The production of semantic representations in children with specific language impairment, autism spectrum disorder, and typical language development

Kacy L. Kreger
ABSTRACT

THE PRODUCTION OF SEMANTIC REPRESENTATIONS IN CHILDREN WITH SPECIFIC LANGUAGE IMPAIRMENT, AUTISM SPECTRUM DISORDER, AND TYPICAL LANGUAGE DEVELOPMENT

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Although differences in processing are well established in children with specific language impairment (SLI) and autism spectrum disorder (ASD), little is known about how these differences impact the type of information they ultimately acquire when learning new words. The purpose of this study was to analyze novel word definitions from children with SLI, ASD, and typical language development (TLD) to determine if the semantic information they learned was influenced by these processing differences. Thirty-six children (12 in each group), matched on expressive vocabulary, participated in a novel word learning study across three sessions. The semantic features of 432 definitions were coded and analyzed based on three processing dimensions: (1) visual vs. verbal vs. both visual and verbal, (2) local vs. global descriptors, and (3) inferred vs. explicit. The results indicate that: (1) children with SLI and ASD relied more on visual information to build their semantic representations than their peers with TLD, and children with SLI and ASD used verbal and a combination of visual and verbal semantic features similarly to their peers with TLD; (2) the groups with SLI and ASD produced more global descriptors than the group with TLD, and the group with SLI produced significantly fewer local
 descriptors than the group with TLD; and (3) all groups made inferences and used explicit information similarly. This study reveals that processing differences in children with SLI and ASD impact the formation and later production of semantic information when using newly acquired words. These results also demonstrate the wide-ranging overlap of expressive language abilities in children with SLI and ASD, highlighting why differential diagnosis of these disorders may be challenging when language alone is observed.
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THE PRODUCTION OF SEMANTIC REPRESENTATIONS IN CHILDREN WITH
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TYPICAL LANGUAGE DEVELOPMENT

BY

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CHAPTER 1

INTRODUCTION

When parents bring their child who has a language delay to a diagnostic that includes an evaluation by a speech-language pathologist, it may be the first time they are told their child has “autism spectrum disorder” or “specific language impairment.” The parents then learn about this diagnosis and that this disorder may have contributed to their child’s atypical development of speech and language. The speech-language pathologist has the responsibility not only to work with other health care professionals to accurately diagnose a child as having autism spectrum disorder (ASD) or specific language impairment (SLI), but also to effectively implement strategies to teach this child language, facilitating their acquisition of new words.

The learning of new words is atypical for both of these populations of children (for SLI, see Marinellie & Johnson, 2002; for ASD, see Kostyuk et al., 2010). Children with SLI demonstrate shallow semantic representations, which impacts how well they use words (McGregor & Appel, 2002). They struggle to learn even highly familiar and commonly used words as robustly as their peers (Marinellie & Johnson, 2002). Children with ASD display challenges in learning and using vocabulary as well (Kostyuk et al., 2010).

Differences in how individuals with SLI and ASD process new information have been widely explored. For example, several researchers have shown visual and verbal information are processed differently in individuals with SLI and ASD compared to their typically developing...
peers (for SLI, see Alt & Plante, 2006; Norrix, Plante, Vance, & Boliek, 2007; for ASD, see Erdődi, Lajiness-O'Neill, & Schmitt, 2013; McCleery et al., 2010). Additionally, when exposed to new objects, children with ASD are known to focus on local, rather than global, information (Fitch, Fein, & Eigsti, 2015; Kuschner, Bodner, & Minshew, 2009). Both populations have demonstrated weak inferencing skills, which require applying previously learned material to newly processed information (Norbury & Bishop, 2002). While these atypical processing patterns are well documented, less is known about how they impact the type of semantic features children with SLI and ASD learn as they build new words in their mental lexicons. Although the weaknesses in word learning and conceptual knowledge are well documented in children with SLI and ASD, little research has explored how differences in processing information may impact how they acquire, and ultimately produce, new words.

The purpose of this study was to analyze the semantic features produced in novel word definitions by children with SLI, ASD, and typical language development (TLD) based on these processing differences. Specifically, the questions explored in this study included: 1) do children with SLI, ASD, and TLD differ on which presentation modality (either visual, verbal, or both) they primarily rely on when learning new words; 2) do children with SLI, ASD, and TLD differ in their use of local and global information; and 3) do children with SLI and ASD produce semantic features that were explicitly taught or inferred differently than their typically developing peers? Discovering the answers to these questions may later influence the cues used to teach new words to children with SLI and ASD and will provide a better understanding of the underlying learning mechanisms in these children.
Word Learning in Typically Developing Children

In order to understand the word learning anomalies in children with language disorders, knowledge of the typical progression in language development is necessary. For instance, memory plays an important role in word learning. Retaining words and their meanings aids in later comprehension (Gupta & MacWhinney, 1997). When children learn new words, they are required to learn the phonology, or the sounds that make up the word, as well as the semantics, or the meanings of words, phrases, and sentences. These two components (semantics and phonology) help to make up the representation of the lexical item, or the novel word (Dollaghan, 1987).

**Phonology**

Learning phonology, or how sounds are combined, is thought be an implicitly learned skill that is stored in procedural memory (Ullman, 2001). Procedural memory helps us learn new motor and cognitive skills, as well as control already established skills. The sounds of the word can help create a representation in the memory of the learner (Dollaghan, 1987) and can be stored in short-term memory after hearing a novel word only one time (Gupta & MacWhinney, 1997). Deficits in being able to produce phonological information accurately may be indicative of a language learning disorder (Dollaghan, 1987).
Lexical Learning

Lexical knowledge, which includes the sounds and meanings of words, is thought to be stored in declarative memory. It is suggested that declarative memory helps individuals learn, represent, and use knowledge about facts and events (Ullman, 2001). Children with TLD are able to learn words without explicit instruction, and this is frequently how they build their lexicons (Sternberg, 1987). McGregor, Sheng, and Ball (2007) found that typically developing children benefited from explicit instruction of new words, as well. Lexical knowledge has been found to be supported by the semantic knowledge of a word and may be learned more readily if information regarding its semantic features are taught directly (McGregor et al., 2007).

Semantic Learning

Semantic knowledge, like lexical knowledge, has also been proposed to be in the declarative memory system (Ullman, 2001). Semantic representations include the referents, or the meanings, of words (Storkel, Armbrüster, & Hogan, 2006). This information is important for learning when and where to use a word (Kostyuk et al., 2010). When a child hears a familiar word, the existing representation in the child’s mind is activated, and the word is able to be recognized and expressed.

When an individual comes across a word with which he or she is unfamiliar, there are no existing semantic representations, and the mismatch between the environment and memory helps to start the process of creating new lexical and semantic representations (Gupta & MacWhinney, 1997). Semantic information is readily learned when children are reintroduced to words over
time (McGregor et al., 2007). Repeated exposures to semantic information have been found to lead to enhanced integration of semantic features and the formation of more robust semantic representations in memory. Based on these findings, it has been recommended that speech-language pathologists increase exposure to semantic information and informative contexts to aid in word learning, particularly with children who struggle to learn new words. However, it is unclear how processing differences in children with language learning delays influence which aspects of these semantic representations are added to their lexicons.

Building a Lexical Network

When an individual hears a novel word, triggering takes place for new information to be stored into memory (Storkel et al., 2006). As outlined by Storkel and her colleagues (2006), word learning undergoes multiple stages. The first stage of word learning is in the recognition that a new word was heard. This step is most likely a critical component of naturalistic word learning and requires the learner to detect that word as unfamiliar. The second stage begins when the listener creates a representation of this novel word. Following this, the listener makes connections from the new representation to existing representations and builds on them based on previous knowledge (Storkel et al., 2006). These phases make up the learning process traditionally known as fast mapping (Carey, 1978; Carey & Bartlett, 1978), or when a listener quickly creates a representation for a novel word after only one exposure (Dollaghan, 1987). Fast mapping includes the semantic, phonological, and syntactic characteristics of the novel word, in addition to other important information regarding the situation in which it was first encountered. Fast mapping does not need to be accurate or complete in order to take place, but over time the
listener adds semantic features to her or his representations based on the characteristics initially learned (Horst & Samuelson, 2008).

To add to the representation of a new word at a later time, the learner undergoes extended mapping, or the learning that occurs with additional exposures to the new word in a variety of contexts (McGregor et al., 2007). While most investigations of word learning look only at the fast mapping phase, extended mapping also plays a critical role in learning the more nuanced, robust meaning a new word. The use of “rich, informative environments that include massed and distributed redundancies” (McGregor et al., 2007, p. 361) has been suggested to facilitate extended mapping and later word retention.

A recent account of word learning devised by Kucker, McMurray, and Samuelson (2015) posits that instead of the fast and extended (slow) mapping phases, children acquire new words through a dynamic process that integrates “in-the-moment” word use and long-term learning (p. 74). In this account, stages of word learning are not necessary because word learning is supported by associations to novel objects or events. The authors provide the example of the word “chicken”; it can refer to the food, bird, or a taunt. To learn this word after one exposure would be incomplete, and therefore it is necessary for the child to make the best decision at that moment and be receptive to new meanings. Over time, when learning the word “chicken,” the child will strengthen and prune prior mappings in his or her lexical framework in order to make inferences about the meaning of that word in a particular context. Because each experience and context shapes the meaning of a word, how a lexical framework is formed may very well depend on one’s ability to process semantic information through different modalities (e.g., visual or verbal), at a global or local level, or through explicit teaching or inferencing. Although the role
of these processing factors specific to the child remains unknown, processing factors inherent to words and their language contexts have been more readily explored.

Factors That Influence Word Learning

Word learning is not only dependent on the individual’s word processing abilities but also on how a word is formed within the context of language. Phonotactic probability, lexical neighborhood density, the interaction between neighborhood density and phonotactic probability, and semantic neighborhood density are all factors that can influence an individual’s ability to learn a new word. Each of these inherent characteristics of a word influence one’s ability to learn the word itself in different ways.

Phonotactic Probability and Neighborhood Density

Phonotactic probability is the “relative frequencies of segments and sequences in spoken words” (Vitevitch, Luce, Pisoni, & Auer, 1999, p. 306). For example, in English, the word “coat” would have a common sound sequence, whereas the word “watch” would have an uncommon sequence (Storkel, 2003). Phonotactic probability is thought to either help or hinder word learning, depending on the sequencing of phonemes in the word (Hollich, Jusczyk, & Luce, 2002; Storkel, 2001; Storkel, Armbruster, & Hogan, 2006; Storkel, Bontempo, Aschenbrenner, Maekawa, & Lee, 2013; Storkel & Hoover, 2011; Storkel & Lee, 2011). High phonotactic probability, for example, can help infants learn new words for the first time (Hollich et al., 2002). High phonotactic probability, as an adult, however, can hinder word learning; adults are more likely to learn a word with low phonotactic probability (Storkel et al., 2006). This example also demonstrates how word learning can change over the course of a lifetime.
Lexical neighborhood density, another factor that influences word learning, is the number of words that sound similar (differing only by one phoneme substitution, deletion, or addition) to the word the listener is trying to learn (Storkel & Morissette, 2002). An example would be “sit”; the neighbors of “sit” include the words “sip, hit, sat,” and “it.” The word “sit” has 36 neighbors and is considered to reside in a dense lexical neighborhood; in contrast, the word “these” only has nine neighbors and is considered to reside in a sparse lexical neighborhood.

Often, lexical neighborhood density and phonotactic probability are studied simultaneously due to their positive correlation (Vitevitch et al., 1999). Low probability in sounds usually relates to low-density neighborhoods, and high probability sound sequences are frequently in high-density neighborhoods. Storkel (2004a) found that typically developing children learn words from dense neighborhoods, or words that have many similar-sounding neighbors, at earlier ages than words that have sparse neighborhoods, or limited numbers of similar-sounding words. However, as previously discussed, adults show the opposite; they recognize uncommon-sounding words more quickly than words of common sound sequences (Vitevitch & Luce, 1999). This change across the lifespan, which occurs in both typical and clinical populations, is important; children more easily learn words from dense neighborhoods when building detailed representations, or semantic features, whereas adults do not (Storkel, 2004b). Phonotactic probability and neighborhood density both interact and influence how individuals learn new words based on their lexicons, which expand with age, and should be controlled for in studies that investigate word learning outside of phonotactic probability and neighborhood density.
Semantic Neighborhood Density

Semantic neighborhood density, or the degree of overlap of semantic features, also influences word learning in children (Storkel & Adlof, 2009). Exposure to a novel word activates other semantic features, or the characteristics that may be shared with other referents, that an individual has stored in his or her semantic memory (e.g., Gupta & MacWhinney, 1997). When words share several semantic features, they are thought to have higher semantic neighborhood density, which impacts their learnability (Storkel & Adlof, 2009). For example, in Storkel and Adlof’s (2009) study, one nonobject was described using a variety of similar terms, such as instrument, trumpet, horn, and tuba. Because so many terms could be used to describe this nonobject, it was considered to have a large semantic set size. In comparison, a nonobject that was harder to compare to other known objects, and therefore had fewer terms to describe it, had a smaller set size. The children had more difficulties naming nonobjects with a larger semantic set size, or a higher semantic neighborhood density, compared to nonobjects with a smaller semantic set size, or a smaller semantic neighborhood density, during a word learning task. When the children used their long-term memory to find terms to describe a nonobject with a higher semantic set size, they created “competition between the semantic representation being created and the already known semantic representations” (Storkel & Adlof, 2009, p. 317). This competition could have slowed the learning of semantic representations for these children.

Mirman and Magnuson (2008) also found that words with many near semantic neighbors (highly similar concepts) were recognized more slowly than words with few near semantic neighbors. Mirman and Magnuson (2008) provided examples of semantic neighbors for the word “car,” which included “Toyota” (an exemplar), “transportation” (a superordinate term), “truck”
(another vehicle), and “drive” (an interaction-related word). Also, other descriptor words can be semantic neighbors of “car,” such as “expensive” or “fast” (p. 66). Mirman and Magnuson (2008) suggested that known words and their characteristics influenced how easily someone learns a novel word. Due to the many near semantic features, providing the word “transportation” to describe the word “car” would cause a slower recognition than a semantic feature of a word with fewer semantic neighbors, such as “moos,” which readily leads to the word “cow.”

Although the impact of phonotactic probability (Hollich, Jusczyk, & Luce, 2002; Storkel, 2001; Storkel, Armbruster, & Hogan, 2006; Storkel, Bontempo, Aschenbrenner, Maekawa, & Lee, 2013; Storkel & Hoover, 2011; Storkel & Lee, 2011), lexical neighborhood density (Storkel & Morrisette, 2002; Vitevitch et al., 1999), the interaction between neighborhood density and phonotactic probability (Storkel 2004a,b), and semantic neighborhood density (Mirman and Magnuson, 2008; Storkel & Adlof, 2009) have been extensively explored, each of these influential factors are inherent to the words themselves, and they therefore cannot be altered to better facilitate word learning for children with language learning deficits. However, there is much that can be changed when a new word is taught. For example, clinicians could use verbal or visual cues, emphasize global or local aspects of the target referent of a word, or teach words explicitly or through inferred context clues, depending on which of these individual processing factors influences how lexical-semantic features are ultimately learned in children with language learning deficits. For children with SLI and ASD to improve their language outcomes, identifying factors that could help these children learn new words is essential.
Word Learning in SLI

Specific Language Impairment

Children diagnosed with SLI make up approximately seven percent of the population (Tomblin et al., 1997). The cause of SLI is unknown, with genetics being a likely factor. Its diagnosis is dependent on the clinician’s observation of spoken language and is described as a “significant deficit in language ability” not caused by hearing loss, nonverbal intelligence, or neurological damage (Leonard, 2014, p. 3). In other words, the impairment is specific to language while other areas remain clinically intact. While the label “SLI” remains controversial among professionals because of a growing body of evidence that other areas of development may also be implicated, the academic, communicative, and economic challenges this population face are widely acknowledged (Leonard, 2014).

Academically, children with SLI often struggle on tasks of reading and writing. Having a large lexicon, or vocabulary, contributes to academic achievement, and early language learning deficits can have a significant impact on success later on in school (Rice et al., 1994). Words and their understanding also are crucial for learning outside of school, having a conversation, and forming meaningful relationships with others. The language deficits experienced by individuals with SLI contribute to social and emotional issues in adolescence and into adulthood (Leonard, 2014). Discovering how children with SLI best learn new words could help clinicians and educators prevent later struggles in academic settings, in forming meaningful relationships, and in the workforce, thus positively impacting their quality of life within a society that values proficient communication.
Phonology

Phonology is tested in the diagnosis of SLI, but the focus is on the individual’s ability to hold the phonological information of a word in his or her short-term memory (McGregor et al., 2012a). In a diagnostic evaluation, children with SLI are typically asked to repeat nonwords of increasing lengths. This is because children with SLI commonly show weaker performance on nonword repetition tasks (Munson, Kurtz, & Windsor, 2005). On these tasks, children with SLI demonstrate a preference for nonwords with high phonotactic probability over nonwords with low phonotactic probability (Munson et al., 2005), similar to the pattern observed in typically developing infants (Hollich et al., 2002). Vocabulary size is predictive of accuracy differences in the production of nonwords, regardless of their phonotactic probability (Munson et al., 2005). This is potentially because children with larger vocabularies have more opportunities to refine their phonological categories (Munson et al., 2005). These findings highlight the detrimental role that the sparser word knowledge children with SLI possess plays on other areas of language, such as speech production accuracy.

Children with SLI often make more errors than their typically developing peers when saying real words and require more exposures to produce them correctly (Gray, 2005). Gray (2005) concluded that deficits in phonological processing may interfere with the comprehension and production of newly learned words in children with SLI and may be more severely impacted than semantic storage and retrieval. This is similar to the findings of Alt and Plante (2006), who found that the phonological complexity of words being learned can affect a child with SLI’s ability to master the lexical label and its associated semantic information. In other words, weaknesses in phonological learning may impede semantic learning in children with SLI. For
children with SLI, there may be an adverse cycle occurring, where limited word knowledge (or vocabulary size) impacts their speech production accuracy, but then deficits in phonological processing influence their ability to acquire lexical and semantic information.

**Lexical and Semantic Learning**

Lexical and semantic learning, managed by the declarative memory system, is thought to be a relative strength in children with SLI (Ullman & Pierpont, 2005). However, because syntactic abilities are a core deficit area in SLI (Leonard, 2014), and syntactic abilities and lexical abilities are positively correlated (McGregor et al., 2012a), it is not surprising that children with SLI possess fewer words in their vocabularies (less breadth of word knowledge; McGregor, Oleson, Bahnsen, & Duff, 2013), as well as show shallower knowledge of word meanings (less depth) than their typically developing peers and that these differences persist over time (Marinellie & Johnson, 2002; McGregor et al., 2013). These weaknesses in depth of word knowledge hold even when the words are highly frequent, common nouns (Marinellie & Johnson, 2002).

Because children with SLI show deficits in word learning and depth of their word knowledge, Gray (2005) sought to determine whether phonological or semantic encoding cues could help children with SLI acquire new words more effectively. When semantic cues were provided to children with SLI, they improved their comprehension of new words, but only the phonological cues helped the children more accurately produce these words. This study suggests that different cues could strengthen each of these areas of processing weaknesses in children with SLI during tasks of word learning. It is unclear how other areas of processing differences impact
which semantic aspects of new words are ultimately acquired in children with SLI or how similar cues may be used to bolster these potential deficits, as well.

**Word Learning in ASD**

**Autism Spectrum Disorder**

The cause of autism remains unknown (Kostyuk et al., 2010). It is a neurodevelopmental disorder that often affects an individual’s communication, engagement in social interactions, and responses to environmental stimuli. ASD is defined as:

Persistent deficits in social communication and social interaction across multiple contexts, as manifested by the following, currently or by history: deficits in social-emotional reciprocity…deficits in nonverbal communicative behaviors…[and] deficits in developing, maintaining, and understanding relationships. (Centers for Disease Control and Prevention, 2015)

ASD currently affects an estimated one in 68 children in the United States (Centers for Disease Control and Prevention, 2015). A delay in learning language is a common characteristic in children with ASD (Kostyuk et al., 2010), although each child is unique. Some children may have a rich vocabulary and high intellectual and social development, and some may need speech and language services, social skills groups, and possibly special education programs.

Academic achievement is often negatively affected when children with ASD have difficulties with comprehension tasks (Minshew, Goldstein, Taylor, & Siegel, 1994). Additionally, children with ASD in regular classrooms often experience low peer acceptance, companionship, and reciprocity due to impairments in social interactions (Chamberlain, Kasari, & Rotheram-Fuller, 2007). These social interactions could be negatively affected by
communication differences that individuals with ASD have, such as difficulties with making
inferences (Dennis, Lazenby, & Lockyer, 2001). Unfortunately, individuals with ASD can
experience challenges later in life, as well. Adults with ASD are often underemployed and, when
employed, often make less of an income than other adults without ASD (Taylor & Seltzer, 2011).
Learning ways to better teach new words to children with ASD could help them overcome
academic and language obstacles, thus creating more positive social interactions with others.

**Phonology**

Although children with ASD show many delays in language development, phonology is
generally the least impaired (Kostyuk et al., 2010). Kjelgaard and Tager-Flusberg (2001) found
that in children with ASD between the ages of 4 and 14, articulation skills were typical. This is
unlike children with SLI, who show a weakness in phonology (Munson et al., 2005). Norbury,
Griffiths, and Nation (2010) found that children with ASD learn the phonological forms of new
words equally as well as their typical peers but are less likely to improve their understanding of
the semantic features of novel words over time. This is consistent with research showing that
semantic understanding and phonological accuracy are two separate abilities that children learn
when adding a new word to their lexicons (Gray, 2005; McGregor & Appel, 2002).

**Lexical and Semantic Learning**

The semantic abilities of people with ASD vary across studies; some researchers
conclude that they do not show deficits in semantics because they are able to categorize as well
as their typically developing peers (Eigsti et al., 2011). However, others have indicated that
people with ASD interpret semantic information differently and are less likely to use semantic probability in real-life situations, when there are more cues to decipher and sort, compared to individuals who are typically developing (Dennis, Lazenby, & Lockyer, 2001).

Whitehouse, Maybery, and Durkin (2007) investigated whether individuals with ASD have challenges in learning semantic features because they pay more attention to the sounds, or phonological aspects, of the words. The authors hypothesized that individuals with ASD are able to encode verbal stimuli but are unable to retrieve the information, which causes them to appear that they have poor semantic knowledge. Using two different cues, semantic and phonological, the authors thought they could discover what type of encoding the children with ASD were applying when asked to remember 20 words provided earlier. They found that when matched on verbal age, nonverbal age, and reading ability, the children with ASD (mean age = 10;11) and the typically developing group (mean age = 8;4) were more successful when semantic cues were provided. These results indicate that children with ASD do not encode semantic or phonological information from the words in a different manner from children with TLD but perhaps are on a “different developmental time-scale” from typically developing children, which is supported by their older chronological age in the study (p. 248).

For some individuals with ASD, challenges in the recall of previously taught words have been proposed to be due to poor semantic processing (Toichi & Kamio, 2002). Harris and colleagues (2006) investigated brain activation in adults with ASD using fMRI technology to analyze lexical semantic processing. Their findings were consistent with behavioral evidence for semantic deficits in individuals with ASD. Impairments in the processes of encoding and retrieval were attributed to abnormal responses in Broca’s area and the left middle temporal
gyrus during semantic processing of the stimuli. Interestingly, this study found that visual cues (i.e., capitalization of words) elicited more typical perceptual processing in children with ASD, and that they seemed to process more semantic and phonological stimuli during the task with enhanced visual cues than during the semantic cues alone task.

Differentiation of SLI and ASD

In some circles, SLI and ASD are considered to be the same disorder, and recent research has investigated their differences and similarities. Riches and colleagues (2012) pointed out that there are traits shared between children with SLI and children with ASD and that there is a high comorbidity, which could suggest a shared genetic cause or potentially the same phenotype. In addition to researchers, clinicians often report that SLI and ASD can make for a “difficult differential diagnosis” (McGregor et al., 2012a, p. 35). The similarities in syntactic deficits and sparse lexicons contribute to the challenges in making these diagnoses. Children with SLI and ASD present with similar limitations in “depth of lexical semantics” and “knowledge of word meaning and… word-to-word relationships” (McGregor et al., 2012a, p. 45). This overlap in symptomatology leads to the perceived similarity in the SLI and ASD phenotypes. Because of these similarities in language challenges, there are also common language intervention goals for both groups of children.

Many children who have a diagnosis of SLI meet clinical standards for the diagnosis of ASD on the social or communication domains of the Autism Diagnostic Interview or the Autism Diagnostic Observation Schedule (Leyfer et al., 2008) or both (Bishop & Norbury, 2002). However, they do not meet the diagnosis of ASD on the other domains (e.g., repetitive and
restrictive behavior) of this assessment. This overlap illustrates the challenges diagnosticians face, as well the need for a better means to differentiate SLI and ASD.

While there are several similarities between SLI and ASD, knowing the differences will also help inform clinical decision making when assessing and treating these two populations. Riches and colleagues (2012) found that children with SLI and children with ASD demonstrated difficulties comprehending synthetic compounds and were likely to view the first noun as the agent of the verb (e.g., the word “taxi” in “taxi driver” was not seen as a noun but as an agent of the verb). These errors were attributed to difficulties in phonological working memory and vocabulary. The authors concluded that although the children with SLI and ASD performed similarly, this was not enough in itself to support phenotypic overlap between the two diagnoses, and more research is required to make claims about SLI and ASD and their language phenotype correlations.

One potential distinction between these two populations is that children with ASD have been speculated to show a bias toward local, or detailed information (Olu-Lafe, Liederman & Tager-Flusberg, 2014), whereas children with SLI have not shown a global or local preference (Akshoomoff et al., 2006). With respect to language in these two groups, children with SLI must have impairments in language in order to be diagnosed, whereas the language abilities in children with ASD are extremely variable, and impairments are not required for a diagnosis (American Psychiatric Association, 2013). In fact, some children with ASD have typical language skills for their age (Kjelgaard & Tager-Flusberg, 2001). Children with ASD are typically diagnosed based on their social deficits, not their delay of language abilities (Tager-Flusberg, Paul, & Lord, 2005). Also, children with SLI often perform more poorly on nonword
repetition tasks than children with typical language and children with ASD (for ASD, see Conti-Ramsden et al., 2001; for TLD, see McGregor et al., 2012a). As seen with phonological and semantic processing distinctions in children with SLI and ASD, one method of better understanding the differences between SLI and ASD is to explore the influence of other areas of processing on the production of language, such as visual and verbal processing, global and local processing, and inferencing skills.

The Current Investigation

Previous studies have primarily employed standardized assessments (Dennis et al., 2001; Erdödi et al., 2013), event-related brain potentials (Cummings & Čeponienė, 2010), MRIs (Kourkoulou, Leekam, & Findlay, 2012; Robertson et al., 2014), and scripted stories followed by a closed set of answers (Botting & Adams, 2005) to capture processing differences in children with SLI or ASD. Few or no studies have investigated how processing differences affected language production in a naturalistic learning scenario. The current study embarked on a different approach. Using open-ended novel word definitions, this study aimed to investigate the influence of processing differences in visual and verbal modalities, global and local processing, and inferencing on which semantic aspects of words children with SLI or ASD ultimately learn and produce. This method provided a glimpse into how children with SLI and ASD learn new words, as well as how they may be differentiated from each other for diagnostic purposes. Knowing how these intrinsic-to-the-learner processing differences (rather than word-specific characteristics, such as phonotactic probability) impact how children with SLI and ASD acquire new words has yet to be explored and is an integral component in learning how to best facilitate word learning in these populations.
Visual Processing

Visual information shapes the way we use language in infancy (McMurray & Aslin, 2004). Infants prefer learning new words by their color, over their shapes, but soon this changes to a shape bias in typically developing children and adults (Landau et al., 1988). Landau and colleagues (1988) stated that a word’s referent shape may be the strongest cue to facilitate word learning in typically developing individuals. Knowing this, it comes as no surprise that visual cues are used to teach new words. Visual supports in interventions for children with SLI and ASD have been investigated and are often found to be facilitative (for SLI, see Washington & Warr-Leeper, 2013; for ASD, see Quill, 1997). Quill (1997) defined visually cued instruction as:

The use of graphic cues as either an instructional prompt to aid in language comprehension and communication, or an environmental prompt to aid organizational skills and improved self-management. (p. 704)

This supportive evidence that visual cues can help teach life skills and academic subjects is surprising, given that several studies have found deficits in visual processing in individuals with SLI and ASD (for SLI, see Schul, Stiles, Wulfeck, & Townsend, 2004; for ASD, see Erdődi et al., 2013). It could be that there are deficits in visual processing, but it remains a relative strength. It is uncertain whether children with SLI and ASD use the visual cues presented during the encoding phase of word learning to facilitate the retrieval of the semantic representations of those same words later.
Visual Processing in SLI

Individuals with SLI have been thought to have slowed processing in visuospatial tasks (Schul et al., 2004). Differences in visual processing begin early on with shape bias (Collisson et al., 2015). Collisson and colleagues (2015) found that children with SLI did not demonstrate a shape bias in an object naming context with novel words, unlike their typically developing peers. Because shape bias is one of the strongest word-learning cues typically mastered in infancy, this study highlights how visual information may be processed differently in children with SLI, and that this difference has direct consequences on their ability to learn new words.

Visual processing has been investigated in children with SLI through the use of digital graphic displays. Schul and colleagues (2004) studied fifteen children with SLI who were matched with typically developing peers. The participants were given a task that assessed the speed of visual processing and a test that was designed to test visual discrimination with and without attention. The children with SLI showed slow visual processing and slow motor responses when compared to the control group. However, they were not different from their matched peers in the speed of visuospatial attentional orienting or the use of attentional cues. The performance of the children with SLI suggested that they had specific difficulty in visual processing when there was less time with the task (i.e., 50 ms versus 1000 ms). These results could indicate that children with SLI rely less on visual stimuli than their typically developing peers during tasks of learning, especially when those tasks occur over a short period of time.

To determine whether incongruent auditory-visual information is processed similarly in a group of preschool children with SLI compared to their typically developing peers, Norrix et al.
(2007) used the McGurk effect, a perception elicited from a person saying /bi/, /di/, or /gi/ while watching the same person say another syllable. Without the visual cue, the groups performed very similarly when exposed to the auditory stimuli. However, when the auditory stimuli were accompanied with the visual stimulus, the group with SLI perceived /bi/ more often than the typical language group. This weak McGurk effect in the group with SLI suggested that they used the visual information less than the group with TLD, who were more influenced by the incongruent visual and auditory stimuli. The authors concluded that despite not knowing why the children with SLI performed differently from the typically developing children, the presence of a reduced McGurk effect demonstrated that their challenges with speech perception may not be limited to the processing of auditory information.

**Visual Processing in ASD**

Similarly to children with SLI, visual processing differences begin early on and affect how children with ASD organize abstract conceptual information before three years of age (Potrzeba, Fein, & Naigles, 2015). Tek, Jaffery, Fein, and Naigles (2008) studied children with ASD and typically developing children to observe if children with ASD had a reduced or absent shape bias. They found that children (age 24 months) with ASD did not demonstrate a shape bias, even though both groups were matched on vocabulary. Similarly, Potrzeba and colleagues (2015) found that children (ages 24 months to 54 months) with ASD did not show a significant shape bias. However, in the aforementioned study, there were a few children with ASD who demonstrated a shape bias, and these children had larger vocabularies. Tek and colleagues (2008)
suggested that children with ASD most likely have difficulties with categorization, which is reflected by their lack of shape bias.

Differences in visual processing extend to other aspects of language, as well. Kamio and Toichi (2000) compared 20 individuals with ASD (mean age = 20.1 years) and 20 controls (mean age = 19.9 years) and their semantic abilities when given word-word pairs and picture-word pairs. This study explored the differences in the groups and their pictorial and verbal semantic systems. Their results demonstrated a picture-word superiority for the group with ASD, while the control group demonstrated a preference for the word-word pairs. Because individuals with ASD relied on the stimuli that incorporated visual cues, a combination of the two presentation modalities, as opposed to verbal input alone, may best facilitate word learning in individuals with ASD.

Erdődi, Lajiness-O'Neill, and Schmitt (2013) studied children with attention hyperactivity disorder, velocardiofacial syndrome, ASD, and typically developing children to better understand the mechanisms of learning impairment and better inform instruction for children with ASD. Their findings demonstrated that the children with ASD had a general weakness in visual learning compared to the typically developing group and the group with ADHD not attributable to visuospatial abilities. The authors did not directly compare visual and auditory learning within the populations, limiting their overall interpretations of visual compared to verbal learning.

Additionally, individuals with ASD have been found to have differences in response to moving visual stimuli in their primary visual cortex and middle temporal area compared to typically developing individuals (Robertson et al., 2014), providing evidence that visual
processing in ASD is not the same as in those who do not have ASD. However, when given more time to process visual stimuli, children with ASD perform similarly to their typically developing peers. Perhaps, as with their peers with SLI, more time is necessary to benefit from visual cues during tasks of learning in children with ASD.

**Verbal Processing**

Verbal processing plays a significant role in word learning, further allowing us to assign semantic features to words in our lexicons (Gupta & MacWhinney, 1997). Children with SLI and ASD often produce their first words at an older age (for SLI, see Trauner, Wulfeck, Tallal, & Hesselink, 1995; for ASD, see Kostyuk et al., 2010) and have difficulties acquiring new words and their semantic representations. These delays in expressive language may be indicative of challenges in verbal processing.

**Verbal Processing in SLI**

Cummings and Čeponienė (2010) found that children with SLI demonstrated semantic integration deficits specifically attributed to verbal processing. Children with SLI were compared to their age-matched peers in a study that measured event-related brain potentials while the participants performed a forced-choice matching task. The stimuli consisted of matching and mismatching visual-auditory, picture-word, and picture-environmental sound pairs. Colorful pictures of objects were presented with a word or an environmental sound (e.g., the ring of an alarm or car honking). The word stimuli included words such as “car” and “alarm.” The visual stimuli were images of common objects that could produce an environmental sound or be named
by a verb or noun. Results showed that in the picture-word trials the children with language impairment were less accurate, and their neural response after the incongruence was significantly delayed compared to the control group. This study was not unlike the Norrix and colleagues (2007) study that found that incongruent auditory-visual stimuli is processed differently in children with SLI in regard to the McGurk effect.

Alt and Plante (2006) also measured how the verbal processing demands required to attach the semantic features to a novel lexical label are influenced by phonotactic probability in children with SLI (age range of participants 48-71 months). During a semantic fast mapping task, the stimuli were introduced in a computer program that displayed an image of the referent of the nonword and its lexical label. They found that children with SLI did not demonstrate differentiation between words with high phonotactic probability and words with low phonotactic probability when picking a target label from a foil. However, the participants with SLI displayed a preference for high phonotactic probability during a different task with fewer demands; they had more difficulty learning nonverbal semantic features when the lexical labels had infrequent phonotactic probabilities. In other words, when the verbal processing demands were high (i.e., infrequent phonotactic probability), the children with SLI were unable to adequately form semantic representations of the novel words as well as their peers with typical language.

In contrast to Alt and Plante (2006), the results of a study by McKean, Letts, and Howard (2014) demonstrated that there were no significant differences between children with SLI and typically developing children, overall or in the nature of the effects of phonotactic probability and neighborhood density. Participants included 12 children, age three to six, with language impairment, and 38 children with typical development, age three to five. Over the course of two
to four sessions, novel words and their referents were introduced in a story, and measures of
word learning were collected. Word learning was not significantly different between the groups
when matched on their vocabularies. This finding may support the idea that children with SLI
benefit from the same verbal cues as typically developing children when words are taught in the
context of a story. When comparing Alt and Plante (2006) and the McKean and colleagues
(2014) study, it is unclear if children with SLI are unable to build new meanings of words into
their lexicons because of phonological processing difficulties or if the children with SLI are
unable to process phonological information efficiently due to limited lexical-semantic
knowledge. Regardless, verbal processing appears to be challenging for children with SLI.

Verbal Processing in ASD

Verbal processing has been found to be challenging for individuals with ASD, as well.
McCleery et al. (2010) studied verbal and nonverbal integration in children with ASD through
recording event-related potentials (ERPs) while the participants were exposed to semantically
matching and mismatching picture-environmental sound pairs (e.g., a picture of a train and the
sound of a train) and picture-word sound pairs (e.g., a picture of a train and the word “train”). In
this study, the typically developing control group exhibited signs of recognition when there was
an incongruence, or a mismatch, in the picture and sound, whereas the group with ASD only did
so in the environmental sound condition, not in the word condition. The authors concluded that
children with ASD have deficits in the automatic activation of semantic representations in the
verbal domain, more so than the nonverbal (but still auditory) domain.
Kamio and Toichi (2000) found that individuals with ASD display a preference for visual stimuli over verbal stimuli. The participants were presented a picture or word on a paper card in order to facilitate semantic priming and then were asked to look at a card with a word fragment and orally produce any words that came to mind. The participants with ASD performed better with pictures and words (e.g., a picture of a bathroom and the word “toothbrush” said aloud) than with only word pairs (e.g., the words “toothbrush” and “bathroom”), in contrast to their typically developing peers, who performed better with word pairs. Although performance was not significantly different across groups, the group with ASD demonstrated functional asymmetry between the visual and verbal semantic systems. This is not unlike the children with SLI, who also demonstrated challenges integrating visual and verbal stimuli.

Global and Local Processing

Global and local processing may be another possible differentiating factor during tasks of word learning in children with SLI and ASD. Global and local processing have been addressed in research with individuals with ASD more so than in individuals with SLI. This is most likely due to the idea that individuals with ASD have weak central coherence, or challenges seeing the “big picture” (Happé, 2005). “Central coherence” is the term used to describe the “everyday tendency to process incoming information in its context – that is, pulling information together for higher-level meaning – often at the expense of memory for detail” (Happé, 1999, p. 217). It has been hypothesized that weak central coherence is a cognitive variation that affects visuospatial and verbal tasks and is at the core of ASD.
Global and Local Processing in SLI

Although visuospatial tasks of children with SLI have been studied (e.g., Schul et al., 2004), less is known about their abilities to process global and local information. Akshoomoff, Stiles, and Wulfeck (2006) studied children with SLI and typically developing children on the Hierarchical Forms memory task and on the Rey-Osterrieth Complex Figure (ROCF) task in order to determine if children with SLI have specific visuospatial processing deficits in regard to local and global processing or whether their performance reflects a more generalized developmental delay.

The Hierarchical Forms task required the participants to study visual stimuli constructed in a way such that there was a larger image of a symbol, which was composed of many smaller symbols, different from the large symbol they were composing. They were presented the drawing for ten seconds to study, then given a 30-second distractor task, and finally asked to reproduce the drawing from memory. The authors found that the children with SLI were less accurate than the typically developing group, but the groups did not differ in accuracy with respect to global and local levels. The authors concluded that the children “may adopt simpler or more immature processing strategies… but global or local processing would not be selectively affected” (Akshoomoff et al., 2006, p. 471).

Children with SLI did more poorly than the typically developing group on the ROCF task, also. The ROCF task required the groups to reproduce a drawing from memory, and performance on this task is known to correlate to visuospatial processing abilities. The results showed that children in the SLI group drew fewer details, less accurate figures, and more
incorrect cluster placement than the control group. The authors stated that the group with SLI used a less accurate, immature strategy when copying the figure, overall, and tended not to draw the main shape in the immediate memory condition, unlike the typically developing group. This indicated differences in visuospatial processing as well as visual memory, but again did not directly reveal differences in global and local processing (Akshoomoff et al., 2006). If individuals with SLI process global and local information typically, unlike children with ASD, it may be a viable way to clinically differentiate between the two disorders.

**Global and Local Processing in ASD**

Individuals with ASD are often characterized as having challenges seeing the whole, or global, aspect of a stimulus and instead are attuned to individual details. This is often described as “seeing the trees, but not the forest” (Robertson et al., 2014, p. 2588). Robertson et al. (2014) used a coherent motion perception test, “likened to watching a group of leaves glimmering on a tree,” and asked young adult participants to judge in what direction the “wind” was blowing (p. 2590). Using a functional MRI, the authors aimed to localize activity in the visual areas or decision-related areas of the brain to identify “atypical neural responses at… the earliest level of visual processing” (p. 2589). Results showed that accuracy was not different between the two groups, but there was a difference in the amount of time needed to identify the movement accurately. The participants with ASD had decreased accuracy when the motion presentation time was short, which indicated an atypical rate of integration of local signals to make up the global whole. The authors attributed the global perceptual deficit that individuals with ASD
experience to differences in visual processing when they are not provided a longer amount of time to complete the task.

Other studies have looked into weak central coherence to explain the global and local processing differences in individuals with ASD. By introducing children with either a current or former ASD diagnosis and children with TLD to a variety of professional paintings, Fitch, Fein, and Eigsti (2015) found that the children with ASD made more local observations about the paintings than the groups with typical development and children who had overcome an earlier ASD diagnosis. Observations that were made about an individual in the painting, a summary description, or an evaluative statement were decided to represent a global focus, while statements surrounding background elements or something not displayed in the painting were considered local descriptors. Because the group with ASD did not produce fewer global details than the other groups, the authors attributed differences in children with ASD to a tendency to focus on specific local details when presented with complex visual scenes under a cognitive load. Fitch and colleagues (2015) also found that symptom severity of ASD did not relate with the global/local focus in the group with ASD, but the relative severity of ASD over a lifespan, not current symptoms, was a predictor of global/local focus.

Contributing to the debate about whether individuals with ASD have a preference toward local information and if this “disrupts” their ability to combine two shapes into a whole object, Olu-Lafe et al. (2014) studied adolescent and adult individuals with ASD and age- and IQ-matched typically developing peers. The participants were asked to choose which shapes (that were altered by color and/or segmented by lines) matched a target shape. Their results revealed that the group with ASD were slower at matching the altered shapes to the target shapes, but
accuracy was similar to the control group. Interestingly, among the participants with ASD, a
scale that measured the participant’s motivation to participate in social situations (i.e., the SRS-
Social Motivation Subscale) was significantly correlated with the rate of response on the shape-
integration task. The authors suggested that there may be a relationship between challenges in
social motivation and performance in cognitive tasks. Additionally, the authors attributed the
slower reaction times to weak central coherence due to the group with ASD experiencing
challenges matching altered shapes to the target.

Kourkoulou and colleagues (2012) encountered results in their study that did not support
weak central coherence. Although they found that individuals with ASD (ages 16-26) had a bias
toward local, rather than global, visual displays, this was not unlike their typically developing
peers. Twelve items were in visual search displays (11 distractors and one target), and the
participants had to recognize whether or not they had seen the displays before by pressing a
button. The authors found that the participants with ASD had more difficulty with novel displays
than their typically developing peers, but this may be attributed to behavioral rigidity. Due to
their challenges with novel displays, the authors predicted that individuals with ASD may focus
narrowly and “would be more distracted by changes in the local context,” but this was not the
same as having the cognitive style of weak central coherence (p. 254).

Additionally, Klin and Jones (2006) wanted to investigate the weak central coherence
hypothesis in individuals with ASD. These authors found that individuals with ASD only
performed more poorly than the control group on a social attribution task and actually did better
than the control group on a physical attribution task. The social attribution task asked
participants to label social attributes to animated shapes, and the physical attribution task
required the participants to recognize visual stimuli as physical, not geometric, phenomena and use the visual stimuli to label the physical attributes. If the group with ASD performed more poorly than the control group on the physical attribution task, it would have supported the hypothesis of weak central coherence due to the requirement of seeing a whole object out of numerous objects (e.g., multiple shapes creating the shape of a rocket). Because the group with ASD did better on the physical attribution task, the results did not support the idea that individuals with ASD have weak central coherence, which contradicted previous research in this area (Happé, 2005). Happé (2005) suggested that using open-ended tasks was the best way to capture weak central coherence in individuals with ASD, due to the inability of having forced choices in a question that demands the participant to formulate his or her own answers. The current study investigated how open-ended questions influence the use of global and local semantic features in children with ASD.

Inferencing

Inferencing is the “abstraction of information that is not explicitly presented” (Botting & Adams, 2005, p. 3) and is another skill that is often studied in children with SLI and ASD. The ability to make inferences requires many different skills and can affect normal language development. Inferencing relies on comprehension and the ability to think about multiple concepts at once and make connections between them.

Vocabulary size is linked to inferencing skills in typically developing children, indicating that inferencing skills play a role in one’s ability to learn new words. Lepola and colleagues (2012) found that inferencing skills contributed to vocabulary knowledge in a narrative listening
context, even when controlling for earlier vocabulary knowledge and sentence memory in a group of typically developing children (ages four to six). Also, Cain, Oakhill, and Lemmon (2004) found that children with below-average vocabulary and reading comprehension had challenges inferencing the meanings of novel words from context. Therefore, it may be that children who have challenges in building vocabulary (e.g., children with SLI and ASD) have difficulties with inferencing as well. Depew and Veale (2010) studied typically developing children, ages four to twelve, and gave them a test of inferencing. The test required them to use information from a scenario and answer questions that elicited inferencing. Their results found that children in the older groups were more accurate than the younger groups. Also, the study found that there were types of inferences that were more challenging, such as cause-effect inferences. This research supports the idea that as children with TLD grow older, their abilities in inferencing become more accurate. Inferencing may contribute to how children with SLI and ASD define new words and how they build upon their semantic representations of newly learned words over time.

Inferencing in SLI

Inferencing has been thought to be difficult for individuals with SLI (e.g., Botting & Adams, 2005). Adams, Clarke, and Haynes (2009) found that children with language impairments performed similarly to younger children on a verbal inference comprehension task. In their study, they gave children with SLI, children with pragmatic language impairment (PLI) who did not have a current ASD diagnosis, and children with TLD an inferential comprehension task. A portion of the TLD group was matched for gender and chronological age, and the
remaining were matched for gender and sentence comprehension. The task required the children to answer questions about a story they were told. The questions were designed to elicit “simple causal inferences” (p. 307). The authors looked for relevant, mature inferences that could have been expected and based on the participants’ past world knowledge in their answers. They found that the groups with language impairment scored lower than their age-matched peers and similarly to the group with TLD that was matched on sentence comprehension.

Botting and Adams (2005) also gave an inferencing task to their groups with pragmatic difficulties, SLI, and TLD. They told a story and gave questions that had closed-ended options (e.g., yes and no). They designed their questions to provide logical inferences (relationships between referents), bridged inferences (new information is related to older information), and elaborative inferences (information from world knowledge is used). Results indicated that the children in both clinical groups scored more poorly than their age-matched peers, but neither group showed differences that were significant from younger children, a finding reminiscent of the Adams and colleagues (2009) study.

Norbury and Bishop (2002) studied the story recall and inferencing abilities of children with ASD, SLI, pragmatic language impairment (PLI), and TLD. To elicit inferencing, the participants were told short stories and asked specific questions. The results indicated that all the participants could make inferences, and did so; however, the three clinical groups performed less accurately than their age-matched peers with typically developing language. Often, the clinical groups provided incorrect inferences that did not suit the story’s context. For the group with ASD, the authors attributed this to weak central coherence. For the children with SLI, the authors attributed errors to deficits in short-term verbal memory. The authors postulated that the
participants in the clinical groups had difficulties in “suppressing irrelevant information… the child [provided] the most typical response related to his own experience” (p. 246). A point of interest was that there were no sharp divides between the different developmental disorders for the type of errors in inferencing. Also, children who had better story recall also had superior inferencing, which could mean that inferencing supports comprehension, or vice versa.

Inferencing in ASD

Norbury and Bishop (2002) found similarities between children with SLI and ASD in inferencing abilities, and although there were no differences between the three clinical groups (SLI, PLI, and ASD), the group with ASD tended to have the lowest scores on the inferencing questions. These deficits could not be attributed to general language skills, but the authors found that more symptoms of ASD (as indexed by the ADOS-G) correlated with poorer inferencing in this study. It may be that the ADOS is predictive of inferencing abilities, due to its measurement of the severity of behaviors related to ASD.

As with the children in the Norbury and Bishop (2002) study, the children with ASD in a study by Dennis, Lazenby, and Lockyer (2001) often had difficulties suppressing knowledge from their own experiences, as shown by their incorrect inferences that were from fixed knowledge. The participants in the Dennis and colleagues (2001) study made inferences from text to fixed knowledge more easily than from text to local sentence context, despite having a typical verbal IQ and group IQ scores close to the population mean. The participants with ASD also failed to make inferences about “mental state verbs when in a context… make inferences about social scripts, understand metaphors… and to produce speech acts” as well as their
typically developing peers (p. 47). Together, these studies demonstrate that children with SLI and ASD often have difficulty making appropriate and accurate inferences as readily as their peers with TLD.

Processing in SLI and ASD and the Current Investigation

Visual and verbal processing in SLI (for visual processing, see Norrix et al., 2007, and Schul et al., 2004; for verbal processing see Alt & Plante, 2006; McKean et al., 2014) and ASD (for visual, see Erdödi et al., 2013, and Robertson et al., 2014; for verbal and visual, see Kamio & Toichi, 2000; for verbal, see McCleery et al., 2010) is different from typically developing peers. All of the aforementioned studies emphasize the role of visual and verbal processing on recognition and comprehension, but little to no research has explored how strengths in one modality (visual or verbal), relative to the other, may be predictive of which words and semantic features individuals with SLI and ASD learn to use and produce. Additionally, there is uncertainty how global processing affects children with ASD’s semantic representations. It is unknown if this will be reflected by an increased number of local details (e.g., nose, tail, feet on a cat), rather than whole-object information (e.g., cat), during the production of word definitions. If so, this may be a way to differentiate children with SLI and ASD. Another area of processing, inferencing, could also affect language production in individuals with SLI and ASD. For example, an inability to create inferences as well as typically developing peers may cause children with SLI and ASD to communicate less effectively, as well as cause challenges in learning new words, semantic features, or other important information that is often expected in conversation and academic subjects. All of these areas contribute to the defining of new words
through semantic representations and can be analyzed to uncover how differences in processing affect the learning of novel words in children with SLI and ASD.

Research Questions

This study investigated how known processing differences (verbal vs. visual, local vs. global, and inferred vs. explicit) in children with SLI, ASD, and TLD can be used to explain differences in semantic learning observed in these three groups. By using previously collected novel word definitions and labels from an extended word learning study, this investigation explored three main questions. First, which presentation modality (visual, verbal, or a combination of the two) do children with SLI, ASD, or TLD primarily use when learning new words? For example, was a semantic feature produced in their definition originally taught verbally, visually, or through both modalities? Individuals with ASD have been found to process visual and verbal information differently from their typically developing peers (Kamio & Toichi, 2000). It has been speculated that children with ASD are visual learners, which has led to visually cued instruction (Quill, 1997). If children with ASD use visual cues more than their typically developing peers, they may rely on the visual modality more heavily than the other groups to learn the semantic information. Also, children with SLI are slower at visual processing (Schul et al., 2004) and have demonstrated semantic integration deficits due to weaker verbal processing (Cummings and Čeponienė, 2010). Because of deficits in both the verbal and visual domains, it was predicted that children with SLI and ASD would produce semantic features that were both verbally and visually presented, due to the extra reinforcement provided.
Second, this study explored whether children with SLI, ASD, and TLD demonstrate differences in local or global processing in their production of novel word definitions by focusing on a local part or whether they describe the novel object as a whole. It has been posited that individuals with ASD process on the local level rather than the global, which may affect semantic processing and provide another way to differentiate SLI and ASD (Kuschner et al., 2009). If a participant included features that were focused on a more local part, for example, ears or a tail rather than recognizing the entire animal, then they would most likely be processing details, which has been thought to be a characteristic trait of ASD (Robertson et al., 2014). Children with SLI demonstrated differences in the ROCF drawing task compared to the typically developing group, but the authors were unable to attribute this difference to local and global processing deficits (Akshoomoff et al., 2006). This study investigated whether global and local processing is a way to differentiate SLI and ASD using a basic definition task. Because individuals with ASD are often characterized as having weak central coherence, it was predicted that the group with ASD would provide more local parts than global features, compared to the groups with SLI and TLD.

Finally, this study aimed to discover whether the semantic features each group included in their novel word definitions were explicitly taught or were inferred. Using information that was not directly taught may be difficult for some individuals with ASD, who have demonstrated deficits in the multiple meanings of words and their interpretations without explicit instruction (Norbury, 2005). Children with SLI have also demonstrated challenges with tasks that require conceptual knowledge to understand new situations (Botting & Adams, 2005). Determining whether children with SLI and ASD fail to utilize inferencing skills as they build semantic
representations of new words would be helpful in shaping future language instruction. In this case, explicit instruction may be a more useful teaching cue to help these children learn new semantic features as they incorporate new words into their mental lexicon, and it was predicted that the groups with SLI and ASD would provide more features that are explicitly taught than inferred.
CHAPTER 2

METHODS

Participants

Data from the participants with SLI and TLD in this study were obtained from a longitudinal study exploring language and motor relationships in children with SLI (Goffman, ongoing) at Purdue University, and the data from the participants with ASD were from an additional study investigating word learning in children with ASD (Gladfelter, 2014). In total, data from 12 children with SLI ($M = 85.08$ months old, range 69-101 months old, three females), 12 children with ASD ($M = 93.83$ months old, range 55-135 months, three females), and 12 children with TLD ($M = 71.83$ months old, range 52-88 months, six females) were included in this study.

Participants across all groups were matched on their raw expressive vocabulary scores on the *Expressive Vocabulary Test-II* (Williams, 2007) (see Table 1; RS = raw score, SS = standard score). Children in each group passed an oral-mechanism examination and a bilateral pure tone hearing screening and were monolingual English speakers. To be included in the study, each participant had to obtain a nonverbal IQ score of 85 or higher on either the *Primary Test of Nonverbal Intelligence* (PTONI; Ehrler & McGhee, 2008), the *Columbia Mental Maturity Scale* (CMMS; Burgemeister, Blum, & Lorge, 1972), or the *Test of Nonverbal Intelligence*, Fourth ed.
(Brown, Sherbenou, & Johnson, 2010), with the exception of one participant (ASD1) who could not be trained to the task. Her data are still included because she was able to successfully participate in the experimental study and her expressive vocabulary score was matched to a control participant.

Table 1. Participant Characteristics

<table>
<thead>
<tr>
<th></th>
<th>SLI n = 12</th>
<th>ASD n = 12</th>
<th>TLD n = 12</th>
<th>F value</th>
<th>p value</th>
</tr>
</thead>
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<tr>
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<td></td>
<td></td>
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<td>5;9 years</td>
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<td>(4;5 – 11;2)</td>
<td>(4;3 – 7;3)</td>
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<td></td>
</tr>
<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>3 F, 9 M</td>
<td>3 F, 9 M</td>
<td>6 F, 6 M</td>
<td>1.10</td>
<td>0.34</td>
</tr>
<tr>
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<td>88.67</td>
<td>94.5</td>
<td>1.41</td>
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</tr>
<tr>
<td></td>
<td>(67 – 97)</td>
<td>(53 – 120)</td>
<td>(68 – 128)</td>
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</tr>
<tr>
<td><strong>EVT-2 Standard Score</strong></td>
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<td>95.75</td>
<td>114.83</td>
<td>15.66</td>
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</tr>
<tr>
<td></td>
<td>(78 – 106)</td>
<td>(79 – 112)</td>
<td>(91 – 135)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Note. EVT = Expressive Vocabulary Test-II (Williams, 2007); F = female, M = male*

Criteria for SLI outlined by Leonard (2014) were used when qualifying participants for the group with SLI. During their initial year in the longitudinal study (Goffman, Purdue, ongoing), each participant obtained a standard score below 87 on the *Structured Photographic Expressive Language Test- Preschool – 2nd ed.* (SPELT-P2; Dawson et al., 2005; for SPELT-P2 inclusion criteria, see Greenslade, Plante, & Vance, 2009). Also in their initial year of participating in the longitudinal study (Goffman, Purdue, ongoing), the children in the TLD group achieved age-appropriate scores (a standard score of 85 or higher) on the *Structured Photographic Expressive Language Test – 3rd ed.* (SPELT-3; Dawson, Stout, & Eyer, 2003) or
the core battery of the *Clinical Evaluation of Language Fundamentals – 4\(^{th}\) ed.* (CELF-4; Semel, Wiig, & Secord, 2003).

In the group with ASD, each participant had an independent diagnosis of and services for ASD per parent report. It was also required that each participant with ASD obtain a score in the autism range on the *Autism Diagnostic Observation Schedule – 2\(^{nd}\) ed.* (ADOS-2; Lord et al., 2012) to confirm their medical diagnosis of ASD. All participants were recruited from Tippecanoe County and its surrounding counties and were tested after receiving approval from the Purdue University IRB protocols for the treatment of human subjects (Gladfelter, 2014).

**The Word Learning Paradigm**

The semantic richness of four novel-word referents was the primary manipulation in the Gladfelter (2014) study. The referents were presented either with no semantic cues, sparse semantic cues, or rich semantic cues. In each of these conditions, each novel word was presented seven times. To track learning over time, all three conditions were given to all participants on three separate days (or 21 total exposures per novel word across all sessions). The no semantic cues condition presented the novel words with different colorful nonsense images that did not have a referent. The sparse semantic cues condition presented the instrument and the tool images in synchrony with their respective auditory stimulus (the novel word). The rich semantic cues condition embedded the vehicle and the animal referents in a children’s story, with both visual and verbal semantic descriptors. During a post-test, the participants were asked to define the novel words.
Definitions

Following the novel word learning paradigm, each participant was asked to define novel words following open-ended examiner prompts: “What does ____ mean?” followed with “What else can you tell me about _____?” (McGregor et al., 2007). These open-ended prompts are unlike some past studies (e.g., Botting & Adams, 2005) which limited their participants to two choices (e.g., “yes” or “no”). Closed-ended choices may not obtain results that are as accurate of what the child knows about a novel word (Happê, 2005). A total of 432 definitions (36 participants X 4 definitions X 3 sessions) from this word learning study provided the data for the current study.

Auditory Stimuli

The novel words used in the original study, which were presented auditorily, consisted of six two-syllable phonetic strings: /fʌʃpəm/, /pʌvgəb/, /bʌpkəv/, /mʌfpəm/, /fʌspəb/, and /pʌbtəm/. Because phonotactic probability and neighborhood density influence a word’s learnability (e.g., Hollich et al., 2002; Storkel, 2001), the phonotactic probability and neighborhood density for the stimulus words were controlled. Recordings of a female native-English speaker reading the story scripts and novel words were loaded into Praat (Boersma & Weenink, 2012) to equate the auditory stimuli for intensity (70 dB HL). These novel words were then presented in synchrony with a matched visual referent in order to attain true word status through a set of external speakers placed in front of the participants. These word-referent pairings were randomized and counterbalanced across participants and groups.
Visual Stimuli

Four cartoon-like visual images were used as visual referents for the novel words (Pounders, Steve, unpublished). Each referent resided in a distinct superordinate semantic category (Gladfelter, 2014). One image appeared as an instrument (Figure 1), one a tool (Figure 2), one a vehicle (Figure 3), and one an animal (Figure 4). The visual stimuli were delivered to participants using Microsoft PowerPoint from a laptop, which was connected to a 76.2 cm Dell monitor screen.

Figure 1. Instrument sparse-cue visual referent.
Figure 2. Tool sparse-cue visual referent.

Figure 3. Vehicle rich-cue visual referent.
Semantic Features

The definitions from the Gladfelter (2014) study were scored for the number of accurate units of information (i.e., semantic features), based on the method used in McGregor, Sheng, and Ball (2007). For example, one participant defined the novel vehicle target as follows: “In the story, Big Brother said his pæbtæm makes donuts [1]. He said it’s shiny [2], and it looks like a motorcycle [3] and it goes faster [4] and faster!” In this example, the child’s definition contained four accurate units of information about the meaning of the target word. In the original Gladfelter (2014) study, a second coder without knowledge of the predictions of the study was trained to calculate the reliability for the number of accurate units of information produced.
For the training, three participants (one from each diagnostic group) were randomly selected using a random number generator, and both coders scored the definitions separately for the number of accurate semantic features. Then within the context of training, consensus building for disagreements was conducted, and disagreements were thoroughly discussed. For the reliability scoring, a new set of definitions from 25% of all sessions equally distributed across groups was selected using the same random number generator to select the participant numbers. The total number of semantic features identified by the author was 270 and by the second coder was 284, with an overlap of 269 semantic features. Reliability was then judged to be between 94.7% (269/284) and 99.6% (269/270). For the current study, the semantic features from all 432 definitions were analyzed based on whether the semantic information was presented verbally, visually, or through both modalities; whether the semantic information was a global or local attribute; and whether the feature was derived through inferencing or if it was taught explicitly.

Data Collection

The semantic features from the 432 definitions collected in the Gladfelter (2014) study were used in the current study. The primary investigator coded all of the 36 participants’ semantic features. To help prevent bias, the principal investigator was blind to the diagnostic category of each participant using a de-identifying alphanumeric coding system devised by the principal investigator’s thesis mentor. The definitions were typed into a Microsoft Word document and placed with the manual (Appendix A) in an individual binder. The principal investigator then used an Excel worksheet with the coding tool (Appendix B) on her personal laptop to code the participants’ definitions. The coding tool was designed with the following
areas in mind: modality (visual, verbal, or both), processing level (global or local semantic descriptors), and learning mechanism (was the information in the definition inferred or explicitly shown/told in the image or story). With the use of preliminary data, a power analysis revealed that a minimum sample of 44 definitions was necessary to identify a significant effect with an alpha level of .05 and a power of .80. This sample came from comparing the mean proportion of visual semantic features produced in the groups with TLD \( (M = 0.4030, SD = 0.4563) \) and ASD \( (M = 0.5977, SD = 0.4485) \). Based on this power analysis, the use of 432 definitions ensured there was enough power to appropriately reject the null hypothesis.

**Reliability and Training**

To assess the inter-rater reliability of the semantic feature coding, one undergraduate research assistant majoring in communicative disorders at Northern Illinois University coded 25% of the definitions (i.e., data from nine participants). These were chosen using a random number generator to select the participant numbers, with an equal distribution across the three diagnostic groups. The selection of 25% of the total data collected fits within the criteria used by Schlosser (2007), which recommends inter-rater reliability be conducted between 20 – 30% of the total data. Reliability training of the undergraduate research assistant included one day (approximately 3 hours) of going over the manual, practicing coding under supervision, and answering questions. The randomly selected set of participants used for the final reliability coding did not include any used during the initial training and were also de-identified using the same alphanumeric system to blind the undergraduate coder and the primary investigator of the diagnostic category of each participant. Disagreements were discussed and then consensus
building took place. When agreements could not be reached, the primary investigator’s coding was utilized during final data analysis.

To determine inter-rater reliability, Cohen’s kappa was derived before consensus building took place. Following the ratings described by Hallgren (2012), the kappa statistics for the modality measure (i.e., visual, verbal, or both) indicated perfect agreement (k = 1.00). For the processing-level coding, there was almost perfect agreement (k = .932 with a 95% confidence interval of .881 - .983), and for the learning mechanism coding, there was again nearly perfect agreement (k = .876, with a 95% confidence interval of .770 - .982).

Coding of Semantic Features

To investigate how each level of processing (verbal vs. visual vs. both, local vs. global, and inferred vs. explicit) contributes to the formation of a word’s semantic representation, each semantic feature was coded following the rules detailed in a coding manual that was developed by the primary investigator (see complete manual in Appendix A).

Coding Manual and Tool

The coding manual was designed to promote consistency across coders and to explain the coding process to the undergraduate research assistant. It was decided that one research assistant, with consistency in the coding process as demonstrated by practice trials, would code participants to account for reliability. The “Introduction” section introduced the thesis project, recognized the undergraduate for her participation and effort, and gave an overview of the coding tool (see Appendix B), which was a Microsoft Excel sheet tailored to manage the
proposed coding system. The coding tool included the following areas for coding: (1) “Definition Details,” (2) “Accuracy,” (3) “Modality,” (4) “Learning Mechanism” and (5) “Processing Level.” The heading “Accuracy” remained in the coding tool but was not utilized in the current study.

The aim of the coding tool was to provide an efficient and accurate way to code the semantic features provided in the participants’ definitions. In the coding tool, under “Definition Details,” there was: (1) “Participant ID,” or the anonymous alphanumeric identification label for each participant; (2) “Group,” which was either ASD, SLI, or TLD; (3) “Session #,” which included a number from 1 to 3 to indicate which session the definition was taken from to track learning over time; (4) “Target Referent,” which included either instrument, tool, animal, or vehicle, depending on what target referent was used to elicit the definition from the participant; and (5) “Feature (word),” which was a semantic feature from the child’s definition that was coded using the “Accuracy,” “Modality,” “Learning Mechanism,” and “Processing Level” columns. The word(s) in the “Feature (word)” column were selected from the Gladfelter (2014) stimuli prior to this study. During the coding process, the “group” was blinded to each coder (the author and the undergraduate research assistant) and replaced with a number (1, 2, or 3) until after the data was analyzed in order to prevent biases. Each semantic feature received its own row in the coding document. This study’s undergraduate research assistant was instructed to use the bolded words provided in the definitions as the semantic feature.
Modality

This measure was used to address the first research question, exploring whether children with SLI or ASD processed visual or verbal information differently from children with TLD. The heading of “Modality” included the following columns: (1) “Visual,” in which a “1” indicated whether the semantic feature was provided in the image for the target referent; (2) “Verbal,” which was marked as “1” if the semantic feature was from the auditory stimuli (this only applied to the animal and vehicle target referents which were embedded in a children’s story); and (3) “Both,” which was marked as “1” if the semantic feature was taught through both the visual (picture) and verbal (story) modalities. A “0” was marked where the semantic feature did not meet the description of the column heading.

An example for a verbally presented semantic feature would be: “It’s Little Sister’s favorite” for the target referent animal based on the story script from the original word learning paradigm. In contrast, if the child described the target referent with a feature that was shown in the picture and stated in the story (e.g., “shiny” for vehicle), then the “Both” column was marked with a “1.” Because the instrument and tool referent definitions were not originally taught with both visual and verbal cues, they were excluded from the modality analysis. Therefore, the number of definitions analyzed for modality was 216 in total (the “animal” and “vehicle” referent definitions solely).
Processing Level

The definitions’ semantic features were analyzed to see if they pertained to a local detail or global object visualized in the images, addressing the second research question. This was only used for visual stimuli and only for nouns that could easily be categorized as local or global aspects of the image. To analyze “Processing Level,” the coders decided if the semantic feature was either: (1) “Global (whole object),” (2) “Local (details or parts),” or (3) “N/A,” indicating coding was not applicable. The coders placed a “1” under “Global (whole object)” if the participant provided a semantic feature that described the target referent as a whole. Or, the coders coded “Local (details or parts)” as “1” if the participant chose a semantic feature that described a part or detail of the target referent. For example, if the child said “antennas” for the animal target referent, it was coded under “Local” because this part of the animal was not the whole, and pertained to a specific attribute of the animal. If the child said a feature such as “pet,” it was marked as “Global (whole object),” because it was referring to the whole referent (superordinate category).

Not every semantic feature was marked for local or global processing because not all semantic features were able to be coded as global or local (e.g., the semantic feature was an action, emotion, or descriptive word). In this case, the coder marked a “1” in the column “N/A.” For example, the coder marked a “1” if the child said “gives kisses” because it could not be separated into global or local parts. This scoring helped determine if participants with SLI and ASD were more likely to learn the target referents as a whole, or in detailed parts, compared to children with TLD.
In order to address the third research question, the definitions were analyzed according to whether the semantic features were explicitly taught or were inferred. For explicit information, the heading “Learning Mechanisms” in the coding manual provided the column “Shown/Told (explicit).” This was coded as “1” if the semantic feature provided was directly presented in either the pictures or embedded within the story. A “0” was placed in this column if the opposite was true (i.e., it is not a semantic feature gained through explicit information). An example of a feature that was “Shown/Told (explicit)” was if the participant said “blue” and “big” for the target referent vehicle because it was depicted as blue in color in the story images and was directly quoted as being “blue and big” within the story script. It was also decided that colors and labels prescribed to nouns would be coded as “Shown/Told (explicit)” because they were semantic features the child acquired from the images (e.g., “gold” for the target referent instrument and “trumpet” for the target referent instrument). Auditory information provided within the story (e.g., “It’s Little Sister’s favorite” for the target referent animal) was additionally coded under this heading. The coders of the definitions referred to their script and pictures when coding for “Shown/Told (explicit).”

In order to determine if participants were using inferencing, the definitions for semantic features that utilize background or prior knowledge to describe the target referent were analyzed. The “Learning Mechanism” heading included “Inferred (implicit),” which was coded for semantic features that were not coded as “1” in the “Verbal” or “Both” columns of the “Modality” heading and were also judged to be from the participant’s prior knowledge. As a first
check to determine whether the feature qualified as “Inferred (implicit),” it could not have been pictured in the images or stated in the story script. Second, if the semantic feature was a noun or a label of the target referent, it was impossible to determine whether the information was garnered from the visual image (e.g., “trumpet” for instrument) or previous knowledge. To provide the most conservative estimate of inferencing skills possible, the semantic feature was required to be a verb (e.g., “plays music” for the target referent instrument) or an adjective (e.g., “friendly” for the animal target referent) in order to be coded as “Inferred (implicit).”

Statistical Analyses

Coding categories (modality of presentation, processing level, and learning mechanism) were examined in two ways. First, potential diagnostic category differences in the type of semantic features produced were examined. This was done using mixed-model ANOVAs with diagnostic group (SLI, ASD, and TLD) as a between-subjects variable. Because participants provided different raw numbers of semantic features within each definition, the proportion of responses within a coding category was calculated individually. Then, the derived coding means of the proportions of responses across all three sessions for each category type (modality of presentation, processing level, and learning mechanism) served as the within-subjects variables. For all statistical analyses, a .05 alpha level was considered significant. To address the first research question, asking which presentation modality (visual, verbal, or a combination of the two) do children with SLI, ASD, or TLD primarily use when learning new words, a 3 (SLI vs. ASD vs. TLD) X 3 (visual vs. verbal vs. both) mixed-model ANOVA was used. To address whether children with SLI, ASD, and TLD demonstrate differences in local or global processing
in their production of novel word definitions, a 3 (SLI vs. ASD vs. TLD) X 2 (global vs. local) mixed-model ANOVA was used. In order to discover whether the semantic features each group included in their novel word definitions were explicitly taught or were inferred, a 3 (SLI vs. ASD vs. TLD) X 2 (inferencing vs. explicit) mixed-model ANOVA was conducted.
CHAPTER 3

RESULTS

Modality of Presentation

Main Effects

The first set of analyses addressed the question of which modality (visual, verbal, or both) do children with SLI, ASD, and TLD use when learning new words. The definitions with the animal and vehicle target referents were analyzed, and this consisted of 216 in total (the instrument and tool target referents were not analyzed because they were not taught with a verbal description). A significant main effect regarding the modality used during the novel word learning paradigm was observed, $F(2, 212) = 198.02, p < .001, \eta_p^2 = .651$. A Tukey HSD test indicated that the participants produced more semantic features that were derived from the visual modality and in both modalities in combination than in the verbal modality alone (see Figure 5, error bars represent standard error).
Group Differences

There was a significant interaction between modality and group, $F(4, 426), p < .001$, $\eta^2_p = .050$ (see Figure 5). A follow-up Tukey HSD test indicated that the groups with SLI and ASD produced significantly more visually presented semantic features than the group with TLD. There was no significant difference between the groups with SLI and ASD ($p > .05$). Also, there were no significant differences between the groups (SLI, ASD, and TLD) in the verbal modality alone nor in their production of semantic features that were presented in both the visual and verbal modalities combined (all $p$ values greater than .05).

Figure 5. Modality of presentation by group.
Processing Level

Main Effects

To discover if children with SLI, ASD, and TLD demonstrated differences in local and global semantic feature production, this study analyzed the definitions for all referents (tool, instrument, vehicle, and animal). Only data that could be determined as a part (local) or the whole (global) were directly compared; the following data does not include semantic features that were coded under “not applicable.” A significant difference between the proportion of global and local semantic features in the definitions was observed, $F(1, 965) = 45.59, p < .001, \eta^2_p = .045$. A follow-up Tukey HSD test indicated that more global semantic features were produced than local semantic features in their definitions of the novel words.

Group Differences

A mixed-model ANOVA revealed significant differences between the groups, $F(2, 965) = 9.37, p < .001, \eta^2_p = .019$. A Tukey HSD test indicated that the groups with SLI and ASD produced significantly more global descriptors than the group with TLD; the groups with SLI and ASD did not significantly differ from each other. In addition, there were significant differences for local processing between groups ($p$ values $>.05$); a Tukey HSD test indicated that the group with SLI produced significantly fewer local semantic features than their typically
developing peers. There were no significant differences between the group with SLI and the group with ASD or the groups with ASD and TLD (all \( p \) values > .05; see Figure 6, error bars represent standard error).

![Figure 6. Processing level by group.](image)

Learning Mechanism

Main Effects

There was a significant effect for the use of semantic features that were inferred compared to explicitly derived in the novel word definitions, \( F(1, 965) = 859.80, p < .001, \eta^2_p = .471 \). A follow-up Tukey test revealed that all three groups of children produced more explicitly taught semantic features than features that were inferred (see Figure 7, error bars represent standard error).
The children with SLI and ASD produced semantic features that were inferred or explicitly taught in the same manner as children with TLD, $F(2, 965) = 1.41, p = .245, \eta^2_p = .003$ (all $p$ values > .05). The groups with SLI, ASD, and TLD produced explicitly taught and inferred semantic features similarly to each other.

**Figure 7. Learning mechanism by group.**

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**Group Differences**

The children with SLI and ASD produced semantic features that were inferred or explicitly taught in the same manner as children with TLD, $F(2, 965) = 1.41, p = .245, \eta^2_p = .003$ (all $p$ values > .05). The groups with SLI, ASD, and TLD produced explicitly taught and inferred semantic features similarly to each other.
CHAPTER 4

DISCUSSION

The results of this study offer insights into how well-known processing differences in children with SLI and ASD affect their later learning and production of semantic features. In order to better understand how differences in verbal and visual processing, global and local processing, and inferencing shape the output of semantic features in word definitions, 432 novel word definitions were analyzed. This information will help clinicians, researchers, caregivers, and educators better assist children with SLI and ASD to develop rich semantic representations, which can impact their academic performance and language abilities. Also, these results continue to reveal similarities in how children with SLI and ASD acquire new words, reinforcing the need to consider symptoms other than language alone when making a differential diagnosis.

Differences in Visual and Verbal Processing Influence Semantic Learning in SLI and ASD

Children with SLI and ASD Benefit from Visual Cues When Building Semantic Representations

The groups with SLI and ASD both produced more visual semantic features in their definitions than the children with TLD, illustrating their reliance on visual input when learning new words. This finding is consistent with the widespread use of visual cues in order to aid in language comprehension and communication, organizational skills, and self-management in
children with SLI and ASD (Quill, 1997). Also, visual supports have been successfully used to help children with SLI improve their syntactic learning (Washington & Warr-Leeper, 2013) and children with ASD improve their overall language development (Quill, 1997). Kamio and Toichi (2000) found that individuals with ASD were more accurate with images than words in a word completion task and called it “pictorial superiority” (p. 864). It could be that the children with SLI and ASD are relying on the visual images to learn about the new words more than their peers with TLD. Taken together, these findings lend support for the use of visual supports to enrich semantic learning in these two populations.

Recently, Trembath, Vivanti, Iacono, and Dissanayake (2015) were interested in discovering the benefits of using pictures and speech and developed an eye-tracking study that incorporated typically developing children, children with global developmental delay, and children with ASD to determine if children with ASD were indeed visual learners. The task required the children to watch eight videos, with an actor asking the child to complete small tasks (i.e., picking up items and placing them in a basket). There were speech-only trials and speech -plus- visual trials. The results did not support a visual learning style in children with ASD because they did not perform better when the visuals were provided. However, the control group and group with global developmental delay performed better when the pictures were shown. The results attained, which were different from the current study, may be due to the participants’ language abilities. Trembath and colleagues (2015) found that task performance was positively correlated to receptive language skills, so it may be that the participants in the current study had stronger receptive language skills and therefore were able to use the visuals provided in their novel word definitions. Also, Trembath and colleagues (2015) mentioned that
visual learning may not be “obvious at the point of teaching, but… becomes evident when children are challenged to recall previously learned information” (p. 3286). The current study asked for the recall of previously learned knowledge, so this may also be a reason the participants with ASD used many visual semantic features in their definitions.

One possibility as to why the current study found an increase in the use of visual semantic features in the definitions from the groups with SLI and ASD may have to do with how the visual information was presented. Research has found children with SLI and ASD demonstrate improved visual processing when provided more time to study the visual stimuli (for SLI, see Schul et al., 2004; for ASD, see Robertson et al., 2014). In this study, the vehicle and animal visual referents were shown to the children in the story at a comfortable pace, which may have allowed the children with SLI and ASD to overcome any visual processing difficulties. Children with ASD also have been found to prefer picture-word pairs in comparison to word-word pairs (Kamio & Toichi, 2000). This pictorial-word superiority for the children with ASD may explain why the current study found that the children with ASD relied more on visually presented semantic features than the group with TLD.

Even though the children with SLI and ASD seem to benefit from the use of visual information during tasks of word learning, images are not always forthcoming about the deeper aspects of a word’s full meaning; there is only so much information that can be attained from an image. In comparison, verbally presented input may provide more semantic depth to a word’s meaning, such as figurative uses (e.g., idioms), alternative interpretations or multiple meanings, and mental state information. These semantic features have been known to be aspects of language learning that children with ASD and SLI struggle to acquire (for SLI and ASD, see
Norbury & Bishop, 2002, and Norbury et al., 2010; for SLI, see McGregor et al., 2013, Roqueta & Estevan, 2010; for ASD, see Dennis et al., 2001, Kostyuk et al., 2010, Loukusa et al., 2007, McGregor et al., 2012b).

Difficulties with Verbal Processing Do Not Prevent Children with SLI and ASD from Learning Verbally Presented Semantic Information

The children with SLI and ASD used verbally provided semantic information as often as the group with TLD in their novel word definitions. Verbal processing has been widely investigated in children with SLI and ASD. Challenges in verbal processing have been thought to be the underlying cause of delayed first word productions in children with SLI (Trauner et al., 1995) and with ASD (Kostyuk et al., 2010). Children with SLI show deficits in phonological processing during tasks of word comprehension and production (Alt & Plante, 2006, and Gray, 2005). In contrast, children with ASD have demonstrated relative strengths in phonology. But, their understanding of semantic features did not relate to their phonological knowledge (Norbury et al., 2010). Because of these established challenges in verbal processing, it was expected that the children with SLI and ASD would have produced fewer verbally acquired semantic features than their typically developing peers. To interpret this seemingly counter-intuitive finding, one major methodological consideration must be taken into account. Because a naturalistic learning context (i.e., a children’s story) was employed to introduce the new words, most of the verbal input was reinforced with co-occurring visual images. This limited the number of opportunities for the children to absorb purely verbal information that was not presented in combination with a visual portrayal. Due to this previous design decision, it is difficult to know whether the children
with SLI and ASD would have performed similarly to their typically developing peers if more information had been presented in the verbal modality alone. This is especially difficult to determine, given the abundance of visually presented semantic features the children with SLI and ASD produced on the same task. However, all three groups of children were given the exact same verbal information within the story context, albeit limited, and they all produced a similar number of verbally taught semantic features, with no significant differences between the groups.

In a thoughtful review article on beneficial learning strategies for children with language impairments, Alt and her colleagues (2012) discuss how intervention for populations with language disorders should reflect the principles used in the teaching of typical learners. In this review, the authors state that “stripping away” complexity and context “may not allow a child’s full linguistic knowledge to emerge” (p.489). An example of complexity could be using sentences instead of words in isolation when introducing a new word. This was done in the present study for the vehicle and animal target referents, which were presented in a short story, and may help children with SLI and ASD demonstrate verbal learning that resembles their peers with TLD. Clearly, future studies should continue to investigate whether children with SLI and ASD use verbal information as well as their peers during word learning tasks in order to discover if verbal cues are contributing to their word knowledge, but there is evidence that suggests clinicians may verbally present semantic information to children with SLI and ASD in the same manner as their peers with TLD.
Due to deficits in both the verbal and visual domains, it was predicted that children with SLI and ASD would produce semantic features that were both verbally and visually presented because of the overlap of verbal and visual reinforcements provided in the story format. This has turned out to be an accurate prediction. Using a semantically rich story context similar to those children are exposed to at home and at school, the children with SLI and ASD learned the semantic features as readily as the group with TLD. Importantly, presenting the semantic information through both modalities did not prevent the children with SLI and ASD from learning the semantic features equally as well as their typically developing peers, in spite of weaknesses in processing either modality alone.

Children with SLI and ASD have been found to be significantly different from children with TLD in previous studies that combined auditory and visual stimuli. A weak McGurk effect in children with SLI demonstrated challenges in speech perception not limited to verbal input (Norrix et al., 2007), as well as semantic integration deficits during picture-word trials (Cummings and Čeponienė, 2010). There have been similar findings for children with ASD, as demonstrated by the McCleery and colleagues (2010) study that found they did not respond to the incongruence of matching and mismatching picture-environmental and picture-word pairs, unlike their typically developing peers. Despite these observed differences, the children with SLI and ASD in the present study were able to retrieve and produce verbal and visual information in their novel word definitions. This may be due to the story format, in which verbal and visual stimuli supported one another, unlike previous studies that were designed to test the participants’
abilities to recognize the incongruence of auditory and visual information (Cummings and Čeponienė, 2010; McCleery et al., 2010; Norrix et al., 2007). The story format used in the current study could have supported the children with SLI and ASD through pairing the visuals and the verbal information together in synchrony, a pairing that commonly occurs in more naturalistic learning contexts. Based on the current findings, clinicians should continue to feel comfortable using these same, multimodality and naturalistic learning contexts in intervention with children with SLI and ASD.

Global and Local Information Is Acquired Differently in Children with SLI and ASD Than Their Typical Peers

The children with SLI and ASD produced significantly more global descriptors than the group with TLD in their novel word definitions. These global descriptors only captured the novel objects at their most basic level of detail. For example, one participant with SLI provided the following definition for the “tool” referent: “Bucket [1]. Blue [2], shiny [3]. Blue. It’s a tool [4].” In comparison, a participant with TLD responded: “Pubtum means like it looks like a bucket [1] and it has gears [2] in it, and it like all these wires [3] and it had a spinny thing [4] in the middle.” Both participants provided four semantic features, but the participant with TLD provided features with a more specific level of detail, whereas the participant with SLI only gave semantic features that described the referent as a whole. It is perhaps unsurprising then that the group with SLI also produced significantly fewer local descriptors than the group with TLD. One explanation for this reliance on global features over local details in children with SLI is that they are compensating for their sparse, less in-depth, semantic representations (McGregor et al., 2013).
An example of this first explanation, in which children with SLI produced fewer local features and more global features due to their sparse semantic representations, was illustrated in McGregor and Appel’s (2002) study. In this study, a participant with SLI used semantic substitutions when producing semantic representations of words (e.g., the participant with SLI described the helmet as a “hat,” which is at the same hierarchical level). Even when defining commonly used, high-frequency nouns, children with SLI have been known to struggle to define these concepts with much depth (Marinellie & Johnson, 2002). One possibility for these shallower semantic representations is that children with language impairments possess fewer words in their vocabularies compared to their typically developing peers (McGregor et al., 2012, 2013). With fewer descriptive words in their mental lexicons, the number of mappings between newly acquired words and words already established would be limited. In essence, the more words one knows, the easier it is to learn new words. However, as mentioned in the methodology, all participants in the current study were controlled on expressive vocabulary. This may explain why the children with ASD and TLD were not significantly different in their use of local features. However, vocabulary differences may not fully explain why the children with SLI and ASD provided more global features.

Another explanation is that the children with SLI and ASD, due to their older age, were providing a superior definitional form than their younger peers with TLD. The use of global terms (demonstrating knowledge of breadth) demonstrates the ability to consolidate the multiple semantic features provided by the target referent through the use of a global term and therefore is arguably a more mature definition form. In contrast, using multiple local details to describe one referent (indicative of knowledge of depth) has been found to be more immature
developmentally (Skwarchuk & Anglin, 1997). The global semantic features could be classified as superordinate, or a word or phrase that describes a general category or class. For example, the word “animal” is superordinate to the word “cow” (p. 298). The word “cow” could also be described as subordinate to the word “animal.” Skwarchuk and Anglin (1997) state that superordinates indicate a mature definitional form that improves as children grow older. This was reflected in their study in which older elementary-age children with TLD provided more superordinate definitions than the younger children. In the current study, the children with SLI and ASD were significantly older than the group with TLD, which may be why they included more superordinate terms; it was developmentally appropriate. Also, Skwarchuk and Anglin (1997) found that nouns derived more superordinate terms in the children’s definitions than verbs or adjectives. Nouns (i.e., instrument, tool, animal, and vehicle) were the target referents in the current study, which also supports the use of superordinate terms.

Although the children with ASD in the present study demonstrated a reliance on global semantic features, they did not differ from the group with TLD with their use of local semantic features. These findings did not fulfill the predictions made earlier because it was expected that the children with ASD would have more local details than whole-object information. These predictions were based on the idea that individuals with ASD have a “cognitive style” that focuses on local rather than global features (Happé, 1999, p. 216). Supporters of the weak central coherence hypothesis in children with ASD have proposed that the best method for capturing this cognitive style is using open-ended tasks because it forces the individual to create his or her own answers (Happé, 2005). Even though the definitions from children with ASD analyzed in the
current study were originally acquired using these ideal, open-ended prompts, the results did not reveal this tendency toward weak central coherence.

This study was not the first that did not find support for the weak central coherence hypothesis; Kourkoulou and colleagues (2012) were unable to attribute local or global processing for the visual processing differences in individuals with ASD. In the current study, a possibility for the lack of evidence supporting weak central coherence could be the target referents used (i.e., the instrument, tool, vehicle, and animal). Plaisted, O’Riordan, and Baron-Cohen (1998) found that individuals with ASD did not demonstrate weak central coherence during a task that required the integration of figures. Plaisted et al. (1998) used letter characters in their experiment to measure visual search rate performance in children with ASD and found that they had superior performance compared to the control group during a task that required the participants to ignore the distractor letters. Perhaps the participants with ASD in the current study were able to integrate the local elements (e.g., the wheels of the vehicle) of the target referents into a whole, as the children in the Plaisted and colleagues (1998) study were able to do with ease.

Other key differences could be within the degree of ASD symptom severity in the current study’s participants. Fitch and colleagues (2015) found that current symptoms of their participants with ASD did not relate with global and local focus, but the relative severity of ASD over the lifespan did. It could be that the children recruited for the current study did not have severe lifetime symptoms and therefore did not present a local bias. The participants with ASD in the current study were all verbal, with spontaneous phrase- and sentence-level productions and had nonverbal IQ scores within the typical range (with the exception of one participant with ASD who could not be trained to the task to obtain a nonverbal IQ score). Perhaps recruiting
individuals with ASD who had longitudinally documented traits that were considered more severe would have resulted in an increase of local semantic features produced.

Visual processing could also be a reason as to why the children with ASD were able to include global semantic features. Robertson et al. (2014) had estimated that individuals with ASD had global perceptual deficits due to differences in visual processing and required longer amounts of time to look at an image compared to their typically developing peers. This additional time to analyze images, Robertson et al. (2014) predicted, provided the participants with ASD enough time to integrate local signals into a global whole. Perhaps the current study provided the individuals with ASD enough time to create a global whole or enough exposure to the images.

An additional aspect of this study that made it unique included using child-friendly cartoon images to acquire global and local features in the novel word definitions. This is different from previous studies that used complex paintings (Fitch et al, 2015) or the Rey-Osterrieth Complex Figure (ROCF; Akshoomoff et al., 2006) to find gestalt or detail focus. The ROCF figure is arguably more complex, as well as the paintings used in the Fitch et al. (2015) study that found that the individuals with ASD had “prioritized the ‘trees’ over the ‘forest’” (p. 1893). “Oil paintings by famous artists [that] included two portraits of individuals, two landscape scenes including humans, and two distant scenes without any individual people” (p. 1891) were used for the Fitch and colleagues (2015) study. These were also more complex than the child-friendly cartoon images in the current study in that they required perspective taking and had multiple elements. These differences could explain how the children with ASD in the current
study were able to describe the novel words in terms that demonstrated an ability to integrate the local details of the target referent into a whole.

It was predicted that global and local semantic feature production would differentiate the group with ASD from the group with SLI. It was thought that the group with ASD would provide more local features than the group with TLD and the group with SLI would be similar to the group with TLD in its use of global and local features. However, both were significantly different from the group with TLD in regard to the use of global features, and the group with SLI included significantly fewer local features than the group with TLD. Therefore, analyzing local features in novel word definitions may be a way to separate the two diagnoses; the group with ASD would be comparable to the group with TLD, while the group with SLI would produce significantly fewer than the group with TLD. Because the original word learning study was not designed to directly target global and local features, this difference between the groups needs to be more fully explored in future studies.

Clinical implications for these results are that there should be a focus on details of new words’ referents and explain how their details differentiate them from other similar words. For example, when teaching children with SLI and ASD the words “tiger” and “lion,” one may want to explain that a tiger has stripes and a lion has a mane. These characteristics may help the children define these new referents more accurately and help them create a more detailed description. The main goal of teaching the details would be to strengthen their vocabulary depth, which would mean arming them with words that are subordinate, such as the words “stripes” and “mane.” An additional benefit of targeting these words is the potential to improve reading comprehension. Ouellette (2006) found vocabulary words that provide depth help children
comprehend what is being read, while breadth supported decoding and word recognition during reading. It is crucial to target these areas of language development because, as McGregor et al. (2013) found, the children with language impairment did not overcome these challenges without intervention.

Children with SLI and ASD Use Inferred and Explicit Information

Similarly to Children with TLD

The group with SLI and ASD were able to make inferences as readily as the group with TLD, which was unexpected given that inferencing has been described as a challenge for children with these diagnoses (for SLI, see Botting & Adams, 2005; for ASD, see Dennis et al., 2001). It was predicted that the children with SLI and ASD would use more features that were explicitly taught than inferred due to their widely documented challenges with inferencing. Even though this prediction manifested, this finding was the same for all groups of children, including the group with TLD. This learning advantage for explicitly taught features may not represent a deficit in inferencing, but rather indicates that all children are more likely to recall features that are directly shown or told. Although this pattern of benefiting from explicit information more so than inferred information is perhaps unremarkable, the ability of children with SLI and ASD to produce as many features using inferencing as their typically developing peers is more surprising.

Inferencing is a developmental skill that improves with age (Depew & Veale, 2010). Because the groups were matched on expressive vocabulary and not age in the current study, this may explain why the children with SLI and ASD were comparable to their peers with TLD in
their use of inferred information. In fact, others have shown that children with SLI perform similarly to younger, typically developing children on verbal inferencing comprehension tasks and provide less mature inferences than their age-matched peers (Adams et al., 2009). Lepola and colleagues (2012) found that inference production in typically developing children at age four “was a unique predictor of vocabulary knowledge” at age five (p. 275). If the children with SLI were matched by chronological age and not expressive vocabulary, there may have been observed challenges with inferencing.

Previous research has found that children with ASD also have challenges making inferences. Norbury and Bishop (2002) found that children with ASD often use knowledge from their own experiences rather than the information included in the material presented. This lack of suppression of their own experiences or difficulties remembering the presented information resulted in inferences akin to the participants using their own bedtime as the answer to a character’s bedtime in the story. Also, Dennis and colleagues (2001) found that children with ASD make incorrect inferences from fixed knowledge and display difficulty making inferences about mental states. The current study did not analyze the inferences for mental states, which may have contributed to the children with ASD’s performance. However, as with the group with SLI, the group with ASD was significantly older than the group with TLD. Perhaps significant differences would have been observed if the groups were matched by chronological age, with the groups with SLI and ASD providing fewer inferences than their age-matched peers with TLD.

Norbury and Bishop (2002) also found similarities between children with SLI and ASD on a set of inferencing tasks. In order to measure inferencing abilities, Norbury and Bishop (2002) asked a series of inferencing questions about a short story that was read aloud. The
authors found that the groups with SLI and ASD were not significantly different in their inferencing abilities but had more challenges answering literal and inferential questions than their age-matched peers with TLD. In contrast, the present study presented the children with more visually driven information (i.e., either images or images paired with a story). It could be that the visual images helped the children with SLI and ASD make inferences more readily compared to a story without images. However, Norbury and Bishop (2002) acknowledged that all of their participants could make inferences “and did so frequently” (p. 245), but not all of these inferences were appropriate/accurate for the story’s context. It could be that visual images helped the children with SLI and ASD make more relevant inferences.

Clinically, one approach to strengthening inferencing skills may be to increase vocabulary knowledge because the groups were matched on expressive vocabulary and performed equally as well. Future research will need to investigate if targeting vocabulary will strengthen inferencing in children with SLI and ASD or if inferencing skills need to be directly taught. Improving inferencing abilities is important because it is tied with “the ability to abstract context dependent meanings, [which] are clearly important skills, not just for academic success, but for successful communication in everyday life” (Norbury & Bishop, 2002, p. 247). It was an unexpected finding that children with SLI and ASD demonstrated inferencing abilities similar to the group with TLD, which suggests their abilities are present but could indicate delayed language abilities for their age.

Furthermore, children with SLI, ASD, and TLD with matched expressive vocabularies are able to learn explicitly taught features comparably well, and this information should influence language intervention. When children with language learning deficits, such as those
with SLI or ASD are directly shown or told pertinent information during tasks of word learning, they may acquire semantic features that build on their depth of word knowledge equally as well as their typically developing peers. As recommended by Alt and her colleagues (2012), approaches known to work with typically developing children should be applied to children with language disorders as well. This finding provides yet another example of how teaching strategies, such as explicit instruction of new word meanings, facilitates learning in all populations of children.

Present Study Adds to the Discussion of SLI and ASD Phenotypes

Currently there is a debate over whether SLI and ASD are different ends on a continuum of the same disorder rather than two distinct disorders (Bishop, 2010; Kjelgaard & Tager-Flusberg, 2001; McGregor et al., 2012a; Riches et al., 2012). The present study analyzed open-ended definitions from children with SLI and ASD based on three known areas of processing differences between these two groups. This information could have tapped into a way to differentiate the two disorders in an expressive language task. However, as the current results stand, the groups with SLI and ASD were not significantly different based on any of the anticipated processing and subsequently production differences.

The current study had predicted there would be differences between the children with SLI and ASD; however, more similarities than differences emerged. This is not unlike previous research that found the two populations performed very similarly in language tasks. McGregor and colleagues (2012a) found an overlap when comparing a group of children with ASD plus concomitant syntactic language impairments (ASDLI) and a group with SLI when they analyzed
their lexicons and word knowledge. The authors suggested that the overlap “points to a similarity in the ASDLI and SLI phenotypes” (p. 35). Riches and colleagues (2012) also found similarities between children with SLI and ASD with concomitant language impairments. They stated their findings of “overlapping difficulties” during tense marking and nonword repetition provided “converging evidence for phenotypic overlap between these two groups” (p. 315).

Aware of these similarities between individuals with SLI and ASD, Bishop (2010) compared different genetic models as to why these populations share similar language traits. She suggested that individuals with SLI and ASD have the same pleiotropic gene (a gene that influences two or more unrelated traits) but have had different co-occurring risk factors that differentiate them outside of language. This model provides an explanation as to why there is a comorbidity of SLI and ASD and helps explain observed findings in both populations. Bishop’s (2010) idea may explain the similarities in the current study between the children with SLI and ASD, whose lack of evident language production differences make it difficult to differentiate the disorders. These findings may help explain why clinicians often report that differentiating SLI and ASD is difficult (McGregor et al., 2012a).

One possible explanation for the phenotypic overlap could be children with SLI and ASD use similar strategies to compensate for similar language and/or processing challenges but that these challenges have different underlying causes. Riches and colleagues (2012) and McGregor and her colleagues (2012a) have shown that children with SLI and ASD perform similarly on the same language tasks. During the current semantic learning study, the children with SLI and ASD applied similar learning strategies, such as relying on visual semantic features and global terms to define the target referents. Riches and colleagues (2012) posited that lexical knowledge could
be a contributing factor to their similarities. This seems to be the case in the current study, which originally matched children with SLI and ASD on expressive vocabulary and subsequently found no significant differences. This may not have occurred if the study had matched the participants by chronological age, nonverbal IQ, or some other non-linguistic factor.

One must also keep in mind that even though likenesses between the groups with SLI and ASD are present, this does not give adequate evidence that they are the same disorder. For instance, the present study did not investigate pragmatics, restricted and repetitive behaviors, nonverbal behaviors, and interpersonal relationships, which are included in the diagnostic criteria for ASD per the DSM 5 (American Psychiatric Association, 2013) but are not necessary for a diagnosis of SLI (Leonard, 2014). Also, this study did not look into every aspect of language, such as phonology or syntax, which may have been more affected in the children with SLI. Therefore, the results from this study cannot completely determine whether these two disorders have the same language phenotype. Without investigating genetic markers of each disorder, there is truly no way of determining if they are one and the same.

Conclusions

Novel word definitions can provide a window into the processing differences in children with SLI and ASD. When producing novel definitions, children with SLI and ASD rely on visuals to create semantic representations more than their peers with TLD but are also able to use verbal and visual modalities comparably to their typically developing peers. This similarity between groups in the use of dual modalities is reflective of the sentiments in the Alt and colleagues (2012) paper that states children with language impairment will benefit from the cues
provided to their peers with TLD, even if they are more complex. When acquiring local and
global information, children with SLI and ASD produce more global semantic features in their
definitions compared to children with TLD, which does not support the idea that children with
ASD have weak central coherence. In fact, children with ASD provide the same amount of local
semantic features and the children with SLI produce even fewer local features than their peers
with TLD. Additionally, children with SLI, ASD, and TLD all show a similar reliance on
explicitly presented information over inferred information, and no group demonstrated an
advantage on either type of learning. Future research needs to investigate if this lack of a
difference on inferencing skills was due to the older ages of the children with SLI and ASD.

In the present study, there was nothing from the current method of coding of the novel
word definitions that could clearly differentiate children from SLI and children with ASD.
Although children with SLI used significantly fewer local semantic features than peers with
TLD, and the children with ASD used the same amount as their typically developing peers, they
were not significantly different from one another. Although this study did not uncover
quantifiable processing distinctions during language production that could be used to
differentiate the two diagnoses, much can be gleamed from the results and carried over into the
clinical setting. Importantly, this study indicates that children with processing differences can
demonstrate abilities that closely resemble those of their typically developing peers, provided the
opportunity to strengthen their semantic representations of new words.
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CODING MANUAL

Definitions of children with ASD, SLI, and typically developing children

Written by Kacy Kreger
Introduction
First of all, thank you for volunteering to help with this master’s thesis project in the department of Communication Disorders and Sciences at NIU. I appreciate your time and effort you will put into this project, and hopefully you will benefit from the experience, as well.

This project is looking at the definitions of school age children who are typically developing, have ASD, or have SLI. All data collecting was done by Dr. Gladfelter at Purdue University, but it is at NIU that we are breaking down all the definitions into parts to further analyze how children with SLI and ASD learn new words. We are looking at a number of areas in the definitions: accuracy (was the definition correct?), the modality (visual, verbal, or both) in which the child received the information, the learning mechanism the child accessed (inferred or shown/told information), and the processing level the child used for the definition (global or local). These areas or categories were designed based on differences found between children with SLI, ASD, and typically developing children in previous research. For example, children with ASD process verbal information differently in the brain than their typically developing peers. Also, there are theories that state children with ASD have more difficulty using inferred information, and look at objects in a more detailed, or local, way. This thesis project is trying to find out if we can see differences in how children with these disorders approach an open-ended semantic task: learning new words and their semantic features.

In order to analyze the definitions, a coding tool was designed. Here is what the top rows look like:

<table>
<thead>
<tr>
<th>Definition Details</th>
<th>Accuracy</th>
<th>Modality</th>
<th>Learning</th>
<th>Processing Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant ID</td>
<td>Group</td>
<td>Session #</td>
<td>Target Referent</td>
<td>Feature (word):</td>
</tr>
</tbody>
</table>

The definitions are also laid out in a meaningful manner:

Participant ID:

**Instrument**
Definition 1 (Session 1 instrument)
Definition 2 (Session 2 instrument)
Definition 3 (Session 3 instrument)

**Tool**
Definition 1 (Session 1 tool)
Definition 2 (Session 2 tool)
Definition 3 (Session 3 tool)

**Animal**
Definition 1 (Session 1 animal)

Note that the session # is in parentheses, the participant ID at the top, the definition is numbered, and that there are multiple targets (in bold) as each heading. These parts will all be important for coding.
There are four target referents: vehicle, animal, tool, and instrument.

- The children were provided novel names for each of these targets.
- Children were told different names—therefore you may see different names in the definitions for the same target.
- The tool and instrument were only in a stand-alone picture. No script was provided.
- The animal and vehicle were in a story, with scripts and more pictures.
- There were also foil targets, which were never taught to the child.

Please keep in mind that although this task may be tedious at times, it is important to be careful when entering and coding data. If errors are made, this will affect the overall results, reliability, and conclusions made.

In order to prevent bias, do not worry about the diagnosis of the participant you are coding, or their definitions. Do not alter the definitions, or try to “help” a participant. Use your best judgment, but don’t be afraid to ask questions or ask for help, because we are happy to assist you with those tough judgment calls—it is clear to us there will be times in coding where the “correct” judgment is not obvious.
Coding Instructions

Coding Steps:
1. Open the coding tool in Excel on your computer.
2. Find the definitions you have been assigned in your binder.
3. Choose one participant you would like to work on (I recommend working on one at a time). Also, it may be helpful to go in order of the list, but this is not necessary.
4. Definition Details
   a. Write the session # in the next column—this is in the definition document, in parentheses
      i. E.g.: Definition 1 (Session 1 instrument)
      ii. You would write “1” in the column.
      iii. Note: there may be multiple words in a definition for session 1 we are looking at, so there may be multiple rows with “1” in this column.
   b. Target Referent column—this is the target written above each definition
      i. E.g.: Definition 1 (Session 1 instrument)
      ii. For this, you would write instrument in the column
      iii. Again, there will be multiple rows that have the same target referent, since each participant had the target three times.
   c. Feature column: you are writing the BOLDED word in the definition
   d. E.g.: Definition 1 (Session 1 instrument)
      It’s a trumpet.
   e. For this definition, you would type trumpet in this column.
   f. If the definition has a -0 or no -# after it, then type a 0 in this column. This means the definition was incorrect.
   g. If the definition is not there (e.g., DNR or did not respond), or “I don’t know,” you would also place a 0 in this column.
   h. Every bolded unit receives its own row—for example if there are two bolded words in a definition, they would each get a separate row with the same session number, group, participant ID, and target referent. However, everything else may be different, depending on the definition.
   i. Some features have two words or more in one unit—this is because of the previous coding done with the data. This is where it gets tricky. If you are unsure where the units separate, please ask Dr. Gladfelter or Kacy. Features count as one unit if there are unimportant “filler” words (e.g., the girl in gives the girl kisses) or if they are describing one idea. The example in gives the girl kisses would take one row, because it is one unit. However, definitions with …blue, shiny… would have two units, because blue and shiny are two separate adjectives. Because the definition ends in a -# (e.g., -4), you can tell how many rows you will have for that definition. This will help you tease apart units of features. Here is an example of what the Excel coding tool would look like with the previous information:
5. **Accuracy**
   a. **Overall**
      i. This stands for overall accuracy. If there is -0, or no -#, place a 0 in this column. If this is so- move to Flipped? and then start the next definition.
      ii. If the definition has a -# at the end and bolded words, place a “1” in this column and move to the Modality headings.
   b. **Naming?**
      i. Please skip this column. This will be done later.
   c. **Flipped?**
      i. If the definition has a -0 or no number, consider if it is describing another target. For example, the child said “blue and shiny” for the animal, when it is clear he/she flipped the definition for vehicle. If it is indeed flipped, write “1” in this column.
      ii. Don’t be surprised if this happens a lot- so be on the lookout!
      iii. Move to the next definition if you fill out this column- do not fill out anything else in this row after this.

6. **Modality**
   a. **Visual**
      i. This is when you need to **analyze the pictures provided in this manual**. The tool and instrument are only pictured in isolation, while the vehicle and animal are pictured in the story.
      ii. Did the feature the child provided correlate to a visual cue? For example:
         1. Said “**instrument**” for instrument- because it looks clearly like an instrument.
         2. Said “**gold**” for instrument- because in the picture it is gold.
         3. Said “**bucket**” for tool- because it looks like a bucket.
         4. Also- if a definition provided by the participant is another word/classification for the target (e.g., “**train**” for the target vehicle), this would be visual only, since they do not verbally say it is a train. This can be confusing, since I could understand how one may believe the child used verbal information to come up with “train”- however, due to reliability between coding, it has been decided that when a child determines a category for a target, it will be visual only (another example would be “**dog**” for the target animal).
      iii. If so- place a “1” in this box.
      iv. Note: an example of a feature that would **not** be considered visual is “**dump water on you**” for the target tool. This is not visual, since the tool was not pictured dumping water on anything.
b. Verbal
   i. This is when you need to **read the script**. The script is only for the animal and vehicle targets, since tool and instrument do not have verbal cues.
   ii. Did the feature the child provided correlate to a verbal cue? For example:
       1. The script says “it’s my favorite!” and the child said “it’s the **little girl’s favorite**!”
       2. Most times, verbal cues accompanied visual cues. So, this will be the most infrequently used column, most likely.
   iii. If so- type a “1” in this box.

c. Both
   i. This is when you need to **read and look at** the script and pictures in the manual for the vehicle and animal definitions.
   ii. Did the feature the child provided include something that was both verbally and visually presented? For example:
       1. “I like my pɅbtəm” is in the script, and there is a picture of the boy hugging the vehicle. The child says “the boy **likes it**.” This is “both” because it is pictured visually, and it is said in the script.
       2. The child said: “it moves **fast**” for vehicle; the picture depicts it moving fast, and the script says it is fast.
   iii. If you would put a “1” in the visual and a “1” in the verbal columns, put a “1” in the both column. **Do not** put a “1” in every column.

7. Learning Mechanism
   a. Inferred (implicit)
      i. Place a “1” in this column if you believe the feature the child said in the definition was taken from world knowledge and past experience.
      ii. To qualify as inferred, the feature must not be mentioned in the script or visually provided. Also, to be inferred, the semantic feature must not be a color or a noun (e.g., it’s a dog). Synonyms (as long as they are not nouns or colors) will be counted as inferred, since this implies previous world knowledge. Adjectives (that are not colors or told in the story) and verbs would be considered inferred. Examples would be:
         1. The child said: “it **makes delicious food**” for vehicle. This is inferred because the child used his/her past knowledge to describe the vehicle as making food that tastes delicious.
         2. The child said: **plays music** for instrument. They had to infer that the object is an instrument, and that it can play music.
   b. Shown/Told (explicit)
      i. Place a “1” in this column if the definition’s feature was shown or told to the child.
      ii. A feature cannot be both shown and inferred. It has to be one or the other.
      iii. To qualify as shown/told, the information must be provided to the child. Examples would be:
         1. The child said: “it’s **gold**” for instrument, because it is the color gold in the picture.
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2. The child said: “it’s blue” for vehicle. This is explicit because it was shown in the picture and described verbally in the script.

8. **Processing Level**
   a. **Global (whole object) column**
      i. Type “1” in this column if the definition relates to the visual aspects of the target referent and if the child described the target as a whole. If he/she picked out a tiny part or detail, do not type “1” here and move on to next column.
      ii. Not all visual aspects will be able to be categorized as global or local. This is because they are definitions that cannot be seen as a whole or part, such as “shiny” or “blue” for vehicle. If this is the case, skip Processing Level and move on to the next definition.
      iii. Examples of whole object descriptions would be:
         1. The child said: “instrument.” This is global because the child described the object as a whole.
         2. The child said: “vehicle” for the vehicle, again this is a whole object the child described.
         3. The child said: “bucket” for tool, and this is global because it is a definition that describes the object as a whole.
   b. **Local (details or parts) column**
      i. Type “1” in this column if the definition provided relates to smaller details on the object. Examples of this would be:
         1. The child said: “there’s a hose” for tool; it’s a smaller feature of the whole tool and therefore is a local part.
         2. The child said: “it has antennas” for animal, because it is a small aspect of the whole animal.
      ii. Note: features must be either local or global, they cannot be both. Also, as stated before, some features may be neither local nor global, and will be skipped for this definition.

9. Do the same thing for all the features of every definition for the participant, skipping participant ID and group, but filling out the other columns.

10. When the participant is completed, save the document (hopefully you are saving during the coding, as well) and put a check mark next to the participant ID on your assignment sheet.
    a. Save the excel document as the _coder’s first name and last initial_ _coding.xlsx_. For example, Kacy Kreger’s would be KacyK_coding.xlsx.
    b. All participants you are responsible for coding will be in the same excel document.
    c. When all assigned participants have been completed, please email completed coding documents to kkreger1@niu.edu.

**EXAMPLE CODING:** A finished definition coded as prescribed by the directions (to code the whole participant, it will be much longer than this example, since this is only demonstrating one definition). The participant ID and group will be added after the coding has been completed.
Definition 1 (Session 1 instrument)
It a **horn** that is kindof wacky. It doesn't mean anything. It just a horn that has a **tube** in it. -2

Here’s a walk-through of the above example:
First bolded word: **horn**
1. Definition details
   a. Participant ID (ID is changed for the coding process)
   b. Group is left blank (will not be given to the coders)
   c. Session # is 1 because above the definition it states (Session 1 instrument)
   d. Feature word is **horn** because that is the first word in the definition bolded.
2. Accuracy
   a. Overall has 1 because there is a -2 at the end, and it is a correct definition.
   b. Naming? is always left blank (we will fill this in later)
   c. Flipped? is blank because it is correct and the definition did not have a tool, animal, or vehicle description in its place.
3. Modality
   a. **Horn** was from the picture of the instrument; no verbal script was provided.
   b. Verbal is left blank because no verbal script was provided
   c. “Both” is left blank (see above)
4. Learning Mechanism
   a. Inferred (implicit) is blank because the feature is a noun
   b. Show/Told (explicit) has a ‘1’ because all the information the child provided was pictured and is a noun.
5. Processing Level
   a. Because **horn** describes the object as a whole, there is a 1 under global (whole object)
   b. Local (details or parts) is left blank because **horn** was meant to describe the whole object pictured.

Second bolded word: **tube**
1. Definition details
   a. Participant ID is the same as the above
   b. Group is left blank (see above; this will be changed later)
   c. Session number is the same as for the previous, since it is still from Session 1
   d. Feature word is **tube** because that is the second and last bolded word in the definition
2. Accuracy
   a. Overall has 1 because it is correct definition, as determined earlier by the -2
   b. Naming? (see above)
   c. Flipped? (see above)
3. Modality
   a. We can safely say horn was perceived from the picture, since there was no script.
   b. Verbal (see above)
   c. Both (see above)
4. Learning Mechanism
   a. This word is not considered inferred (implicit) because the feature is a noun.
   b. Shown/told has a “1” because it is a noun and pictured.
5. Processing Level
   a. Global (whole object) is left blank because the child referred to the horn having a tube in it- which means it was a part from the horn.
   b. Local (details or parts) has a 1 because tube was described by the child as a part of the whole.

Also, here is a fake participant for you to refer to when coding:

Participant ID: SLI30

**Instrument**
Definition 1 (Session 1 instrument)
DNR

Definition 2 (Session 2 instrument)
Trumpet.-1

Definition 3 (Session 3 instrument)
It plays music.-1

**Tool**
Definition 1 (Session 1 tool)
I don’t know.-0

Definition 2 (Session 2 tool)
It’s gold.-0

Definition 3 (Session 3 tool)
It has eyes.-1

**Animal**
Definition 1 (Session 1 animal)
Little Sister likes it.-1

Definition 2 (Session 2 animal)
It’s pink and has a tail.-2
Definition 3 (Session 3 animal)
It eats donuts.-1

Vehicle
Definition 1 (Session 1 vehicle)
It’s blue.-1

Definition 2 (Session 2 vehicle)
It’s big.-1

Definition 3 (Session 3 vehicle)
Big Brother’s favorite.-1

*Note: (Under Modality) Verbal because a “favorite” cannot be seen, but was part of the story script.

*Participant ID and Group will be added after the coding

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<th>Session #</th>
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<th>Flipped?</th>
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Tool (no script provided)
Picture 1. (Picture of Big Brother and Little Sister playing in backyard. In backyard are both stimuli and 2 foils) Narrator: Big Brother and Little Sister like to play outside together.
Narrator: Big Brother said, “I like my pΛbtəm. It’s my favorite!”

**Picture 2.** (Picture of Big Brother with item 1 and a foil 1 item in background). Narrator: Big Brother said, “I like my pΛbtəm. It’s my favorite!”

NAME
Picture 3. (Picture of Little Sister with item 2 and a foil 2 item in background). Narrator: Little Sister said, “I like my f'Aspob. It’s my favorite!” NAME
Je t’écoute. (Picture of Big Brother riding item 1 and foil 2 in background). Narrator: Big Brother said, “My pAbtôm is blue and big. ATTRIBUTES 1 & 2. I drive my pAbtôm. FUNCTION 1 My pAbtôm drives fast!” FUNCTION 2
Picture 5. (Picture of Little Sister petting item 2 and item 2 kissing/licking her and foil 1 in background). Narrator: Little Sister said, “My fAspøb is soft and small. **ATTRIBUTES 1 & 2.** I cuddle my fAspøb. **FUNCTION 1** My fAspøb gives kisses! **FUNCTION 2**
**Picture 6.** (Picture of Big Brother standing next to item 1 and catching donuts shooting out the back of item 1 and foil 1 in background). Narrator: Big Brother said, “My pAbtəm makes donuts! **FUNCTION 3** Watch me catch them!”
Picture 7. (Picture of Little Sister feeding a donut to item 2 and foil 2 in background).
Narrator: Little Sister said, “My fAspəb eats donuts! **FUNCTION 3** Watch me feed it!”
Picture 8. (Picture of Big Brother hugging leg of item 1 with foil 2 item in background). Narrator: “My pAbtəm is shiny. ATTRIBUTE 3 I like my pAbtəm. “NAME said Big Brother.”
Picture 10. (Picture of Big Brother and Little Sister playing in backyard. Item 1 is shooting donuts with Big Brother riding it and Little Sister is feeding item 2 a donut and petting it. Foils 1 & 2 are still in backyard as well.) Narrator: Big Brother and Little Sister like to play outside together.
APPENDIX B

EXCEL CODING TOOL
<table>
<thead>
<tr>
<th>Definition Details</th>
<th>Accuracy</th>
<th>Modality</th>
<th>Learning Mechanism</th>
<th>Processing Level</th>
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