (D'Souza et al., 2016), indicating that weak central coherence does not apply to *all* individuals with ASD. Ellis Weismer and colleagues (2016) found that only children with ASD *and* poor vocabulary skills demonstrate this local processing over global processing. These studies all suggest that visual processing may co-vary with language skills, which could potentially contribute to difficulties learning word labels. More specifically, children who may be local processors may be slower learners and may benefit from the use of a variety of highly iconic (refer to section 1.2.1 on iconicity, below) and visually simple stimuli rotated systematically to target generalization when learning new words.

1.3.3 Difficulty inhibiting distractor information

Another factor that impacts children with autism is a limited ability to inhibit distractor information, which leads to limited or incorrect picture to word mapping (Adams & Jarrold, 2012). While this is not a visual process, difficulty inhibiting distractor information directly impacts a child's ability to focus on the appropriate visual stimulus, impacting word learning. There is also a relationship between increased autism symptomatology and increased distractibility, such that inability to inhibit visual information outside of the focus of attention and sensory overload is associated with higher ASD symptom severity (Ronconi et al., 2018). These differences in focus of attention also appear to be linked to specific ASD phenotypes, specifically children with pragmatic language deficits (DiCriscio & Troiani, 2018). So, not only do children with more severe ASD demonstrate an increased difficulty in focusing their attention to the correct stimulus, but they also demonstrate difficulty with determining what is important vs. unimportant in the stimuli, causing sensory overload that prevents successful picture to word mapping. Therefore, children with ASD and high ASD severity may perform better with visually simple stimuli.

1.3.4 Changing visual processing profiles

Evidence suggests that children with ASD have interesting profiles regarding word to picture mapping. However, there is controversy on what the weaknesses might be. Typically developing children gradually shift from an over-emphasis on local details to a more mature, global bias in mid-childhood (Poirel et al., 2011). Not only do children with autism demonstrate differences in sensory processing, including visual processing, that is significantly different from matched controls, but Kern et al. (2006) found that children with ASD have visual processing profiles that over time become more like their typically developing peers (less hypo- or hyper-sensitivity), suggesting that optimal stimuli for each child may change as skill profiles evolve. For example, a young child with ASD or a child with ASD who has low intellectual ability may need highly iconic visual stimuli to start, but as they develop intellectually, iconicity does not appear to be as crucial.

Taken together, these various theories regarding visual processing differences in individuals with ASD suggest that the specific characteristics of visual stimuli could play a crucial role in the success of word learning in children with ASD. These studies also suggest that many child characteristics, such as language and vocabulary skills, intellectual ability and ASD severity, may influence visual processing and consequently, word learning. Additionally, due to changing visual processing profiles throughout development, visual stimuli selection may also need to be adapted based on age, amongst the other previously mentioned characteristics (i.e. language skills, intellectual ability, ASD severity).

1.4 Effect of Visual Stimuli on Word Learning by Children with ASD

Visual stimuli, such as line-drawings, photographs and three-dimensional objects (see Table 1 for examples), are frequently used to enhance communication and teach new word labels to children with ASD. Symbols, as a part of augmentative and alternative communication (AAC) systems are used by children with ASD in early stages of language development to communicate wants and needs (Ganz & Simpson, 2004). Visual stimuli (i.e. photographs, line-drawings, objects), are often described by their characteristics (e.g. iconicity, color, shape) to compare stimuli types to each other or to real items that they represent. Visual stimuli characteristics as well as current evidence regarding performance by children with ASD on each stimulus type will be discussed.

1.4.1 Iconicity of stimuli

Iconicity refers to the perceptual similarity between a symbol and its referent, with symbols that are highly iconic (e.g. color photographs) characterized as transparent, symbols that are moderately iconic (e.g. black-and-white line drawings) characterized as translucent and symbols with little or no resemblance to their referent (e.g. written words) characterized as opaque (Fuller 1997). Mixed results have been found regarding the effect of iconicity of visual stimuli with children with ASD. A few studies found that when learning words, children with ASD learn more words quicker when they are transparent, rather than translucent (Hartley and Allen, 2015a; Hartley and Allen, 2015b; Tek, Jaffry, Fein & Naigles, 2008), suggesting the color photographs or objects would be superior to black and white line-drawings. Additionally, some suggest that iconic symbols may only be appropriate for sophisticated symbol users who comprehend spoken language and demonstrate picture recognition (Stephenson, 2009). While others argue that the use of iconic symbols could be a good choice for people with severe intellectual disabilities due to low cognitive demands (Wilkinson & McIlvane, 2002).

1.4.2 Color of Stimuli

Another commonly used characterization of visual stimuli is the use of color. Recall that color directly contributes to the iconicity of a symbol, in that a symbol with the full color of the real item that it depicts is highly iconic of the item. Conversely, a black and white, or grayscale symbol of a referent would only be moderately iconic (or translucent) of the depicted item. While colored symbols may increase iconicity, children with ASD may not generalize labels to different colored variations of objects due to deficiencies in category formation (Tek et al. 2008). For example, a child may recognize a green apple when taught using a photograph of a green apple but may not recognize the red apple as an apple. However, despite these difficulties with generalization to differently colored objects, Hartley & Allen (2015a) found that children with ASD were still twice as likely to identify expressive labels to objects when the referent was a color picture than when the referent was a black and white/grayscale picture, indicating that for most individuals with ASD, color symbols are superior to non-color symbols.

1.4.3 Shape of Stimuli

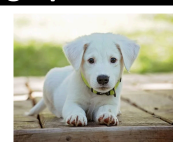
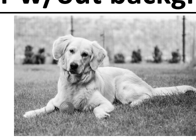
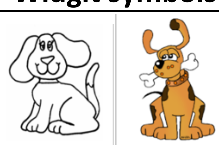
The shape of a symbol is the final visual stimuli characteristic that will be discussed. When describing visual stimuli, shape simply refers to the overall shape of the depicted item. For example, a ball would be round, or a crayon would be an oblong object with a pointed end. At as early as 15 months, typically developing children primarily utilize the shape of the symbol, for count nouns, to identify or label a referent, while secondarily utilizing the color, size or texture of the symbol to aid in identification (Graham & Diesendruck, 2010). It appears that children with ASD rely more on the color of the symbol than the shape (Tek et al., 2008). For example, if taught to label a ball with a symbol of a blue ball, a child with ASD may not be able to identify a yellow ball as a ball. So, while typically developing children tend to demonstrate a shape-bias, or tendency to rely on the shape of a symbol to identify a referent, children with ASD do not.

While it appears that most children with ASD perform better with highly iconic, colored pictures or objects, word learning interventions continue to utilize a range of visual stimuli, with most AAC systems including line-drawings as the visual symbols. Below, each stimuli type included in this study (i.e. line-drawings, photographs, & objects) will be described based on their degree of iconicity, color and shape.

1.4.4 Line-Drawings

Line-drawings are drawn representations of referents that may be black and white, grayscale or color. Line-drawings, especially Picture communication symbols® (PCS®), are frequently used with children with ASD and other developmental disabilities as a part of high and low tech AAC systems. Additionally, line-drawings typically come from commercially available symbol sets (e.g. Bliss symbols, widgit symbols, PCS®, etc.; see Table 1 for examples), and may vary in terms of iconicity and detail (Schlosser, 1997). Some line-drawings (e.g. clip art) are created with substantial detail and are aimed at resembling the visual appearance, color and shape of its referent (i.e., highly iconic). Other line-drawings (i.e., Bliss symbols), however, are less iconic. PCS® relate their representations to the visual appearance of its referent (Lloyd & Fuller, 1990) by maintaining a close shape with the referent and use minimal lines to reduce detail. Bliss symbols focus more on portraying semantic information (McNaughton, 1993) and are therefore much less iconic than PCS®. Another type of commercially available line-drawing, widgit symbols, which are visually similar to PCS®, are considered opaque, or moderately iconic and may share shape and/or color with its referent. Based on the evidence from the visual processing literature (refer to section 1.3 for more detail), children with ASD, especially those with severe ASD symptomatology, language impairment and intellectual disability, may perform better with clip art, Widgit symbols and PCS® than with Bliss symbols, due to their low level of iconicity. Overall, due to their low iconicity, it is expected that children with ASD, especially those with severe language impairment and high ASD severity would learn word labels more slowly when using line-drawings than with photographs or objects.

Table 1. Examples of visual stimuli (photos from: https://goboardmaker.com/pages/boardmaker-online; https://www.blissymbolics.org/index.php/symbol-files; https://widgitonline.com/dual_language; http://clipart-library.com/free-images-of-dogs.html; https://www.farmandfleet.com/products/821144-schleich-female-golden-retriever.html; https://pixabay.com/photos/puppy-dog-pet-animal-cute-white-1903313/; https://pixabay.com/photos/dog-animal-canine-pet-portrait-3277414/; https://pixabay.com/photos/golden-golden-retriever-futrzak-2763246/)

Line drawings	Objects	Photographs
 **PCS®**	 **miniature dog**	 **Color w/ background**
 **Bliss symbols**	 **Partial or toy dog**	 **Color w/out background**
 **Widgit symbols**	 **Real dog**	 **B&W w/ background**
 **Clip art**		

1.4.5 Photographs

Visual stimuli that are color photographs of actual referents, as previously stated, are the most iconic two-dimensional stimuli type, only falling behind three-dimensional objects.

Photographs can be black and white, grayscale or color (Beukelman & Mirenda, 2013), with color being the most iconic (transparent) and black and white being the least iconic (translucent). Additionally, photographs may include a contextual background or no background at all. One study found that children with severe cognitive delays were able to learn to visually match objects with photographs of the objects both with and without background (Dixon,1981), suggesting that photographs may be relatively easy for children with ASD to learn and that background may not impact performance. The shape of the referent in photographic symbols tends to be highly representative of the referent. Based on the characteristics of photographs, it would be expected that children with ASD would perform well when learning to label using them. However, based on evidence regarding overselectivity and weak central coherence, some difficulties with generalization of photographs that are different colored and shape from the actual referent would be expected.

1.4.6 Objects

Objects are the most highly iconic symbols that can be used and are considered tangible symbols because they can be touched and manipulated. Objects may be miniature (i.e. small ball), partial (i.e. a piece of a blanket) or the real object (Beukelman & Mirenda, 2013). Miniature objects, or small versions of objects, may be used when the referent is too big, for example. Miniature objects that are much smaller than its referent may be more difficult for children with intellectual disabilities to recognize than two dimensional photographs (Mirenda & Locke, 1989). Partial objects may also be used when the referent is too large or when tactile similarity cannot be achieved with a miniature object (Beukelman & Mirenda, 2013). Real objects may include items that are identical, similar or associated to their referents. For example, a referent for a cup could be a duplicate of the cup that a child uses, a different colored cup like the one the child uses or a generic cup. Real and miniature objects maintain a close shape with the referent, while partial objects may not. The color of the object symbol selected, may vary from the actual referent, but can usually be controlled, if needed. Objects, especially real objects and miniature objects are considered highly iconic, and, therefore, may be the best visual stimulus type to use to teach word labels to children with ASD. Due to their high iconicity and similarity to the referent, it is expected that the use of objects during vocabulary intervention would decrease the incidence of overselectivity and weak central coherence, subsequently increasing the rate of learning.

1.4.7 Does visual stimuli selection impact word learning outcomes?

When learning word labels, children with intellectual disability who are nonverbal performed best to worst in the following order on the following visual stimuli: objects, color photographs, black-and-white photographs, miniature objects, black-and-white line symbols (PCS®), Blissymbols, and written words (Mirenda & Locke, 1989). Other evidence suggests that children with ASD may do best with highly iconic, color symbols (objects, color photographs; Hartley and Allen, 2015a). However, some variability has been observed based on child characteristics (mental age, language skills, ASD severity). Despite these findings, no known studies have been found to consider the type of stimuli as an important factor when evaluating word learning outcomes during intervention. Moreover, while visual stimuli have been investigated in children with ASD who are nonverbal, no studies have compared performance with different visual stimuli across children with different language abilities.

1.5 Study aims

While evidence exists regarding visual processing in children with ASD and minimal verbal skills, conflicting evidence and lack of visual stimuli selection guidelines necessitates further organization and evaluation in the extant literature. The purpose of this scoping review is to ***(1) synthesize the scope of what is known about visual stimuli use during vocabulary interventions for children with ASD, (2) investigate how visual stimuli selection may impact intervention outcomes, and (3) determine if child characteristics (i.e. child's language skills, ASD severity) impact the types of stimuli used and/or intervention outcomes.***

To fulfill the study purpose, the following study questions were identified as a part of the scoping review protocol (See protocol in methods section, below):

(1) Does visual stimuli selection in language intervention impact outcomes in children with ASD? If so, how; (2) Does the relationship between visual stimulus selection and language outcomes vary by the child's pre-treatment language skills; and (3) Does intervention mode influence the type of visual stimuli selected and/or the outcomes of the intervention?

1.6 Hypotheses

Based on existing evidences in the field, it is hypothesized that: (1) Visual stimuli selection will impact outcomes during vocabulary interventions with children with ASD. Specifically, it is expected that studies that included more iconic visual stimuli (e.g. object or photographs) would show a higher rate of learning than studies that included less iconic visual stimuli (e.g. line-drawings); (2) The relationship between visual stimuli and outcomes will be exacerbated when considering child language ability, such that children with ASD who are non-verbal or minimally verbal would perform even poorer with less iconic stimuli (e.g. line-drawings) and would perform best with highly iconic stimuli (e.g. objects). Additionally, it is expected that children with ASD who have average language skills may perform equally as well with line-drawings as they would with photographs or objects; (3) Language intervention type will have an impact on the visual stimuli selected, such that child-centered interventions will be more likely to include objects as visual stimuli, while clinician directed and hybrid interventions may use a variety of visual stimuli. Additionally, it is expected that interventions that include technology would not include three-dimensional objects and interventions that involve AAC as a communication mode may be more likely to include line-drawings, which are commonly used symbols with SGDs and PECS.

Chapter II: Methods

2.1 Consideration of Literature Review type

When selecting the appropriate method to address the aims of this study, both a systematic review and scoping review were considered. A typical systematic review aims to answer a specific question or series of questions according to predetermined factors detailed in the protocol, whereas a scoping review incorporates a broader approach, designed to map the literature and address a broader research question (Peters, et al., 2005) and summarizes and disseminates research findings as well as identifies research gaps in the existing literature (Arksey & O'Malley, 2005). The aim of this study is, ultimately, to map the scope of the literature and outline the impacts of visual stimuli selection for children with ASD broadly. Based on the goals of this study and with consideration of the purposes of both systematic and scoping reviews, I determined that the aims of this review most closely align with that of a scoping review. Therefore, I selected a scoping review to address the aims of this study.

2.2 Protocol

A scoping review protocol (see Appendix A) was developed based on the methods outlined by both Arksey and O'Malley (2005) and Peters et al. (2015). The framework adopted for conducting a scoping review (Arskey & O'Malley, 2005) includes 5 stages: Stage 1: identifying the research question, Stage 2: identifying relevant studies, Stage 3: study selection, Stage 4: charting the data, and Stage 5: collating, summarizing and reporting the results. The methodological format follows these stages while incorporating the guidelines outlined by Peters et al. (2015). Additionally, I used the Preferred Reporting Items for Systematic Review and Meta-Analysis extension for Scoping Reviews checklist (PRISMA-ScR checklist; see Appendix A) as a guide for developing the methods of this protocol. Once finalized, but prior to initiating the review search, I pre-registered this protocol in the Open Science Foundation (OSF) online registry, https://osf.io/qymza.

2.2.1 Stage 1: Identifying the research questions

Research questions were identified to facilitate the mapping of visual stimuli selection for word learning interventions in the ASD literature, especially as it relates to language level and ASD severity. Preliminary literature searches suggest that visual processing differences exist in individuals with ASD (Walton & Ingersoll, 2013; DiCriscio & Troiani, 2018), with even more differences within children with ASD based on language skills (Ellis Weismer et al., 2016). Based on these findings, the following research questions for the scoping review were identified: (1) Does visual stimuli selection in language intervention impact outcomes in children with ASD? If so, how; (2) Does the relationship between visual stimulus selection and language outcomes vary by the child's pre-treatment language skills; and (3) Does intervention mode influence the type of visual stimuli selected and/or the outcomes of the intervention?

2.2.2 Stage 2: Identifying relevant studies

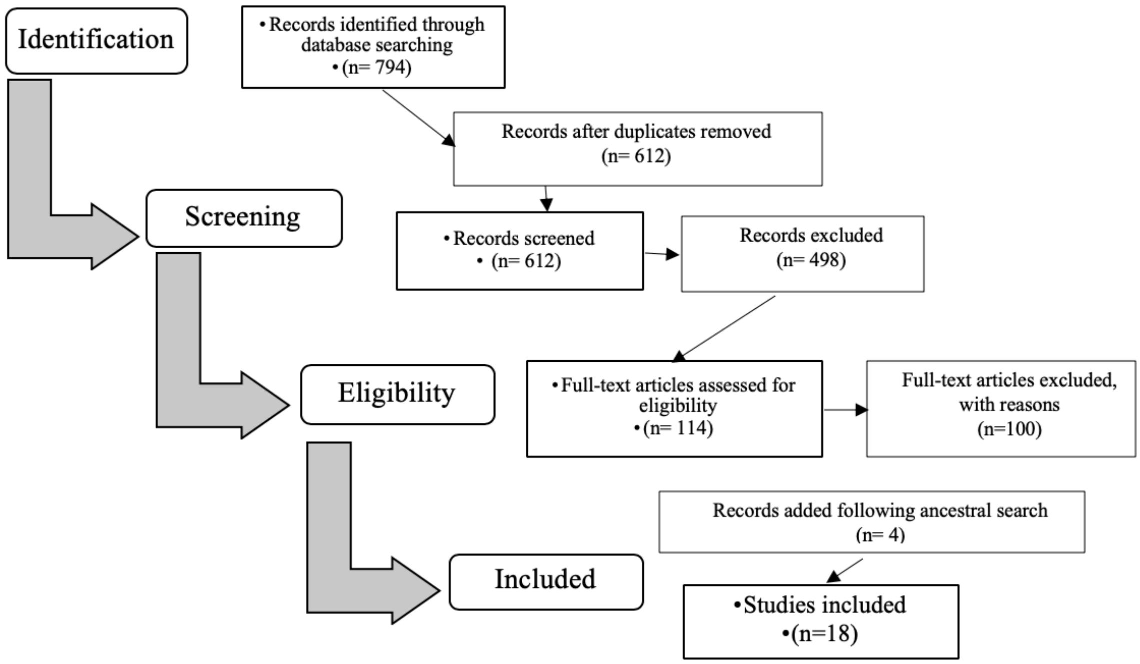


Figure 1. Flow chart for searching and screening articles for inclusion.

The steps followed during stages two (identifying relevant studies) and three (study selection) followed the basic flow-chart as indicated in Figure 1. During stage 2, the identification of studies was completed as detailed below. Stage 3 details the screening, eligibility, and selection of included studies.

The study identification phase of Stage 2 involved an initial literature search using the search strategy as outlined in table 2. This search strategy was intended to identify articles that included (1) included children with ASD as participants; (2) involved an intervention; and (3) involved visual stimuli. The following databases were searched in the order below to identify journal articles: PsycINFO, PubMed, Education Resources Information Center (ERIC), Linguistics and Language Behavior Abstracts (LLBA) and the What Works Clearinghouse (WWC). Then a search of the grey literature was conducted using Google, and the American Speech Language Hearing Association (ASHA) website (asha.org) with no additional articles identified to be included. In addition to the search terms, each database search was restricted by date (after 1960), participant age (3-21; if available), and to exclude books by selecting other search parameters. Each search was modified based on the database specifications to fit these restrictions. The initial database search identified 794 studies (PsychINFO (n= 351); PubMed (n= 65), ERIC (n= 33), LLBA (n= 341) and WWC (n=4)). Duplicate articles (n= 182) were removed before moving on to the screening phase of the search process (See Figure 1), which left 612 articles to be screened.

Table 2. Search Strategy

item #	Search term
1	autism
2	autism spectrum disorder*
3	ASD
4	1 or 2 or 3
5	language
6	intervention
7	program
8	treatment
9	therapy
10	6 or 7 or 8 or 9
11	visual stimuli
12	picture
13	symbol
14	graphic
15	11 or 12 or 13 or 14
16	4 and 5 and 10 and 15

2.2.3 Stage 3: Study Selection

Eligibility/Inclusion criteria

The screening phase involved reviewing titles and abstracts of identified articles for inclusionary and exclusionary criteria to remove irrelevant studies. Studies were *included* if they targeted children with ASD (ages 3-21) and involved a language intervention targeting receptive or expressive labeling. Studies that did not include language level (or verbal skills), only involved children with high-functioning autism (or Asperger's), and did not include a description of visual stimuli used during the intervention were *excluded*. All study designs, such as randomized controlled trials (RCTs), quasi-experimental studies, single case design studies, case control studies and qualitative studies were eligible for inclusion, because the purpose of the review was to gather all information related to the topic, not assess the quality of the information found. Systematic and other review studies were excluded from this study. Articles were not excluded based on language of the children in the study if the study was translated to or written in English. All 612 studies' titles and abstracts were screened for inclusionary and exclusionary criteria. As seen in Figure 1, 498 articles were excluded during this phase, leaving 114 studies to go through the final eligibility screening phase. 21 studies were excluded because of incomplete or lacking description of the visual stimuli (See Appendix C for a full summary of reason for study exclusion). Studies that were unclear as to whether they fit the inclusionary criteria were kept and went through the next phase of the study selection process.

Next, the full-text of the remaining articles were read, and each study was assessed for eligibility based on the previously defined inclusionary and exclusionary criteria (see above). A reason for exclusion was provided for each study that was excluded (n= 100) in this phase (See Appendix C for details about number of studies excluded for each reason). As seen in Figure 1, this left 14 studies to be included in the full scoping review. To ensure that the original search did not leave out articles that should be included in this search, a final ancestral search was completed. This search involved screening the titles and reviewing the full text of the references from the included articles. The ancestral search identified an additional 4 articles to be included in the scoping review. A total of 18 articles (14 from the primary search + 4 from the ancestral search) were identified to be included in the scoping review.

Search Calibration and Reliability

To calibrate the eligibility criteria, a random sample of 20 articles were independently screened by the primary author and a secondary reviewer (graduate student). The reviewers independently identified the articles that should be included and excluded based on the defined inclusionary and exclusionary criteria and obtained 90% agreement. After a discussion about the disagreements, the reviewers we able to clarify eligibility criteria and agree 100% on the studies to include. The primary reviewer completed the rest of the screening phase independently.

2.2.4 Stage 4: Charting the Data

Once the reviewers reached 90% agreement on study selection, data was extracted from the studies and were charted in a tabular format. The table includes the following extracted data from each of the studies: (*1) Study (author(s)/year of publication), (2) study design, (3) # of participants, (4) participant age range, (5) participant language level, (6) intervention type, (7) Technology/no technology, (8) target of intervention (9) response mode of communication, (10) visual stimuli used, (11) number of words taught, (12) number of words learned, (13) number of sessions, (14) words learned/per session, and (15) rate of learning* (See Results section to view the data tables). The data to be extracted and included in the table varied from the preregistered plan. Changes were made to the data tables once studies were identified and I saw the need to align study information and group results. Specifically, outcome and outcome measures were operationalized and were replaced with number of words taught, number of words learning, number of sessions, words learned/session and rate of learning. ASD severity was left off due to lack of reported information from the majority of studies (<20%). Technology/no technology and response mode of communication were added as variables to better describe intervention characteristics to answer study question 3.

Information such as the *year of publication, study design, number of participants,* and *participant age range* were taken directly from the article and stated verbatim in the results tables. Other data (i.e. *participant language level, intervention type, target of intervention, visual stimuli, number of words taught, number of words learned, number of sessions, number or words learned per session, and rate of learning*) were coded according to the specifications that I predetermined to align terminology between studies to better allow for comparisons and groupings across studies.

As seen in Table 3, *Participant language level* was coded as either nonverbal, minimally verbal, emerging verbal or verbal. Study descriptions were used to determine which category or ranges of categories the participants fell in. Participants who were described as mute, with no functional language or only able to imitate were coded as nonverbal. Those described as having 1-20 expressive words, verbally, or using only 1-word utterances were coded as minimally verbal. Participants were coded as emerging verbal if they were described as using more than 20 words expressively or spoke in phrases of 3-4 words. Participants were coded as average verbal if they were described as having no expressive language deficits or scored in the average range on a standardized language assessment.

Table 3. Participant Language Level Descriptions

Language Level	Description
Nonverbal	Mute; no functional language; imitation only
Minimally verbal	1-20 expressive words, verbally; 1-word utterances
Emerging verbal	>20 words expressively, speaks in 3-4-word phrases
Average verbal	No expressive language deficits, average score on standardized assessment

Intervention types were coded as either clinician directed, client-centered or hybrid approaches. Studies that were described as following a child's lead and responding to the items that a child is interested in were coded as child-centered approaches. Studies that involved a drill set predetermined by the clinician or a technology program were described as clinician directed. All other studies were coded as hybrid approaches, where a combination of client-centered and clinician directed approaches were used. Additionally, studies were coded as AAC or non-AAC and technology-based or non-technology-based. I made a posteriori decision to include AAC and technology due to the variability found in the studies included in this review as well as potential differences between visual stimuli selected for use with technology or AAC (e.g. objects cannot be used on a device/computer). Studies that were coded as using AAC involved the child participant using AAC (low or high tech) as their mode of communication. Non-AAC studies involved the child participant using a mode other than ACC to communicate (e.g. verbal, sign). Interventions that were coded as technology-based included studies that incorporated a tablet or computer as either a part of the intervention (e.g. a computer game or app) or included a high tech AAC device (e.g. a speech generating device) as the mode of communication.

The *target of intervention* was coded as either receptive or expressive labeling. All studies were required to be a vocabulary (labeling) intervention in order to be included, but some studies referred to labeling as word learning, tacts/tacting, receptive or expressive identification or discrimination. Studies that targeted a receptive response (e.g. pointing, touching, clicking) were coded as receptive interventions. While, studies that targeted an expressive response (e.g. verbal production, touching icon on an AAC device, giving a PECS symbol) were coded as expressive interventions.

Visual stimuli were coded as either line-drawings, photographs or objects. Stimuli were coded as line-drawings if they were specifically called line-drawings, described as Boardmaker™, Picture Communication Symbols (PCS), Board builder or writing with symbols. Stimuli were coded as photographs or objects if they specifically described the images as photographs or objects. Some stimuli were coded after viewing the images/stimuli based on the description of a book, curriculum or assessment that I could access. Studies were not included if the description of the visual stimuli was not sufficient enough to code as one of these categories.

The *number words taught* was extracted from text reported by each study. In the case where there was a range of number of words taught, an average was taken for each study.

The *number of words learned* was extracted from tables, graphs or text reported by each study. In the case where there was a range of number of words learned, an average was taken for each study. For example, in a study with 2 participants, if one child learned 6 words and another child learned 10 words, the average of 8 words was reported for the study. In some situations, the number of words learned was not clearly reported. For example, percent correct responding for a given word was provided across sessions with no criteria regarding whether or not the word was learned. In order to obtain a number of words learned for studies that did not report words learned, graphs were visually inspected to determine if accuracy for given words or sets of words was consistently at or about 70% accuracy, a criterion that is commonly used clinically for mastering an objective. For instance, if performance on a target was above 70% accuracy and a clear change from baseline it was considered learned, while a target that was at or below 70% accuracy or demonstrated no clear change from baseline was not considered learned.

The *number of sessions* was extracted from tables, graphs or text reported by each study, similar to the number of words learned. In the case where there was a range of number of sessions to mastery, an average was taken for each study. Additionally, in single-case design studies where a baseline phase was used, only the intervention sessions were counted in this total. So, if there were 5 baseline sessions out of a total of 29 study session, only 24 sessions were counted.

The *number of words learned per session* was calculated for each study based on the number of sessions completed and the number of total words learned. The number of words learned was divided by the number of sessions competed to get the average number of words learned per session for each study. The rate of learning was then computed to align the results of each study to allow for comparison between studies.

Rate of learning was calculated for each study by dividing the number of sessions completed by the number of total words learned, giving the average number of words learned per session. The number of sessions and total number of words was extracted from tables, graphs or text reported by each study. Once rate of learning was calculated, studies were coded as having low, average or high rate of learning (See Table 4). Average was defined by the average range as calculated from the included studies within 0.5 standard deviation from the calculated mean (0.31-1.59). Anything below the average range was considered a low rate of learning and anything above the average range was considered a high rate of learning.

Table 4. Rate of learning classifications with ranges

	Low	Average	High
Rate of learning range (average words learned per session)	< 0.31	0.31-1.59	> 1.59

Search Calibration and Reliability

Using a random sample of five included studies, the pre-specified data abstraction plan was checked for calibration between the primary author and secondary reviewer (graduate student). The primary author and secondary reviewer reached 75% agreement after one round of calibration. The primary author determined that the disagreements were largely due to lack of specificity in the coding manual. The manual was updated to add clarity and subsequently, 100% agreement was achieved. Once calibration was achieved, the primary reviewer completed the charting and data abstraction through the remainder of the articles.

Critical/Quality Appraisal

Methodological quality appraisal or risk of bias of the included articles was not conducted due to the nature of the scoping review. This approach is consistent with scoping reviews of clinical topics (Arskey & O'Malley, 2005).

2.2.5 Stage 5: Collating, Summarizing and Reporting the Results

A main results table was created with all extracted data from each study together to show the range of studies and information extracted as a part of this scoping review. From this table, gaps in the literature were identified, as well as areas for future research and systematic reviews. The review findings show the scope of the current evidence for visual stimuli selection across vocabulary interventions for children with ASD.

Additionally, specific results tables were created to answer each of the study questions (1-3). To answer each of the study questions, data were sorted and inspected for trends and number of studies that meet specific criteria (e.g. number of studies that demonstrate a quick rate of learning).

To answer study question 1 (Does visual stimuli selection in vocabulary intervention impact outcomes in children with ASD? If so, how?), a table was developed with the key information necessary to answer this question (e.g. visual stimuli, rate of learning, etc.). Within the table, studies were sorted by visual stimuli type and then by rate of learning.

To answer question 2 (Does the relationship between visual stimuli selection and language outcomes vary by the child's pre-treatment language skill?), a table was created with the key information needed (e.g. participant language skills, rate of learning, visual stimuli, etc.). The chart was organized by participant characteristics (i.e. language level, age) to allow for visual inspection of the data and to look for trends to answer the study question.

To best answer question 3 (Does intervention type have an effect on type of stimuli selection?), tables (Table 13 & Table 14) were created including the key information (e.g. intervention type, visual stimuli, etc.) and were organized by intervention type and then stimuli type. The outcomes of the studies included in each stimuli type were compared to look for consistency of findings for the stimuli type. Patterns for each question were then described (See Results section below).

Chapter III: Results

3.1 Overview of Results

Error! Not a valid bookmark self-reference. provides a complete description of all of the extracted data coded for each study included in this scoping review. This table shows that the range of year of publication for the included studies is 1981-2019 (*Median=2011*). Throughout the results, median is often reported due to the nature of the data not having a normal distribution. The author believes that in the situations where median is reported, this is the best representation of the average, as compared to the mean.

3.1.1. Overview of Participant Characteristics

Participant characteristics coded included the number of participants, the age range of the participants and the language level of the participants. The number of participants in each study ranged from 1-28 (*Median=2*). The participants age ranged from 2 years to 20 years and 10 months (*Median=4 years*). Participant language level was coded as nonverbal, minimally verbal, emerging verbal or average verbal. It should be noted that some of the studies included participants with a range of verbal abilities, therefore these studies were included in the total number of studies included in multiple language level categories (e.g. if the study included minimally verbal to emerging verbal, the study was counted twice, once in each language category). Five studies included participants who were nonverbal, 14 studies included minimally verbal participants, 5 studies included emerging verbal participants and 1 study included students with average verbal skills. While there was a range of participants in the included studies, the majority of included studies used single case design and included young children with minimal verbal skills.

Table 5. Overview of extracted data coded for the studies included in this scoping review

Study	Study design	# of part.	Part. age (yrs)	Part. Lang. level	Intervention type	Tech / no tech	Target of intervention	response mode of comm	Visual stimuli used	# words taught	# words learned	# session	words learned / session	rate of learning
Berkowitz (1990)	SSD-simultaneous treatment	4	12;3 - 20;10	Non-verbal	Clinician directed	No	receptive labeling	pointing	line-drawings	6	6	150	0.04	low
Carr (1981)	SSD-multipl	6	6-11	Non-verbal	Clinician	No	receptive labeling	touching	objects	24	24	15	1.6	high
Drager et al. (2006)	SSD-multiple baseline across sets	2	4;0-4;5	Minimally verbal	Clinician directed	No	receptive & expressive labeling	pointing	objects and line-drawings	12	receptive=11; expressive=8	32	receptive 0.34; expressive .25	receptive-average; expressive- low
Ganz et al. (2010)	SSD-multi-treatment	1	3	Minimally verbal	Hybrid	No	receptive labeling	giving	objects	8	0	16	0	low
Ganz et al. (2015)	SSD-multiple baseline	1	4	Minimally verbal	Hybrid	Yes	receptive labeling	touching	photographs	3	0	24	0	low
Hetzroni & Ne'eman (2013)	SSD-alternating treatment	4	6	Non-verbal-Emerging verbal	Hybrid	Yes	receptive labeling	clicking	line-drawings	58	20	17	1.18	average
Kagohara et al. (2012)	SSD-multiple probe	2	13-17	Minimally verbal	Clinician directed	Yes	expressive labeling	touching	photographs	30	27	16	1.69	high

Study	Study design	# of part.	Part. age (yrs)	Part. Lang. level	Intervention type	Tech / no tech	Target of intervention	response mode of comm	Visual stimuli used	# words taught	# words learned	# session	words learned / session	rate of learning
Lorah & Karnes (2016)	SSD-multiple baseline	2	3;8-4;0	Minimally verbal	Hybrid	Yes	receptive labeling	touching	photograph s	3	3	6	0.5	average
Lorah, Parnell & Speight (2014)	SSD-multiple baseline	3	3-5	Minimally verbal	Clinician directed	Yes	expressive labeling	touching	objects	4	4	10	0.4	average
Massaro & Bosseler (2006)	SSD-within subjects	5	8-13	Minimally-Emerging verbal	Hybrid	Yes	receptive labeling	clicking	Photographs & line-drawing	24	21	19	1.05	average
McGee et al. (1983)	SSD-multiple-baseline	2	15;10-12;7	Minimally verbal	Hybrid	No	receptive labeling	giving	objects	12	8	22	0.36	average
Novack et al. (2019)	RCT	28	2;6-8;10	Minimally-Average verbal	Clinician directed	Yes	receptive language	touching	photographs & line-drawings	125	50	12	4.17	high
Remington & Clarke (1983)	SSD-alternating treatment	2	10-15	Non-verbal-Minimally verbal	Clinician directed	No	expressive labeling	signing	line-drawings	10	10	30	0.33	average
Sepulaveda (2016)	SSD-within subjects multiple treatments	6	2-5	Non-verbal - Emerging verbal	Clinician directed	No	receptive labeling	pointing	photographs	18	18	82	0.22	low

Study	Study design	# of part.	Part. age (yrs)	Part. Lang. level	Intervention type	Tech / no tech	Target of intervention	response mode of comm	Visual stimuli used	# words taught	# words learned	# session	words learned / session	rate of learning
Simpson, Keen & Lamb (2015)	crossover design	22	3.5-8	Minimally verbal	Hybrid	Yes	receptive labeling	clicking	line-drawings	8	4	19	0.21	low
Van der Meer et al. (2015)	SSD	1	10;2	Minimally verbal	Clinician directed	Yes	expressive labeling	touching	Photographs	12	10	7	1.43	high
Wherry (1983)	SSD-simultaneous treatment	1	5	Minimally verbal	Clinician directed	No	receptive labeling	touching	objects	27	3	18	0.17	low
Wolfe, Blankenship & Rispoli (2018)	SSD-multiple probe across participants	2	4-7	Emerging verbal	Clinician directed	No	expressive labeling	pointing	objects	4	4	13	0.31	average

3.1.2. Overview of Intervention Characteristics

Intervention characteristics coded included the intervention type, use of technology, use intervention target (i.e. receptive or expressive labeling), visual stimuli used and the mode of communication. The intervention types were coded as clinician directed, hybrid or client-centered. 11 studies included interventions that were considered clinician directed, 7 studies included interventions that were considered hybrid, and no studies included interventions that were considered client-centered. Additionally, the interventions used in the studies were coded for using technology or no technology. Nine studies were found to include technology, while nine were found not to include technology as a part of the intervention. Intervention targets were coded as either receptive or expressive labeling. 6 of the included studies targeted expressive labeling, while 13 targeted receptive labeling. One of the studies included both receptive and expressive labeling. The response mode of communication was coded as pointing, touching, giving, clicking, or signing. Four studies were coded as using pointing as a response mode, 8 were coded as touching, 2 were coded as giving, 3 were coded as clicking and 1 was coded as signing. The visual stimuli used during the interventions were coded as line-drawings, photographs or objects. 7 studies were coded as using line-drawings, 7 were coded as using photographs, and 7 were coded as using objects. Of the included studies, clinician directed and hybrid interventions were used, with half incorporating technology. More studies targeted receptive labeling over expressive labeling and a variety of communication response modes were used, with the exception of verbal responding. Visual stimuli were equally split between objects, photographs and line-drawings.

3.1.3 Overview of Outcome Measures

Intervention outcomes were tracked by calculating the rate of learning from the number of words learned and the number of sessions conducted. The number of words taught during the interventions was also collected and were found to range from 3-150 words (*Median=12*). The number of words learned was also collected and was found to range from 0-150 (*Median=8*). The number of intervention sessions conducted as a part of these studies was tracked and found to range from 3-250 (*Median=18*). The words learned per session was calculated and the range was found to be between 0 and 4.17 (*Median=0.38, Mean=0.84, SD=1.06*) words per session. Finally, the rate of learning was coded for each study as being either low, average or high rate of learning. 8 studies were coded as having a low rate of learning, 7 studies were coded as having an average rate of learning and 3 studies were coded as having a high rate of learning. Most studies had either low or average rate of learning.

3.2 Answering the research questions

To answer the three identified research questions, additional tables were created to include only the necessary data from each study. These tables were appropriately sorted to aid in answering the specific research question. Below, you will find a section addressing each research question with the associated table and additional graphs.

3.3 Research question 1

The first identified research question was, *Does visual stimuli selection in language intervention impact outcomes in children with ASD? If so, how?* To answer this question, only relevant information (i.e. visual stimuli used, words learned per session, and rate of learning) were included in the tables. To further investigate other potentially relevant factors, participant age, and target of intervention were also included. Additionally, three separate tables were created to investigate outcomes by stimulus type (i.e. line-drawings, photographs & objects).

There were 7 studies associated with each type of visual stimuli. Some studies included more than one type. When these occurred, the study was included in all relevant tables. When multiple visual stimulus types were used in a single study, the stimuli were either alternated as a part of a single case design or were used interchangeably throughout the entire treatment. Table 6, Table 7, and Table 8, below, provide the relevant extracted data for line-drawings, photographs and objects, respectively.

Table 6. Studies that used line-drawings organized by rate of learning.

Participant age	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
12;3-20;10	receptive labeling	pointing	line-drawings	.04	low
3.5-8	receptive labeling	clicking	line-drawings	0.21	low
10-15	expressive labeling	signing	line-drawings	0.33	average
4;0-4;5	receptive labeling	pointing	objects and line-drawings	0.34	average
8-13	receptive labeling	clicking	photographs and line-drawings	1.05	average
6	receptive labeling	clicking	line-drawings	1.18	average
2;6-8;11	receptive labeling	touching	photographs & line-drawings	4.17	high

Table 7shows that out of the 7 studies that included line-drawings, 2 had low rate of learning, 4 had average rate of learning and 1 had a high rate of learning.

Table 7 Studies that used photographs organized by rate of learning.

Participant age	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
4	receptive labeling	touching	photographs	0	low
2-5	receptive labeling	pointing	photographs	0.22	low
3;8-4;0	receptive labeling	touch	photographs	0.5	average
8-13	receptive labeling	clicking	photographs & line-drawings	1.05	average
10;2	expressive labeling	touching	Photographs	1.43	high
13-17	expressive labeling	touching	photographs	1.69	high
2;6-8;11	receptive labeling	touching	photographs & line-drawings	4.17	high

Table 8 shows that out of the 7 studies that included photographs, 2 had a low rate of learning, 2 had an average rate of learning, and 3 had a high rate of learning.

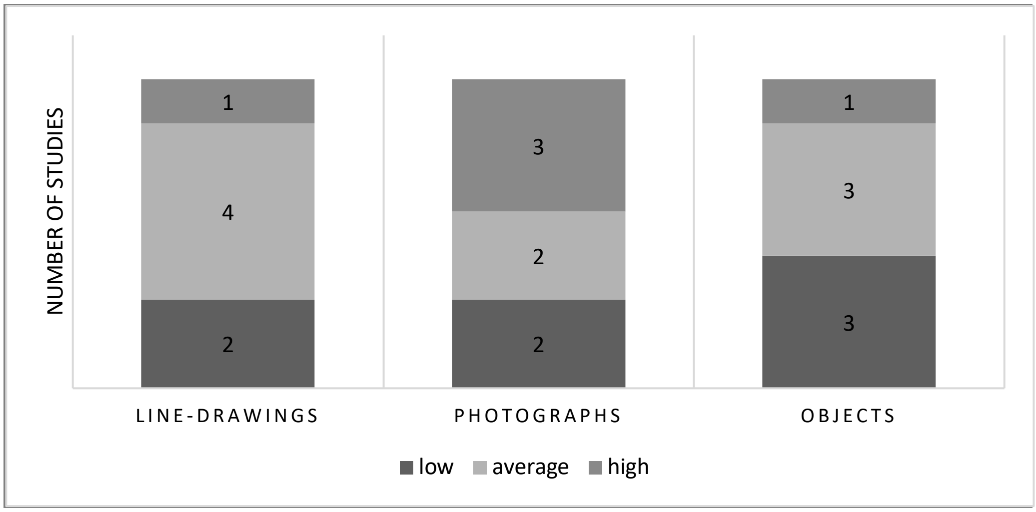
Table 8 Studies that used objects organized by rate of learning.

Participant age	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
3	receptive labeling	giving	objects	0	low
5	receptive labeling	touching	objects	0.17	low
4;0-4;5	receptive & expressive labeling	pointing	receptive: objects & line-drawings; expressive: objects	receptive 0.34; expressive .25 (.30)	receptive-average expressive-low (low)
4-7	expressive labeling	pointing	objects	0.31	average
15;10-12;7	receptive labeling	giving	objects	0.36	average
3-5	expressive labeling	touching	objects	0.4	average
6-11	receptive labeling	touching	objects	1.6	high

Table 9 shows that out of the 7 studies that included objects, 3 had a low rate of learning, 3 had an average rate of learning and 1 had a high rate of learning.

Tables 4, 5, and 6 showed that rate of learning was relatively variable within each stimulus type. Figure 2 provides a summary of the data across stimulus types. Here, you can see the predominate type of learning: average rate of learning for line drawings, high rate of learning for photographs, average and low learning for objects. Although there was large variability within stimulus type, there is a small trend for photographs to potentially lead to better learning than line drawings, which may promote better learning than objects. However, given the large variability, it is important to consider how other characteristics may have impacted learning, as posed in research questions 2 and 3 (see below).

Figure 2. Breakdown of # of studies for each stimulus type that demonstrated low, average or high rate of learning.



3.4 Research question 2

The second identified research question was, *Does the relationship between stimuli selection and language outcomes vary by the child's pre-treatment language skills?* To answer this question, only relevant information (i.e. participant language level, visual stimuli used, words learned per session, and rate of learning) were included in the tables. To further investigate other potentially relevant factors, participant age, and target of intervention were also included. Additionally, four separate tables were created to investigate outcomes participant language level (i.e. nonverbal, minimally verbal, emerging verbal & average verbal). 7 Studies included children who are nonverbal, 13 studies included children who are minimally verbal, 7 studies included children who have emerging verbal skills and one study included children with average verbal skills. Some studies included children with a range of verbal abilities, therefore some studies are repeated in multiple tables corresponding to the verbal abilities included (e.g. nonverbal-emerging verbal was included in the nonverbal, minimally verbal and emerging verbal tables). Table 9, Table 10, Table 11, and Table 12, below, provide the relevant extracted data for nonverbal, minimally verbal, emerging verbal and average verbal, respectively.

Table 9. Studies that included children who are nonverbal, organized by stimulus type and rate of learning.

Participant language level	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
nonverbal	receptive labeling	pointing	line-drawings	0.04	low
nonverbal	expressive labeling	sign	line-drawings	0.33	average
Nonverbal-emerging verbal	receptive labeling	click symbol	line-drawings	1.18	average
Nonverbal-emerging verbal	receptive labeling	point	photographs	0.22	low
nonverbal	receptive labeling	touch	photographs	0.5	average
nonverbal	receptive labeling	touch	objects	1.6	high

Table 9 shows that of the 7 studies that included children who are nonverbal, 3 used line-drawings, 2 used photographs and 1 used objects. One of the studies that used line-drawings had a low rate of learning, while 2 had an average rate of learning. One of the studies that used photographs had a low rate of learning and one had an average rate of learning. It's interesting to note that the best learning occurred in the one study that used objects. This suggests that objects may be a good choice for children who are non-verbal. However, further research is needed to strengthen and confirm this claim.

Table 10. Studies that included children who are minimally verbal, organized by stimulus type and rate of learning.

Participant language level	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
Minimally verbal	receptive labeling	clicking	line-drawings	0.21	low
Nonverbal-emerging verbal	receptive labeling	clicking	line-drawings	1.18	average
Minimally verbal	receptive & expressive labeling	pointing	line-drawings	receptive-0.34; expressive-0.25 (0.30)	receptive-average; expressive-low (low)
Minimally verbal-emerging verbal	receptive labeling	clicking	line-drawings	1.05	average
Minimally verbal-	receptive labeling	touching	line-drawings	4.17	high

average verbal					
Minimally verbal-emerging verbal	receptive labeling	clicking	photographs	1.05	average
Minimally verbal-average verbal	receptive labeling	touching	photographs	4.17	high
Minimally verbal	receptive labeling	touching	photographs	0	low
Nonverbal-emerging verbal	receptive labeling	pointing	photographs	0.22	low
Minimally verbal	expressive labeling	touching	Photographs	1.43	high
Minimally verbal	expressive labeling	touching	photographs	1.69	high
Minimally verbal	receptive labeling	giving	objects	0	low
Minimally verbal	receptive labeling	touching	objects	0.17	low
Minimally verbal	receptive & expressive labeling	pointing	objects	receptive-0.34; expressive-0.25 (0.30)	receptive-average; expressive-low (low)
Minimally verbal	receptive labeling	giving	objects	0.36	average
Minimally verbal	expressive labeling	touching	objects	0.4	average

Table 10 shows that 13 studies included children who were minimally verbal. Of the 13 studies, 5 line-drawings, 6 used photographs and 5 used objects (note: 3 of the studies included two types of stimuli). Of the studies that included line-drawings, 2 had a low rate of learning, 2 had an average rate of learning and 1 had a high rate of learning. Of the studies that included photographs, 2 had a low rate of learning, 1 had an average rate of learning, and 3 had a high rate of learning. Of the studies that included objects, 3 had a low rate of learning, 2 had an average rate of learning and no studies had a high rate of learning. Again, the results for children who are minimally verbal are mixed, but more studies with photographs had a high rate of learning than the other stimuli types, suggesting that photographs may promote word learning in children who are minimally verbal.

Table 11. Studies that included children with emerging verbal skills, organized by stimulus type and rate of learning.

Participant language level	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
minimally verbal-emerging verbal	receptive labeling	clicking	line-drawings	1.05	average
nonverbal-emerging verbal	receptive labeling	clicking	line-drawings	1.18	average
minimally verbal-average verbal	receptive labeling	touching	line-drawings	4.17	high
nonverbal-emerging verbal	receptive labeling	pointing	photographs	0.22	low
minimally verbal-emerging verbal	receptive labeling	clicking	photographs	1.05	average
minimally verbal-average verbal	receptive labeling	touching	photographs	4.17	high
Emerging verbal	expressive labeling	pointing	objects	0.31	average

Table 11 shows that 7 studies included children who are at the emerging verbal level. Of the 7 studies, 3 included line-drawings, 3 included photographs and 1 included objects. Of the studies that included line-drawings, 2 had an average rate of learning and one had a high rate of learning. Of the studies that included photographs, one had a low rate of learning, one had an average rate of learning and one had a high rate of learning. The study that included objects had an average rate of learning. Again, the results for children with emerging verbal skills are mixed, but on average, the rate of learning appears higher with line-drawings, suggesting that line-drawings may be the optimal choice for children with emerging verbal abilities.

Table 12. Study that included children with average verbal skills, organized by visual stimulus type and rate of learning.

Participant language level	Target of intervention	response mode of comm	Visual stimuli used	words learned/session	rate of learning
minimally verbal-average verbal	receptive labeling	touching	photograph & line-drawings	4.17	high

Table 12 shows that there was only one study that included children with average verbal skills. This study used both line-drawings and photographs and had a high rate of learning, which is expected given the verbal abilities of the participants, but it is not possible to draw conclusions about how stimuli impacted learning with only one study.

Figure 3. Average rate of learning across stimuli types for each of the 4 participant language levels.

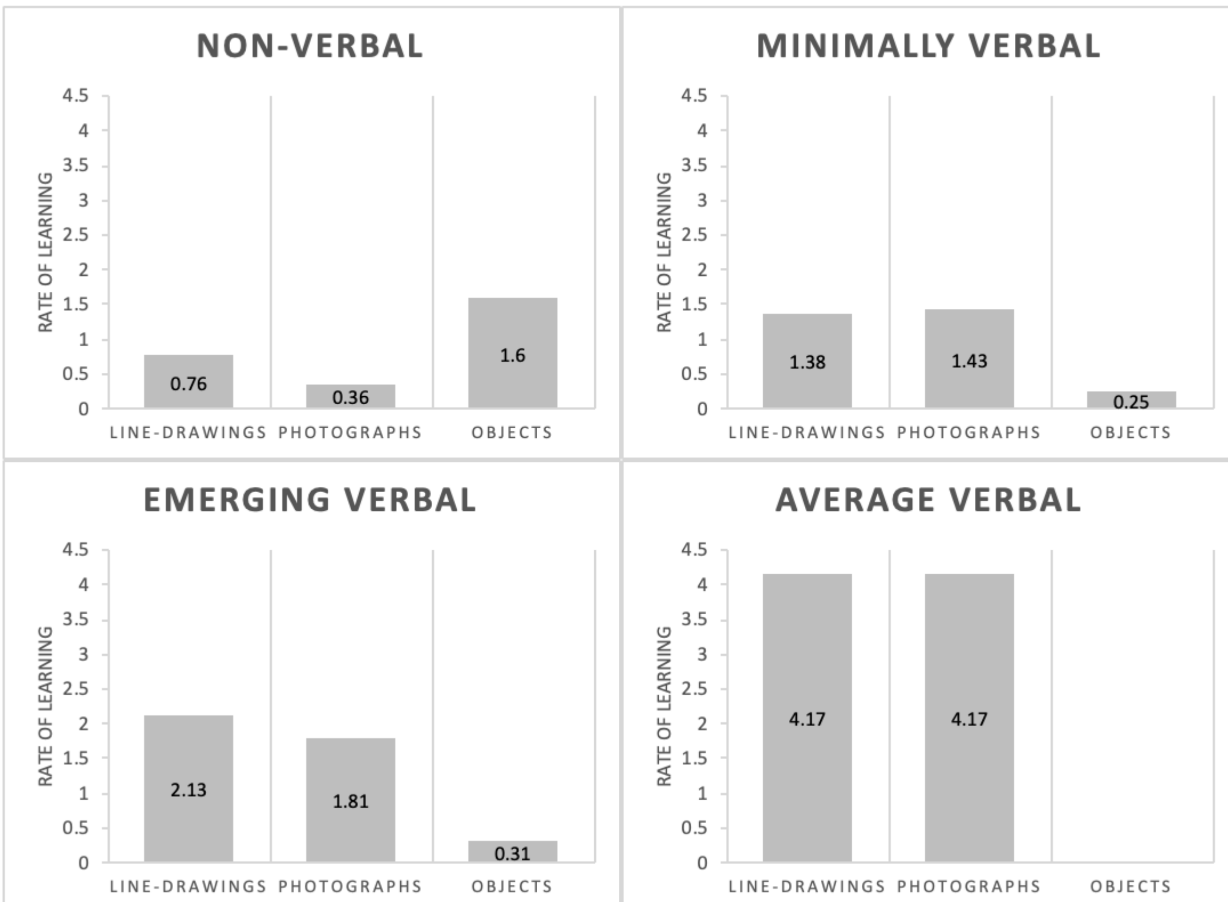


Figure 3 provides a summary of the average rate of learning across verbal ability and stimulus types. As shown in Figure 3, the average rate of learning for children who are nonverbal was 0.76 for line drawings, 0.36 for photographs, and 1.6 for objects. This suggests that objects may promote a better rate of word learning for nonverbal children, although this is a tentative hypothesis based on only one study and warrants replication. Also shown in Figure 3, the average rate of learning for children who are minimally verbal was 1.38 for line drawings, 1.43 for photographs, and 0.25 for objects. This suggests that photographs or line-drawings may promote a better rate of word learning for children who are minimally verbal. Additionally, Figure 3 shows the average rate of learning for children who have emerging verbal skills was 2.13 for line drawings, 1.81 for photographs, and 0.31 for objects. This suggests that line-drawings may promote a better rate of word learning for children with emerging verbal skills. Only one study included children with average verbal skills, with an average rate of learning of 4.17. Again, due to limited evidence from one study, no conclusions were drawn regarding children with average language skill's performance with visual stimuli. However, it appears that as expected, children with average verbal skills demonstrate a higher rate of learning than children with lower verbal abilities.

3.5 Research question 3

The third identified research question was, *Does intervention type have an effect on type of stimuli selection?* To answer this question, only relevant information (i.e. intervention type, technology used, target of intervention and visual stimuli used) were included in the tables. Additionally, three separate tables were created to investigate stimuli selection by intervention type (i.e. client-centered, hybrid and clinician directed). Table 13 and Table 14, below, provide the relevant extracted data for studies that included hybrid and clinician directed interventions. As seen in Tables 13 and 14, 7 studies included hybrid interventions and 11 included clinician directed interventions. None of the included studies used a client-centered intervention, therefore there is no table for client-centered interventions. Some of the studies included both receptive and expressive labeling as well as more than one type of visual stimuli, therefore, studies are repeated in the tables below to be included with each intervention target and visual stimuli type used within the study.

Table 13. Studies that included hybrid interventions, organized by stimulus type.

Intervention type	Tech/ no tech	Target of intervention	response mode of comm	Visual stimuli used
Hybrid	Yes	receptive labeling	clicking	line-drawings
Hybrid	Yes	receptive labeling	clicking	line-drawings
Hybrid	Yes	receptive labeling	clicking	photographs and line-drawings
Hybrid	Yes	receptive labeling	touching	photographs
Hybrid	Yes	receptive labeling	touching	photographs
Hybrid	No	receptive labeling	giving	objects
Hybrid	No	receptive labeling	giving	objects

Table 13 shows that 7 studies included hybrid interventions. Out of the 7 studies, all of which targeted receptive labeling, 3 included line-drawings, 3 included photographs and 2 included objects. Of these interventions, 5 included technology while 2 did not. The 2 studies that did not use technology, used objects as the visual stimulus. The studies that included technology used either line-drawings or photographs. These results indicate that visual stimuli selection is mixed across hybrid interventions, but that objects are not used during interventions that incorporate technology.

Table 14. Studies that included clinician directed interventions, organized by stimulus type.

Intervention type	Tech/ no tech	Target of intervention	response mode of comm	Visual stimuli used
Clinician directed	No	expressive labeling	signing	line-drawings
Clinician directed	No	receptive labeling	pointing	line-drawings
Clinician directed	No	receptive labeling	pointing	line-drawings
Clinician directed	Yes	receptive language	touching	line-drawings
Clinician directed	Yes	expressive labeling	touching	photographs
Clinician directed	No	receptive labeling	pointing	photographs
Clinician directed	Yes	expressive labeling	touching	Photographs
Clinician directed	Yes	receptive language	touching	photographs

Clinician directed	No	receptive labeling	pointing	objects
Clinician directed	Yes	expressive labeling	touching	objects
Clinician directed	No	receptive labeling	touching	objects
Clinician directed	No	receptive labeling	touching	objects
Clinician directed	No	expressive labeling	pointing	objects
Clinician directed	No	expressive labeling	pointing	objects

Table 14 shows that 11 studies included clinician directed interventions. Out of the 11 studies, 4 included line-drawings, 4 included photographs and 5 included objects. Additionally, 5 studies included technology, while 9 studies did not. Out of the studies that included technology, 3 used photographs, 1 used line-drawings and 1 used objects. Out of the studies that did not use technology, 3 used line-drawings, 1 used photographs and 5 used objects. Out of the studies that used clinician directed interventions, 6 targeted expressive labeling, while 8 targeted receptive labeling. Of the studies that targeted expressive labeling, 1 used line-drawings, 2 used photographs and 3 used objects. Of the studies that targeted receptive labeling, 3 used line-drawings, 2 used photographs and 3 used objects. These results indicate that, similar to the hybrid interventions, visual stimuli selection is mixed across clinician directed interventions.

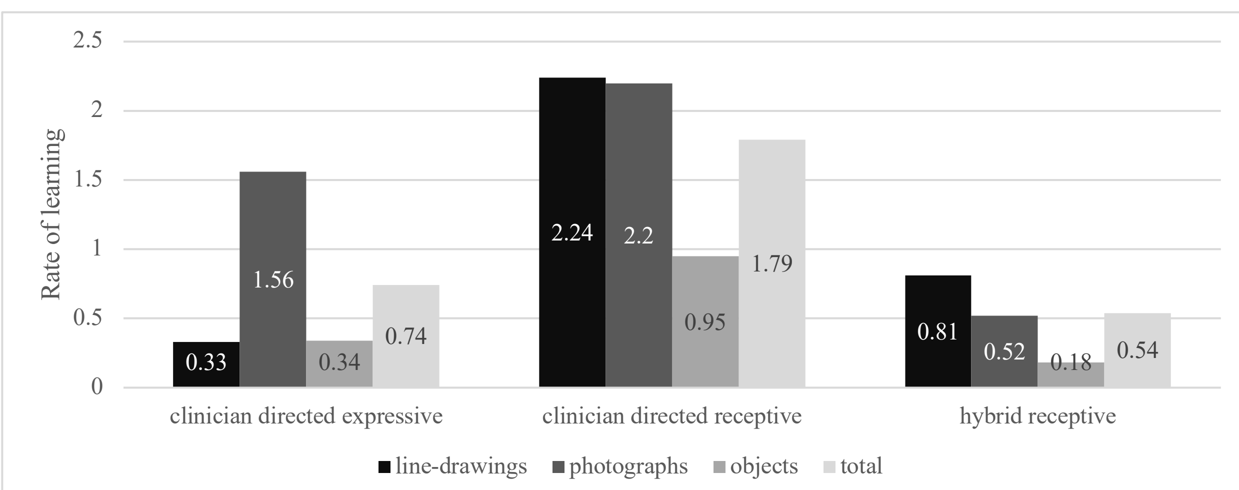


Figure 4. Average rate of learning for each intervention type (i.e. hybrid, clinician directed) that used each stimulus type (i.e. line-drawings, photographs, objects) broken down by target of intervention (i.e. expressive and receptive

labeling).

To further investigate the relationship between visual stimuli and intervention types, the intervention types were sorted by the intervention targets (i.e. expressive vs. receptive labeling) and average rate of learning across each group. Figure 4 shows the average rate of learning by stimulus type for each intervention group coded. Beginning with general learning patterns across the different intervention types, the lightest bar shows the overall learning (total) for the type of intervention. Here, clinician directed receptive interventions resulted in a higher rate of learning ($M = 1.79$) than clinician directed expressive ($M = 0.74$), which was higher than hybrid receptive ($M = 0.54$). As shown in Figure 4, Within each type of intervention, the influence of stimulus type on learning varied. Beginning with the clinician directed receptive interventions, studies that targeted receptive labeling and used line-drawings ($M = 2.24$) or photographs ($M = 2.20$) demonstrated higher rates of learning than those that included objects ($M = 0.95$). Turning to the clinician directed expressive, studies that included photographs resulted in a higher rate of learning ($M = 1.56$) than studies that included objects ($M = 0.34$) or line-drawings ($M = 0.33$). Finally, in the hybrid receptive interventions ($M = 0.54$), studies that included line-drawings ($M = 0.81$) demonstrated a higher rate of learning than those that included photographs ($M = 0.52$) or objects ($M = 0.18$). Taken together, the different stimuli facilitated learning across different interventions: line-drawings and photographs seemed to work best in clinician directed receptive and photographs seemed to work best in clinician directed expressive. There was no clear stimulus advantage for hybrid receptive.

Additionally, to investigate the relationship between visual stimuli and intervention types even further, the intervention types were sorted by technology vs. no-technology and average rate of learning across each group. Figure 5 shows the average rate of learning by visual stimuli type for each intervention type, broken down by use of technology. Beginning with general learning patterns across the different intervention types, the lightest bar shows the overall learning (total) for the type of intervention. Here, clinician directed interventions that included technology resulted in a higher rate of learning (M = 2.37) than clinician directed interventions that did not include technology (M = 0.48) as well as hybrid interventions that included technology (M = 0.67) and did not include technology (M = 0.18). Overall, across both hybrid and clinician directed interventions, studies that included technology demonstrated higher rates of learning than those that did not include technology. Additionally, clinician directed interventions that included technology appear to be better than all of the other interventions, which show low rates of learning with no real difference between stimuli. Focusing on the clinician directed interventions that included technology, studies that included line-drawings (*M = 4.17*) demonstrated a higher rate of learning than photographs (*M = 2.43*) or objects (*M = 0.4*). Overall, clinician directed interventions that incorporate technology and use line-drawings may best facilitate word learning in children with ASD.

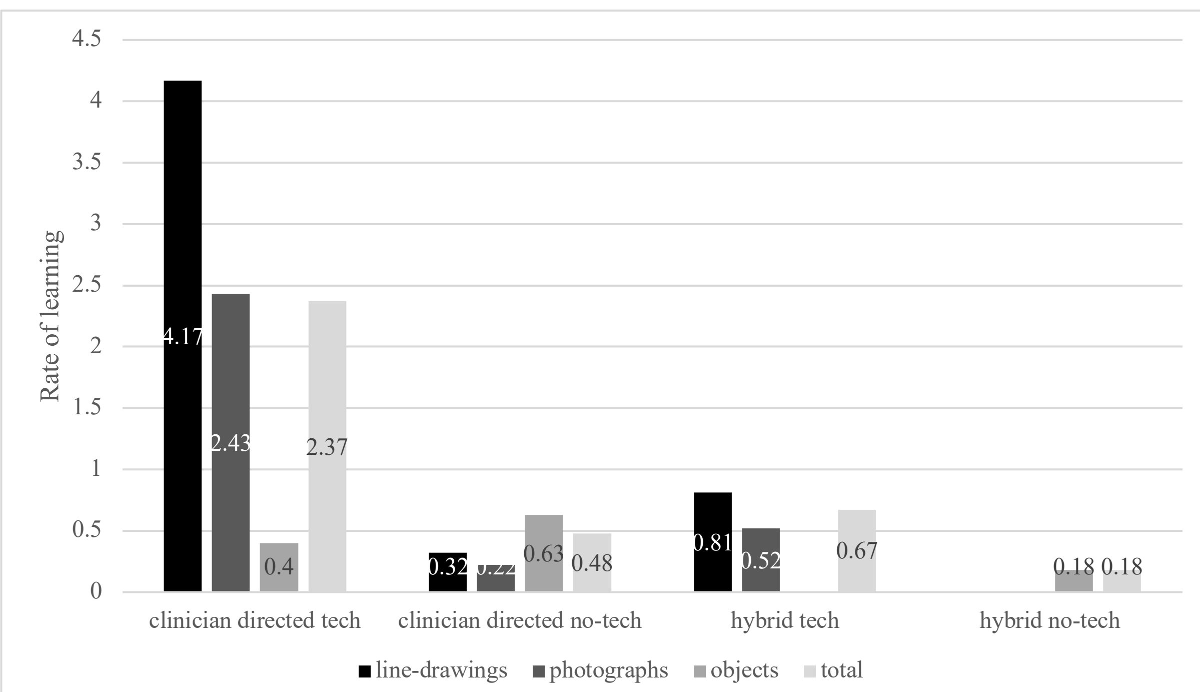


Figure 5. Average rate of learning for each intervention type (i.e. hybrid, clinician directed) that used each stimulus

type (i.e. line-drawings, photographs, objects) broken down by technology vs. no-technology.

Chapter IV: Discussion and conclusions

The aim of this study was to synthesize the scope of what is known about visual stimuli use during vocabulary interventions for children with ASD, to investigate how visual stimuli selection may impact intervention outcomes, and to determine if child characteristics (i.e. child's language skills, ASD severity) impact the types of stimuli used and/or intervention outcomes. The results of this scoping review indicate that there is great variability in visual stimuli selection during vocabulary interventions with children with ASD. However, preliminary patterns were identified in how stimuli selection may influence performance depending on the child's language abilities as well as how stimuli selection relates to intervention characteristics. These preliminary observations serve as a good foundation for future empirical research. Additionally, study limitations, considerations for clinical implementation as well considerations for future research are discussed.

4.1 Does visual stimulus selection impact vocabulary intervention outcomes?

The type of visual stimuli used in the studies included in this scoping review were equally distributed between line-drawings, photographs and objects, with 7 studies included each group. These results indicate that there is potentially no preference for choosing one stimulus type over the other when targeting vocabulary with children with ASD. To look at this further and to determine if one stimulus type produced greater vocabulary outcomes than the other, rate of learning (outcomes) were tracked for each study.

Through this review, I found mixed results for each stimulus type (i.e. line-drawings, photographs, objects), with each type having studies with all levels of *rate of learning* (i.e. low, average, high; see Figure 2 for more details). However, high rate of learning was the most prevalent rate of learning for photographs. Whereas, average rate of learning was the most prevalent rate of learning for studies that included line-drawings and low rate of learning was the most prevalent rate of learning for studies that included objects. Therefore, when considering the result irrespective of child and intervention characteristics, the findings of this review indicate that the use of photographs, when teaching word labels to children with ASD, is slightly preferred over line-drawings. Additionally, the use of line-drawings facilitate word learning to a greater extent than objects in the studies included in this review. These results suggest that visual stimulus selection may play a role in vocabulary intervention outcomes. To further investigate these findings, review results were tracked by child characteristics (i.e. language level).

4.2 Does the relationship between visual stimulus selection and intervention outcomes vary by child characteristics?

There were interesting patterns of how the influence of visual stimuli on rate of word learning varied by language level. For children who were nonverbal, objects appeared to be associated with the highest rate of learning. These results differ from the main conclusion of photographs being superior when language level was not taken into consideration. Therefore, for children with ASD who are non-verbal, these findings suggest that objects may be the best option to achieve the highest rate of learning. This finding is consistent with evidence that objects may be easiest for children who rely on iconicity to learn referents due to objects high level of iconicity (Hartley and Allen, 2015a; Mirenda & Locke, 1989). However, this finding should be interpreted with caution due to the small number of studies that included children with ASD who are non-verbal and with only one study finding a high rate of learning.

For children with ASD who are minimally verbal, photographs demonstrated a higher rate of learning than those that included line-drawings or objects. As compared to children with

ASD who are non-verbal, children with ASD who have minimal verbal skills not only do better with photographs, but apparently perform worse with objects. Although it would be expected that as language level increases that children would be more successful with less iconic stimuli (Mirenda & Locke, 1989; Ellis Weismer et al., 2016), it was not expected for the highest iconic stimuli (objects) to be associated with a decrease in rate of learning. When considering visual stimuli for children with ASD and minimal verbal skills, it appears that photographs may be the best option to achieve the highest rate of learning. This finding should also be interpreted with caution due to a small sample of included studies. However, out of the included studies, more included children with minimal verbal skills than any other language level.

For children with emerging verbal skills, both line-drawings and photographs demonstrated a high rate of learning. However, line-drawings appeared to be associated with a slightly higher rate of learning. Therefore, for children with ASD who have emerging verbal skills, line-drawings appear to be slightly superior to the other visual stimuli types. When considering that as children with ASD's language skills become more like their typically developing peers, and are therefore less likely to demonstrate overselectivity or weak central coherence, this result was expected as these children may not require as visually simple or iconic stimuli to learn.

While only 2 studies included in this review involved children with average verbal skills, both of the studies demonstrated a high rate of learning. One study used line-drawings, while the other study used photographs. No studies used objects with this group of children with ASD. While no preferred or optimal visual stimulus type is identified for children with ASD and average verbal skills, it appears that these children demonstrate a high rate of learning with any stimuli used.

Again, the results of this scoping review demonstrate the expected pattern that language level and rate of learning have a positive relationship, in that as language level increases, so does rate of learning (Smith et al., 2007). Additionally, as language level increases, children are able to demonstrate greater success with using less iconic visual stimuli.

When compared to the existing knowledge regarding overselectivity and weak central coherence theory, the results of this study are consistent with the expected patterns that children with ASD and poorer language skills would perform best with more iconic and visually simple stimuli (Ellis Weismer et al., 2016), and that as children with ASD's language develops their visual processing becomes more like typically developing peers (Kern et al., 2006). Additionally, the finding that children with ASD who are nonverbal perform best with objects is consistent with the finding that highly iconic and visually simple visual stimuli would be most appropriate for children with ASD who are nonverbal and most likely have more cognitive delays (Wilkinson & McIlvane, 2002).

4.3 Does intervention type have an impact on visual stimulus selection?

Another purpose of this scoping review was to determine the scope of visual stimuli use for each category of language intervention (i.e. client-centered, hybrid, clinician directed) and determine if stimuli selection varied by intervention type. The results of this review indicate that visual stimuli selection is mixed during vocabulary interventions for children with ASD. Within studies that incorporated hybrid interventions, line-drawings and photographs were used equally as often, with objects closely behind. For studies that included clinician directed interventions, more studies included objects, with line-drawing and photographs closely behind.

In general, more studies included clinician directed interventions than hybrid interventions, with higher levels of learning associated with clinician directed interventions than with hybrid interventions. This result is consistent with previous findings that empirical evidence for the use of hybrid interventions to teach children with ASD is limited (Koul et al, 2001). Similarly, the lack of inclusion of client-centered approaches was expected based on limited positive evidence for use of this approach with children with ASD (Elliot et al., 1991). Additionally, studies targeting vocabulary are difficult to control for when the client is driving the vocabulary being used and the intervention is not prescribed by the clinician.

When the interventions were divided into expressive vs. receptive labeling, results showed that performance was higher for receptive labeling than for expressive labeling, which is consistent with previous findings (McDaniel et al., 2018). Additionally, results indicate that irrespective of participant language level, when using a clinician directed intervention approach to target receptive labeling, both line-drawings and photographs may be associated with greater word learning. However, when using a clinician directed intervention to target expressive language, photographs may promote greater learning. It is unclear why these patterns were found. However, it is expected that clinicians would be more likely to use photographs to teach expressive labeling because the child would most likely be expressing the referent using a line-drawing as a part of an AAC system. Similarly, it is expected that clinicians would be more likely to teach children the receptive labels of items using their expressive symbol system, which again is most likely to be line-drawings but could also be photographs. These are preliminary findings related to the effect of visual stimuli on specific intervention related factors as no other known evidence exists. Further investigations should be conducted to better determine the relationship between intervention types, visual stimuli and word learning by children with ASD.

Another intervention factor of interest was the inclusion of technology. The findings show that the use of technology during interventions positively affects word learning across all intervention types (i.e. clinician directed and hybrid), which is consistent with previous findings that technology may facilitate attention and learning in children with ASD (Moore & Calvert, 2000; Bossler & Massaro, 2003). Furthermore, the results indicate that during clinician directed interventions that include technology, line-drawings may be related to high rate of learning. However, conclusions should not be drawn based on these results due to too few studies included in each group. It is suspected that line-drawings show the highest rate of learning because the study that included line-drawings during a clinician directed, technology-based intervention involved children with emerging verbal skills, who also were found to perform best with this stimuli type, in general.

Interventions have both active and inactive ingredients, with visual stimuli, perhaps, being thought of as inactive ingredients in vocabulary intervention. As this study found, visual stimuli are not specified by the intervention. However, patterns emerged regarding visual stimuli use with interventions that incorporate technology and target receptive labeling. It appears that, as with child language level, specific intervention characteristics may be associated with specific visual stimuli as well as increased rate of learning for children with ASD. Thus, tailoring visual stimuli to a client based on the intervention characteristics as well as their skill profile is recommended. The results of this review suggest that tailoring the stimuli to the child and the intervention may cause the visual stimuli to become more of an active ingredient during interventions, especially for child with ASD and language impairment.

4.4 Limitations

As previously stated, the results of this scoping review should be interpreted with caution for many reasons that will be discussed below.

It should be noted that this scoping review was an exploratory review study with a small sample of studies included. While results and conclusions were drawn from these 18 included studies, many studies were excluded from the review for a variety of documented reasons (see Appendix C). Due to this small sample size, this review may not be representative of the studies on word learning in this population or of the heterogeneity of the population. Additionally, of the studies that were included in the scoping review, a large portion of the included studies used small sample research designs or case study design. While these types of studies provide important data, the generalizability of the data found in these studies may be less than those that include large samples, such as randomized control trials (Alnahdi, 2015).

Additionally, none of the 18 studies included in this scoping review were specifically designed to answer the research questions addressed. Due to the lack of existing studies that look at visual stimuli selection, specifically, the studies included in this review were used to get a preliminary glimpse at the effect that visual stimuli selection may have during vocabulary interventions with ASD. Studies were included based on their use of a vocabulary intervention to teach new words to children with ASD as well as their inclusion of a description of the visual stimuli used to teach the words during the intervention.

Furthermore, many studies incorporated multiple types of stimuli and children with various language abilities that could not be split up, therefore while results were separated by language or stimuli type, these groups were not mutually exclusive. Studies that included multiple stimulus types and multiple language categories were included in the tables for each group that was included. So, for example, if a study included both photographs and line-drawings, the extracted data for the study was included in the table about photographs and again in the table about line-drawings. This makes the results of this study less precise because it is not clear if the stimuli that drove the outcome or if it’s really a combination of stimuli that drives the outcome.

Finally, while coding the data for this review, it was noted that intervention studies were measured and reported in various ways, making it difficult to compare across studies. As others have reported, it difficult to compare language outcomes across reports, because of the lack of uniform measurement approaches to assessing language skills and the lack of uniform terminology for describing language outcomes in ASD (Tager-Flusberg et al., 2009). To align the results of the studies included in this review, rate of learning was calculated based on the number or words learned and the total number of sessions. While this method was effective at aligning the outcomes to allow for comparison of the studies, averages were often taken between participants, collapsing differences between participants with different language levels and performance. By using this method of calculating the average rate of learning, individual variability was lost. Future word learning intervention studies should consider clearly reporting the number of words learned, the number of words taught, as well as the total number of intervention sessions conducted.

4.5 Considerations for future research

This scoping review was an exploratory study to look at what is known about visual stimuli selection and use with children with ASD in the current literature. The results of this review lay the foundation for further investigation into visual stimuli selection, especially as it relates to child-specific characteristics. To elucidate the findings from this study, future studies should investigate the impact of child-related factors (i.e. child language ability, non-verbal reasoning, ASD severity) on visual stimuli, including explicit comparison of visual stimuli during a vocabulary intervention, to provide a means to feature-match the child to the optimal visual stimulus type for use during language interventions.

4.5.1 Need for uniformity in reporting treatment research

Several factors related to lack of uniformity in reporting participant characteristics as well as intervention outcomes were barriers that negatively impacted this review. Below, suggestions are made for improving and standardizing reporting for visual stimuli descriptions, participant language level, ASD severity, and intervention outcomes.

Many studies were excluded from the scoping review only because they lacked enough detail regarding visual stimuli and could not be coded. These were studies that met all other inclusionary criteria but did not fully describe the visual stimuli used. This resulted in losing a large number ($N = 21$) of studies for inclusion in this review (See Appendix C for details about reasons for exclusion). While this is not a direct limitation of this scoping review, it is a general limitation of vocabulary intervention studies with children with ASD. The lack of adequate description of visual stimuli, and exclusion of these studies in this review is critical and could have impacted the overall results of this study. When publishing future intervention studies, authors should consider providing detailed information regarding the visual stimuli used in the study. Visual stimuli descriptions should clearly state what type of stimulus is being used (i.e. photograph, line-drawing, object) with descriptions of whether the symbols are in color, gray-scale or black and white. Objects should be described as full objects, miniature objects or partial objects (see Intro for description of objects). For example, when describing line-drawings, the specific software that the stimuli came from should be included as well as descriptions of how iconic the stimuli were. Additionally, measures of iconicity and complexity should be further investigated to provide a standard measure for each of these constructs in which to compare and rate visual stimuli. Currently, language used to describe, and measure iconicity and complexity varies, indicating the need for further standardization in use of terms (Motamedi, Little, Nielsen

& Sulik, 2019). As Motamedi and colleagues (2019) suggest, a combination of behavioral and theory-neutral data-driven approaches should be used to form a more complete understanding of iconicity and complexity. Once standardization of terms and measures is achieved, a visual stimuli database for line-drawings and photographs that includes measures of iconicity and complexity should be developed. This database would make a significant impact in furthering research in the area of visual stimuli selection for use during language interventions by providing a means to systematically compare visual stimuli both within and across studies.

Similarly, child characteristics were not consistently and adequately reported across intervention studies. Only studies that included a description of the participants' language ability were included in this review. 4 studies were excluded in the screening phase of the search due to lack of description of language skills. Additionally, only 4 out of 18 studies included information regarding participants' ASD severity. Therefore, I made the decision to exclude ASD severity as a factor in the results of this review. Future studies including children with ASD should provide a more detailed description of ASD severity to allow for better replication and analysis.

Having an agreed upon description for verbal abilities as well as ASD severity is critical when comparing participants across studies ad well as for replication purposes. While inclusion of "gold standard" autism scales (e.g. ADOS, Lord et al., 2008; Autism Diagnostic Inventory-R, Rutter et al., 2003) has improved reporting on ASD severity in more recent studies, even fuller reporting of scores, such as subtest scaled and standard scores and descriptions of skill profiles, may be needed for replication and comparison between studies. Descriptions of language ability for children with ASD should also be more standardized to include number of words/symbols used expressively and receptively as well as standard scores from formal assessments, if appropriate to administer. Finally, to provide more complete participant characteristics in order to be able to feature-match children to visual stimuli, non-verbal reasoning should be reported based on formal assessment data, including standard scores.

4.6 Considerations for clinical implementation

While these findings should be considered with caution, they also lay the foundation for a deeper understanding regarding visual stimuli selection with children with ASD. When selecting visual stimuli for use during vocabulary treatment, interventionists, including speech-language pathologists and special education teachers, should primarily consider the child's language level. An interventionist working with a child with ASD who is non-verbal might want to start with using objects, but if word learning is slow, then the interventionist might want to probe the use of photographs and line-drawings to see if that would support better learning. An interventionist working with a child with ASD who is minimally verbal might want to start with using photographs, but if word learning is slow, then the interventionist might want to probe the use of objects and line-drawings to see if that would support better learning. An interventionist working with a child with ASD who has emerging verbal might want to start with using line-drawings, but if word learning is slow, then the interventionist might want to probe the use of objects and photographs to see if that would support better learning. Children with ASD and average verbal skills may perform adequately with all stimuli types, but interventionists should still probe with each stimulus type to determine the best type for the individual child. It should be noted that while these are recommended starting points based on the results of this scoping review, the evidence is mixed and there appears to be great variability between children. This variability may be accounted for by various factors (e.g. ASD severity, non-verbal intelligence) in which evidence is lacking or that have not yet been considered. All visual stimuli selection should be conducted on an individualized basis, as it is expected based on these findings, that visual stimulus selection is not one-size-fits-all. Further research is needed to determine other child-related factors that may play an important role in determining rate of learning for children with ASD across the visual stimulus types.

Additionally, based on these results, speech-language pathologists and special education teachers should expect to see an increased rate of learning as a child with ASD's language level increases. These interventionists should expect children who are nonverbal to learn approximately 0.36-1.6 words per session, children who are minimally verbal to learn approximately 0.25-1.43 words per session, children who have emerging verbal skills to learn 0.31-2.13 words per session and children with average verbal skills to learn about 4.17 words per session. Therefore, while there is a range in expectations, more sessions may be required for a child who has ASD and is non-verbal to acquire a new word label than a child who has ASD and has emerging verbal skills.

4.7 Conclusion

Overall, the results of this study indicate that further investigation is warranted regarding visual stimuli selection for children with ASD. It appears that visual stimuli selection may be an important factor and possible active ingredient during word learning interventions with children with ASD. More specifically, visual stimuli should be tailored to each child based on language level.

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Appendices

Appendix A: Scoping Review Protocol (as submitted to OSF online registry)

TITLE: Considering visual stimuli as an active ingredient in language intervention with children with ASD: A Scoping Review

Anticipated Completion date: May 01, 2019

Team Members: Adrienne Pitt, Kelly Berry (reliability only)

Review Questions

Does visual stimuli selection in language intervention impact outcomes in children with moderate to severe ASD? If so, how?

Does the relationship between stimuli selection and language outcomes vary by the child's pre-treatment language skills or ASD severity or age?

Does intervention type have an effect on type of stimuli selection?

Search Strategy

1. Initial search in databases (to be completed by the primary researcher):

Add modifiers for date (after 1960), age (3-17)

Search Strategy- General terms

1	Autism
2	ASD
3	Autism Spectrum Disorder*
4	1 or 2 or 3
5	language
6	intervention
7	program

8 treatment

9 therapy

10 6 or 7 or 8 or 9

11 visual stimuli

12 picture

13 symbol

14 graphic

15 11 or 12 or 13 or 14

16 4 and 5 and 10 and 15

Use the search strategy to search in the following databases:

PsycINFO

PubMed

ERIC

LLBA

WWC

Google search (for gray literature)

ASHA website (for gray literature)

Database for dissertations and theses

-Save all of the articles that were identified in step 16 in an excel document

2. Second search for additional studies (to be completed by the primary researcher):

-Go through the articles for new keywords and index terms across databases)

-Update search strategy as indicated and complete the search with the new strategy in all databases. (record this information in the excel file as before).

3. Search the reference list of all identified articles to look for any additional studies (to be completed by the primary researcher):

-Add these to the list of articles.

-Combine identified relevant articles from each database into one spreadsheet.

-Remove duplicates.

-Primary researcher will remove articles that do not fit the inclusionary criteria or meet the exclusionary criteria.

Inclusionary criteria (include articles based on these criteria):
1. Article involves children with ASD between the ages of 3 and 18
2. Article involves a language intervention (receptive or expressive)
3. Any study design (RCT, quasi-experimental, SCRD, Case studies, qualitative)
Exclusionary criteria (exclude articles based on these criteria):
1. Article does not include verbal skills or language level
2. Article only involves children with high functioning Autism or Asperger's
3. Article does not include description of visual stimuli used in the intervention

-Calibration of selected articles will take place.

-Graduate research assistant will independently screen a random sample of 20 articles that were identified in the initial search based on the inclusionary and exclusionary criteria.

-If 90% agreement is met between the primary researcher and the graduate research assistant, calibration is complete.

-If 90% agreement is not met, another set of 20 randomly selected articles will be screened. This will continue until 90% agreement has been met.

-Changes may be made to the inclusionary and exclusionary criteria descriptions during the calibration process.

-Data from the selected studies will be charted in a table by the primary researcher based on the following items:

1. title
2. author(s)
3. year of publication
4. study design
5. participant age range
6. participant language level(s)
7. intervention type
8. visual stimuli used
9. ASD severity
10. Outcomes

-The primary researcher will complete data abstraction for the first 20 articles.

-Calibration will take place for 5 randomly selected articles of the first 20 articles by the graduate research assistant

-Once 90% agreement of data abstraction has been obtained between the primary researcher and the graduate research assistant, calibration is complete, and the primary researcher will complete the data abstraction for the remainder of the selected articles.

-Critical quality appraisal of selected articles will not take place-this is consistent with the purpose of a scoping review.

-Tables will be organized based on study characteristics to look for patterns in the results to answer the previously identified study questions.

Appendix B: Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) Checklist

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
TITLE			
Title	1	Identify the report as a scoping review.	
ABSTRACT			
Structured summary	2	Provide a structured summary that includes (as applicable): background, objectives, eligibility criteria, sources of evidence, charting methods, results, and conclusions that relate to the review questions and objectives.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the review questions/objectives lend themselves to a scoping review approach.	
Objectives	4	Provide an explicit statement of the questions and objectives being addressed with reference to their key elements (e.g., population or participants, concepts, and context) or other relevant key elements used to conceptualize the review questions and/or objectives.	
METHODS			
Protocol and registration	5	Indicate whether a review protocol exists; state if and where it can be accessed (e.g., a Web address); and if available, provide registration information, including the registration number.	
Eligibility criteria	6	Specify characteristics of the sources of evidence used as eligibility criteria (e.g., years considered, language, and publication status), and provide a rationale.	
Information sources*	7	Describe all information sources in the search (e.g., databases with dates of coverage and contact with authors to identify additional sources), as well as the date the most recent search was executed.	
Search	8	Present the full electronic search strategy for at least 1 database, including any limits used, such that it could be repeated.	
Selection of sources of evidence†	9	State the process for selecting sources of evidence (i.e., screening and eligibility) included in the scoping review.	
Data charting process‡	10	Describe the methods of charting data from the included sources of evidence (e.g., calibrated forms or forms that have been tested by the team before their use, and whether data charting was done independently or in duplicate) and any processes for obtaining and confirming data from investigators.	
Data items	11	List and define all variables for which data were sought and any assumptions and simplifications made.	
Critical appraisal of individual sources of evidence§	12	If done, provide a rationale for conducting a critical appraisal of included sources of evidence; describe the methods used and how this information was used in any data synthesis (if appropriate).	
Synthesis of results	13	Describe the methods of handling and summarizing the data that were charted.	

SECTION	ITEM	PRISMA-ScR CHECKLIST ITEM	REPORTED ON PAGE #
RESULTS			
Selection of sources of evidence	14	Give numbers of sources of evidence screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally using a flow diagram.	
Characteristics of sources of evidence	15	For each source of evidence, present characteristics for which data were charted and provide the citations.	
Critical appraisal within sources of evidence	16	If done, present data on critical appraisal of included sources of evidence (see item 12).	
Results of individual sources of evidence	17	For each included source of evidence, present the relevant data that were charted that relate to the review questions and objectives.	
Synthesis of results	18	Summarize and/or present the charting results as they relate to the review questions and objectives.	
DISCUSSION			
Summary of evidence	19	Summarize the main results (including an overview of concepts, themes, and types of evidence available), link to the review questions and objectives, and consider the relevance to key groups.	
Limitations	20	Discuss the limitations of the scoping review process.	
Conclusions	21	Provide a general interpretation of the results with respect to the review questions and objectives, as well as potential implications and/or next steps.	
FUNDING			
Funding	22	Describe sources of funding for the included sources of evidence, as well as sources of funding for the scoping review. Describe the role of the funders of the scoping review.	

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews.

* Where *sources of evidence* (see second footnote) are compiled from, such as bibliographic databases, social media platforms, and Web sites.

† A more inclusive/heterogeneous term used to account for the different types of evidence or data sources (e.g., quantitative and/or qualitative research, expert opinion, and policy documents) that may be eligible in a scoping review as opposed to only studies. This is not to be confused with *information sources* (see first footnote).

‡ The frameworks by Arksey and O'Malley (6) and Levac and colleagues (7) and the JBI guidance (4, 5) refer to the process of data extraction in a scoping review as data charting.

§ The process of systematically examining research evidence to assess its validity, results, and relevance before using it to inform a decision. This term is used for items 12 and 19 instead of "risk of bias" (which is more applicable to systematic reviews of interventions) to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g., quantitative and/or qualitative research, expert opinion, and policy document).

From Tricco, A. C., Lillie, E., Zarin, W., O'Brien, K. K., Colquhoun, H., Levac, D., ... & Hempel, S. (2018). PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Annals of internal medicine, 169(7), 467-473.

Appendix C: Table displaying reasons for exclusion and number of studies that were excluded for each identified reason from all phases of the search.

Reason for exclusion	# of studies excluded
Not a vocabulary intervention	384
Not ASD	147
Visual stimuli not described	21
Visual stimuli not used	20
Not in English	13
Out of age range	7
language skills not described	4
outcomes not measurable	1
duplicate data	1
TOTAL	598