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THE FLEXIBLE LANGUAGE AND MEANING EXTENSION (FLAME ?) HYPOTHESIS: A CONSTRUCTIONIST APPROACH TO AUTISM

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THE FLEXIBLE LANGUAGE AND MEANING EXTENSION (FLAME) HYPOTHESIS: A CONSTRUCTIONIST APPROACH TO AUTISM

Nicole Cuneo

A DISSERTATION

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OF DOCTOR OF PHILOSOPHY

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Abstract

Autism is often characterized by unique language differences, yet fundamental linguistic research in this area remains underexplored. This dissertation addresses that gap by integrating a usage-based constructionist approach with the study of autism. Through the lens of the Flexible Language and Meaning Extension (FLAME) hypothesis, it revisits and expands current understandings of autistic language. The FLAME hypothesis offers a fresh perspective on how autistic individuals construct and convey meaning, distinguishing between item-based knowledge and flexible generalizations.

Three experimental studies compare autistic and non-autistic adults on matched tasks that either require or do not require flexible meaning extension. Results consistently show that while autistic adults excel in structured or fixed-language contexts, they face greater challenges when tasks demand flexible interpretation. These findings suggest that language difficulty in autism may lie in flexibility rather than language ability itself. The final chapter presents a five-year review of autism language research, highlighting sampling gaps and offering practical recommendations for researchers and clinicians. Together, this work aims to advance a more nuanced understanding of language in autism and support more meaningful linguistic engagement for autistic individuals.

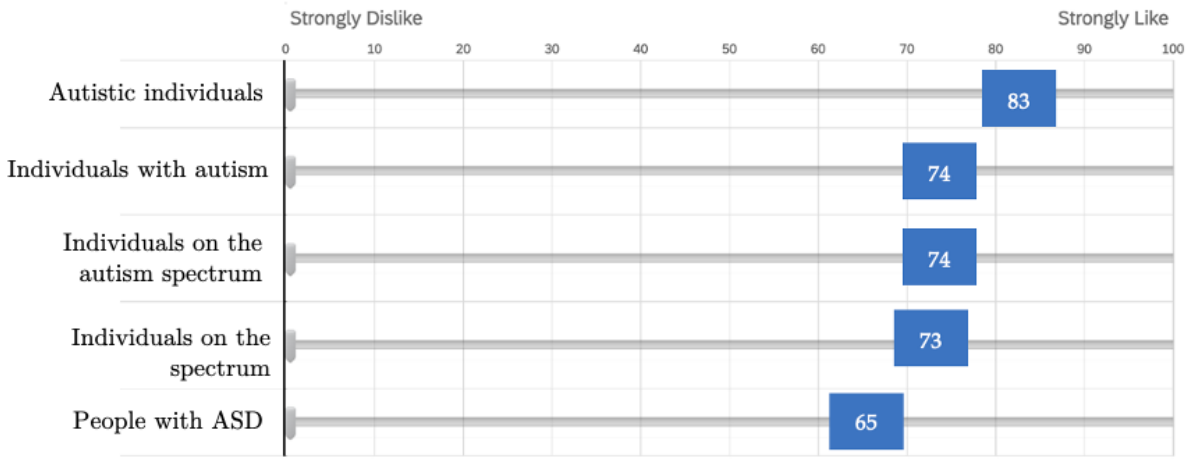
Positionality Statement & Terminology Preference

Discussions about how to refer to a person's autism diagnosis, when appropriate, are ongoing discussions in autism research (Bury, 2023, Botha et al. 2023, Fecteau, 2024, Singer et al. 2023).

Best practice is to ask individuals how they prefer to be identified whenever appropriate and possible. As an author, I do not personally identify as autistic, and therefore, this work prioritizes the terminology preferences of our participants.

In our studies, we provided our adult participants with the following instructions:

"We recognize that people have different preferences regarding terminology, and we want to honor those preferences. Below, we ask for your reactions to a set of descriptions. These terms were selected from an adult terminology preference study and do not reflect the language or opinions of the researchers."



Participants rated each term using a slider ranging from 0 (Strongly Dislike) to 100 (Strongly Like). Notably, all groups showed a numerical preference for the term autistic individuals. Accordingly, this is the term I will predominantly use in this text.

For more anti ableism practices, see Bottema-Beutel (2021) and Fletchter-Watson (2024).

1. Introduction

At the core of my dissertation is the question posed by the Autistic Self-Advocacy Network (2019): *How can we help autistic people communicate?* Addressing this question requires a deeper understanding of when and how autistic language differs from non-autistic language and the linguistic and cognitive factors that shape these differences.

To begin to answer this question I introduce the FLAME framework (Chapter 1.2), that allows a novel theoretical hypothesis, integrating linguistic theory (Chapter 1.3) with autism research (Chapter 1.4). Through three empirical studies (Chapters 2-4), I test this hypothesis and gather evidence for the idea that autistic language use tends to be less flexible than non-autistic language.

Finally, I contextualize these findings within the broader literature and lived experiences of autistic individuals, highlighting the real-world relevance of this research (Chapter 5). Ultimately, this work not only contributes to theoretical discussions of autism and of linguistics broadly, but also has practical implications for accessibility, education, and advocacy (Chapter 5), ensuring that communication support is informed by the lived experiences of autistic individuals.

1.1 Autism

Autism is a developmental condition defined by the DSM-5 based on two primary criteria (APA, 2022), one of which includes restricted and repetitive behaviors often described as inflexible or rigid. This rigidity reflects a strong preference for sameness, seen in routines, special interests, and lower tolerance for uncertainty (for review, see Petrolini et al., 2023; APA, 1994). Perceptually, it has been linked to enhanced visual and auditory discrimination, superior visual search, and a tendency to perceive categories as distinct rather than overlapping (Eigsti & Fein, 2013; Mottron et al., 2006; Dakin & Frith, 2005; Soulières et al., 2007). While advantageous in some contexts, this may hinder categorization by reducing sensitivity to similarities and relationships (Happé & Booth, 2008; Happé & Frith, 2006). Autistic individuals are less likely to form complex categories (Church et al., 2010; for review see Vanpaemel & Bayer, 2021) and perform less accurately in similarity judgment tasks (Plaisted et al., 1998). They are also less likely to adjust tone perception based on statistical averaging across trials, a pattern found in non-autistic individuals and in people diagnosed with autism early on but who later lose their autism diagnosis (Braida et al., 1984; Eigsti & Fein, 2013; Jaffe-Dax & Eigsti, 2020; Lieder et al., 2019). Overall, rigidity is a well-documented feature of autism, extensively studied as a core characteristic of the condition (for further review, see Petrolini et al., 2023).

The second core criteria in the diagnosis refers to persistent deficits in social communication and social interaction across multiple contexts. Most research and interventions addressing communication challenges in autistic individuals have focused on social cognition differences (Anderson et al., 2007; Baron-Cohen, 1993; Carpenter & Tomasello, 2000; Ellis Weismer & Kover, 2015; Kuhl et al., 2005; Mundy, Sigman, & Kasari, 1990; Osterling & Dawson, 1994; Paul et al., 2013; Sigman & McGovern, 2005). The current diagnostic manual notably omits direct references to language.

The omission of references to language in autism diagnosis criteria elides how crucial language is to the autism experience. Language delay and linguistic differences compared to same aged peers is one of the most common reasons parents seek an autism evaluation worldwide (Kozlowski et al., 2011). In fact, language difficulties were a defining feature in the earliest clinical description of autism (Kanner, 1943). Currently, up to 30% of the autistic population requires support to communicate (Tager-Flusberg & Kasari, 2013; Yoder, Watson, & Lambert, 2013) and this number may be a low estimate, with some studies reporting that up to 46% of adults have minimal verbal ability (Radford et al, in preperation).

Notably, language plays a central role in adult independence, making it a critical area of study. Greater independence as well as community integration and support may enhance long-term social and vocational opportunities (Farley et al., 2009). For example, Friedman (2019) found that vocabulary diversity was significantly associated with vocational success, with individuals possessing a robust vocabulary being more likely to secure employment or pursue higher education. Importantly, as mentioned above, helping autistic adults communicate effectively is a fundamental priority championed by the autistic community itself (ASAN, 2019).

Research and interventions often neglect fundamental linguistic mechanisms and core aspects of language (Mercado et al., 2020). As a result, the basic linguistic differences of language used by autistic individuals remain largely understudied- and the core focus of this dissertation. Many clinical assessments also fail to capture subtle distinctions in linguistic abilities, limiting our understanding of individual variability (Tafolla, Singer, & Lorde, 2025). Identifying the underlying mechanisms of language difficulties in autism is crucial for developing targeted interventions and improving long-term outcomes (for review, see Schaeffer et al., 2023). This thesis aims to bridge that gap by examining the often-overlooked linguistic factors that shape communication, offering a deeper understanding of diverse communication styles.

1. 2 The FLAME hypothesis

As discussed in Section 1.1, autistic individuals often exhibit rigidity in non-language domains. This dissertation seeks to bridge this aspect of the autism diagnosis to the language domain. To achieve this, I will incorporate insights from a usage-based approach to language (explored further in Chapter 1.3). This integration serves as the foundation for the FLAME Hypothesis of autism and language:

- When Flexibility in Language and Meaning Extension (FLAME) is required, autistic adults will experience greater difficulty than non-autistic adults.
- When language use follows rigid, rule-based structures, autistic adults will show relative strength compared to non-autistic adults.

1.2.1: Defining the Portion of the Spectrum Under Study

This dissertation focuses on a particular subset of autistic individuals: verbal, education-matched autistic adults. Studying adults rather than children allows for an examination of long-term differences between autistic and non-autistic individuals, contributing to the broader goal of improving communication in autistic adults.

Though a large body of literature examines children with autism, findings on its applicability to adult language outcomes are mixed. Language trajectories in autism vary widely-some individuals show improvement over time, while others experience stagnation or decline at young ages (Magiati et al., 2014). Very few strong childhood predictors of long-term language outcomes have been identified, with IQ being one of the only consistent predictors (Farley et al., 2009; Mason et al., 2020). This results in the possibility that studies of children may simply identify delays rather than long-term deficits. Therefore, I chose to study language abilities in autistic adults as a way to better understand long-term outcomes in language, to help provide long-term support and to inform targeted interventions that may be used in children or youth.

A key challenge in work on autism and language is the heterogeneity of language abilities within the autistic population. For sure, methodological differences across studies, including small and diverse samples, inconsistent assessment timelines, and varying measurement tools, likely contribute to mixed findings. Many clinical assessments fail to capture subtle linguistic distinctions, limiting our understanding of individual variability (Tafolla, Singer, & Lorde, 2025). For these reasons, identifying the mechanisms underlying language difficulties in autism remains crucial for developing effective interventions (Schaeffer et al., 2023). To address this, my research targets a subset of autistic adults: those who are verbally able. My studies match the educational attainment of the target population in non-autistic to ensure that any observed differences in

language are not confounded by issues unrelated to language or general exposure to education or language.

The present dissertation has its limitations. By focusing on verbally able, education-matched autistic adults, we cannot draw conclusions about all autistic individuals or the full range of language abilities. Future research is needed to explore whether current findings extend to individuals with diverse verbal abilities, including non-verbal autistic individuals. I will return to this discussion in Chapter 5, where I examine recent autism language research that includes a larger sample of the population. In Chapter 6, I explore broader implications and future directions.

1.3: Flexibility in Language and Meaning Extension: A Usage Based Approach

The FLAME hypothesis of autism arises from a recognition that language categories need to be flexible to be used in new contexts and with new individuals. The theory behind FLAME is rooted in extensive research in the usage-based constructionist approach to language, which views language as a network of intricate item-specific knowledge and as generalizations at various levels of complexity and abstraction (Bybee, 2010; Goldberg, 2003, 2006, 2019; Goldberg & Suttle, 2010; Tomasello, 2003). The approach emphasizes that we learn generalizations through language use, by gathering statistical information from the utterances we encounter and their interpretations in context; since new information is related to prior information, similar instances are presumed to cluster together to form an inter-related network of learned pairings of form and function: a constructionNet.

The constructionist approach recognizes that language is not comprised of categorical rules, let alone universal categorical rules. Because our knowledge of language is based on exemplar-based generalizations, constructions are rarely definable by any set of necessary and sufficient features (Bybee, 2010; Goldberg, 1995, 2003, 2006; Jackendoff, 1983; Lakoff, 1987; Tomasello, 2003). Put differently, though memory of exemplars is important to the creation, development, and use of our language network, they do not explain our entire knowledge of language.

To better understand this flexibility, imagine a group of co-workers from different departments—marketing, engineering, finance, and design—gathering to discuss a project. Each person brings expertise and jargon from their field, but to collaborate effectively, they must communicate their ideas in a way that others can understand. One approach is to use familiar terms without considering the diverse backgrounds in the room. For example, if someone casually mentions “polysemy” without explanation, their colleagues may be confused, leading to misunderstandings and inefficiencies. A more effective approach is to adjust language based on the

audience. Instead of simply saying “polysemy,” one might define it as “a word with multiple related meanings” or provide examples, such as “the word cap, as used to refer to a cap on your head or a cap on a bottle.” Flexibility adapting or explaining terminology to others’ prior knowledge and current understanding is essential for successful communication. That is, effective communication involves adapting language to fit new contexts and diverse listeners.

Another example of the importance of flexibility comes from language development. Imagine if word learning occurred by associating each word uniquely with the specific contexts in which it was used. A child may have only witnessed the word door being used to describe the types of doors typical in houses. If the child is unable to flexibly extend the meaning of the word to include barn doors, revolving doors, or sliding doors, she would not use the word door to apply to these cases. But we are always encountering new contexts, and efficient communication requires an ability to flexibly extend and recognize new types of doors and new uses of the word door, beyond the specifics of witnessed examples. In fact, lexical meaning is dynamically constructed, with conversational feedback often used to update one's own understanding of meaning (Hawkins, 2019)- a process observed even in child-parent conversations (Leung, Yurvoksy, & Hawkins, preprint).

Not only is much of meaning context-dependent and negotiated in conversation, but the same word form is typically used in various related but distinct contexts, as illustrated above with the word cap (Lakoff, 1987; Murphy, 2002; Wittgenstein, 1953). As another example, in English, dish can refer to a plate, a meal, or the act of serving food, and it can also be used metaphorically (e.g., dish the dirt). Sign may refer to a stop sign, a gesture, a sign language lexeme, a spiritual symbol, or writing one’s name. Even for seemingly concrete meanings, subclusters exist—like different types of cup (drinking cups, measuring cups, etc.).

Words like dish, sign, and cup are polysemous, where one word has multiple related meanings. About 80% of English words are polysemous (Bayen, Piepenbrock, et al., 1993), unlike homonyms, which have unrelated meanings and make up only 4% of English words. Using conventional phrases for new situations is more effective for neurotypical communication, with context helping distinguish interpretations (Piantadosi et al., 2012). While dictionaries try to group polysemous meanings under one entry and homonyms separately (Rodd et al., 2002), polysemy and homonymy exist on a continuum (Apresjan, 1974). Importantly, polysemous meanings are conventional and must be learned, because they differ across languages (Rzymski et al., 2020). Srinivasan and Rabagliati (2015) found certain types of recurrent polysemy types across 14 languages, but critically, the specific meanings involved vary (Srinivasan & Rabagliati, 2015). For instance, even though using the same word for an animal and its meat is common(e.g., rabbit, chicken), it is not universal even in English (e.g., cow vs. beef).

The examples above illustrate how individual word meanings are flexible. Flexibility is also needed for multiword phrases and grammatical structures. This idea relies on the observation that grammatical constructions are themselves associated with functions which are flexibly extended. For example, the partially-filled construction “the X-er, the Y-er" can be used with an open-ended range of instances (Kay and Fillmore, 1988; Culicover and Jackendoff, 1999). Knowledge of this English construction includes idiomatic instances (e.g., the more, the merrier; the bigger they come, the harder they fall; the bigger, the better), and the construction contains open slots that can be filled with an open-ended range of comparative phrases (e.g., the more chocolate she eats, the more she wants). The construction expresses the general notion that one variable (depicted by the second phrase) is dependent on another variable (depicted by the initial phrase). Its more specific interpretation depends on the expressions that fill the open slots of the construction. For instance, if we take two seemingly unrelated adjectives like soft and brave and use them in this construction-

the softer, the braver- the structure forces that we construe a relationship between them, namely that being or becoming "softer" results in being or becoming "braver."

Another example of a grammatical construction is What's X doing Y, which again, predictably, includes conventional instances (e.g., What's this fly doing in my soup?). The construction implies that the fact that X is doing Y is unexpected and suggests that the speaker disapproves (Kay and Fillmore, 1999). Notice that the construction supplies this interpretation of unexpectedness and disapproval when the construction is used with entirely new words such as What are tomatoes doing in my shopping cart?

The aforementioned constructions might be labeled idiomatic, since they are relatively uncommon and convey quite particular interpretations. But constructional meaning is by no means limited to "idiomatic" cases (Goldberg, 1995). For instance, consider the "double object" construction (Verb Obj1 Obj2) as in examples (1)-(3):

(1) She gave him something.

(2) She kicked them the ball.

(3) He baked her a cake.

The verb, give, is the most frequently used verb in this construction (Sethuraman, Casenhiser, & Goldberg, 2004), and a wide range of verbs are also possible. In each case, the double-object construction implies literal or metaphorical intended transfer between an animate agent and an animate recipient (Green, 1974; Goldberg, 1995). Underscoring this point, if a nonsense verb is used in the construction (e.g., She mooped him something), people interpret the novel verb to convey the meaning "give" and in fact are highly likely to provide the word give, since give accounts for the lion's share of exemplars of the double object construction (Goldberg, 1992; Ahrens, 1995; Johnson & Goldberg, 2012). In this way, grammatical constructions facilitate a

degree of compositionality in language as they constrain how comprehenders interpret combinations of slot-fillers semantically (see Goldberg, 2015).

1.4 Prior work to support the FLAME Hypothesis of Autism Language

As highlighted in usage-based research on language, FLAME plays a key role in language learning and language use among non-autistic individuals. This dissertation extends FLAME to the verbal autistic population, which is known to face challenges with generalization in behavioral and perceptual domains.

A core diagnostic criterion for autism includes rigid behaviors (Chapter 1.1). Here, we ask: Do these observed rigid behaviors extend into the language domain? And can a usage-based approach to language provide a clearer framework for understanding the heterogeneity of language differences in autism?

In the original account of autism, the first autistic patient is described as having "specific literal, inflexible" meanings for words, noting the individual's apparent inability to generalize language use to different contexts (Kanner, 1943). Subsequent studies have corroborated this description, with autistic individuals often relying on memorized, verbatim utterances and showing a lack of novel language production (Perkins et al., 2006; Prizant & Rydell, 1984). These individuals may use precise terms for general expressions (Perkins et al., 2006) and echo phrases verbatim (Karmali et al., 2005; Stribling et al., 2007; Valentino et al., 2012). For instance, much of an autistic person's conversational input may be directly adopted from their conversational partner (Dobbinson et al., 2003), and they often treat common collocations, like "brush your teeth," as indivisible units (Johnson et al., 2007). This may even contribute to phenomena like pronoun reversals, in which autistic individuals are more likely to use 'you' instead of 'I' when referring to themselves (e.g., saying 'you do this' instead of 'I do this') (Naigles et al., 2016).

Interestingly, autistic individuals often display advanced expressive language skills that can exceed their comprehension abilities, a pattern that contrasts with neurotypical development where comprehension generally precedes production (Groen et al., 2008; Kover et al., 2013; Maljaars et

al., 2011). Autistic individuals may produce complex verbal chunks, such as nursery rhymes or TV ads, despite showing little flexibility in language use (Johnson et al., 2007). This linguistic profile suggests that autistic individuals possess a repertoire of stored phrases without necessarily demonstrating adaptability in their use.

Autistic adults also face difficulties with tasks involving thematic integration, such as storytelling (Geelhand et al., 2020), although there is considerable individual variation on this point. In fact, pragmatics—the application and modification of language in different contexts—emerges as a particularly challenging area, even when controlling for general language ability (Schaeffer et al., 2023). Challenges arise when tasks require the flexible extension of word meanings (Cuneo et al., 2024), the making of normative judgments on novel stimuli (Wilson & Bishop, 2020), or the interpretation of implied or non-literal meanings (Dindar et al., 2023; Wilson & Bishop, 2020). As one autistic adult reflected: “I wish people were more mindful of things that are ambiguous in communication. I’m fortunate to have memorized so many idioms and metaphors that I can instantly translate them in my head” (Cummins et al., 2020).

When language is less ambiguous and requires little inference, relying on memory and item specific knowledge, studies show that autistic adults can perform as well as or better than neurotypical adults. For example, autistic adults excel in tasks like memorizing new words (Cuneo et al., 2024), context-independent vocabulary tests (Wilson & Bishop, 2020), and lexical knowledge (Schaeffer et al., 2023).

In non-autistic language use, item-specific knowledge plays a crucial role in certain linguistic tasks, such as learning and storing irregular word forms like past tense verbs (e.g., "went") (Plunkett & Marchman,Virginia, 1993), ordering adjectives (Boyd & Goldberg, 2011; Pawley & Syder, 1983), and conversational borrowing (J. K. Bock, 1986; K. Bock & Loebell, 1990; Clark, 1973; Ferreira, 2003; Garrod & Pickering, 2004; Hawkins et al., n.d.; Konopka &

Bock, 2009; Pickering & Garrod, 2004). However, while these rigid patterns are a natural feature of neurotypical language, they may be over-relied upon in autistic adults.

Part of the usage based approach discusses the language network, or the construction net, which relies on clustering similar instances together. This ability is seemingly impacted in autistic adults. For example, in a false memory task (Beversdorf et al., 2000; Roediger & McDermott, 1995), participants are shown a list of words associated with a central "gist" word, such as "bed," "rest," and "awake," without presenting the gist word itself—like "sleep." Non-autistic individuals frequently exhibit false memories, falsely recalling hearing the unlisted gist word (e.g., "sleep") as part of the original set, likely due to clustering related concepts in memory. In contrast, autistic individuals typically do not experience this effect. This phenomenon has been substantiated in a meta-analysis of 36 studies, which found that autistic participants not only exhibited lower suggestibility and fewer false memories but also outperformed control groups in memory tasks (Griego et al., 2019).

A series of studies examined polysemy (or words with multiple related meanings) among individuals with autism (Floyd & Goldberg, 2021; Floyd et al., 2021). Work by Floyd & Goldberg (2021) demonstrated the ease with which non-autistic individuals both learn and remember polysemous words (multiple related meanings) compared to homonymous words (multiple unrelated meanings), an advantage that is exhibited even a week after learning. This same experimental setup was conducted with autistic children, where it was found that their performance was equal to non-autistic children in their capacity to learn homonymous words, however, autistic children did not demonstrate any advantage in identifying given meanings of polysemous words (Floyd et al., 2021). Put differently, their retention of the meanings of novel words was uninfluenced by whether those meanings were related or unrelated.

1.5 The proposal

This dissertation proposal plans to build on the autism language literature by combining the usage based paradigm of language learning (Chapter 1.3) with insights from autism literature to form the FLAME hypothesis of autism language (Chapter 1.2).

This hypothesis seeks to explore the distinction between two key aspects of language: those that rely on item-specific knowledge and those that depend on generalizations. By examining this distinction, we aim to better predict and understand which aspects of language autistic adults excel in and which present challenges. The FLAME Hypothesis of Autism Language addresses each of these aspects.

Through this lens, we gain deeper insights into language flexibility dynamics, supporting the constructionist view and enhancing our understanding of autism. This paves the way for more effective interventions and promoting meaningful linguistic engagement for individuals on the autism spectrum. The following studies are designed to address different levels of language, from word meaning through grammatical patterns.

Study Blue Print The three experimental studies in my thesis test a powerful theoretical framework using systematic methodology that allow me to compare potential strengths and weaknesses within autistic individuals and between autistic and neurotypical groups. All studies each include two distinct tasks. One task requires flexible extension of meaning (FLAME), while the other task does not require any extension of meaning. Crucially, the blocks will be matched in study design to the extent possible. Half of the participants will perform the flexible extension task before the non-extension task, and the other half will perform the non-extension task first; each task will include attention checks. Thus, I will manipulate whether FLAME (Flexibility in

Language and Meaning Extension) is required or not and will then directly compare performance on the two tasks, within and across autistic and non-autistic participants.

- Hypothesis: When matched on language ability, autistic individuals will show greater difficulty on tasks requiring flexible meaning extension than on tasks that do not. This pattern is also expected relative to the performance of their non-autistic peers.

1.6 An overview of the following chapters

Chapter 2: Flexibility in Meaning Extension vs. Novel Word Learning Chapter 2 examines how autistic and neurotypical adults differ in extending the meaning of familiar words versus learning new words. In study 1, the sample included 160 participants, with 80 autistic and 80 neurotypical adults. Results revealed that autistic adults found tasks involving flexible meaning extension more challenging than neurotypical peers, though they excelled in a novel word-learning task without flexible extension requirements. These findings suggest that it's not language difficulty per se but rather the flexibility component in language that may pose challenges for autistic individuals (Cuneo et al., 2024).

Chapter 3a: Multi-Word Constructions vs. Fixed Language Chunks The third chapter seeks to extend the findings in word meaning to include phrase meaning. In this chapter study 2 contrasts performance on flexible multi-word constructions with fixed, memorized language chunks. Among 135 participants (61 autistic and 74 non-autistic adults), autistic participants again demonstrated greater difficulty with flexible constructions compared to non-autistic adults, while matching their peers on tasks involving fixed chunks. This study suggests that the challenges autistic individuals face with language may lie specifically in contexts requiring flexible interpretation, with routine or rigid constructions being well within their strengths (Cuneo & Goldberg, 2025).

Chapter 3b: Consensus and Flexibility in Prototypical Word Recall The second half of the third chapter shifts to examining consensus in recalling prototypical words within construction clusters. With 120 participants (60 autistic and 60 neurotypical adults), study 3 found that neurotypical adults displayed greater consensus in prototypical word recall, suggesting a more flexible approach

to categorization. In contrast, autistic adults showed more individual variation, consistent with a tendency toward distinct, less flexible categories (Cuneo & Goldberg, 2025).

Chapter 4: An Action Based 5 Year Review Chapter 4 seeks to address the sample limitations of Studies 1–3, particularly the lack of representation across the full autism spectrum. This study conducts a comprehensive review of language research from the past five years, synthesizing key findings and offering practical recommendations for clinicians and researchers working with autistic individuals (DeMarchena et al, *to appear*).

Chapter 2: Taken from: Cuneo, N., Floyd, S., & Goldberg A.E. (2024). Word meaning is complex: Language-related generalization differences in autistic adults. *Cognition, 244*.

In addition, this work was presented at the following places:

Cuneo, N (2025, Princeton) Neurodiversity in Design: How Language Research informs Digital Accessibility. To present at the CPACC Training Workshop. Princeton, New Jersey.

Cuneo, N (2025, Princeton) Beyond Accessibility: Crafting Digestible and Engaging Content for Neurodiverse Audiences. Talk presented at the Princeton UX Research Group & OIT Department. Princeton, New Jersey.

Cuneo, N (2024, Philadelphia) Flexible Language and Meaning Extension; A Constructionist Approach to Autism. Talk presented at the AJ Drexel Autism Institute. Philadelphia, Pennsylvania.

Cuneo, N, Floyd, S, & Goldberg, A. (2023, Sydney) Word meanings are complex: implications for communication differences in autistic individuals. Poster accepted at the 2023 Cogsci Conference, Sydney, Australia.

Cuneo, N, Floyd, S, & Goldberg, A. (2023, Stockholm) Word meanings are complex: implications for communication differences in autistic individuals. Poster presented at the 2023 International Society for Autism Research (INSAR), Stockholm, Sweden.

Cuneo, N, Floyd, S, & Goldberg, A. (2023, Durham) Word meanings are complex: implications for communication differences in autistic individuals. Poster presented at the 2023 Meeting of Language and Autism (MOLA), Durham, US.

Cuneo, N, Floyd, S, & Goldberg, A. (2023, Denver) Word meanings are complex: implications for communication differences in autistic individuals. Poster presented at the 2023 Linguistic Society of America (LSA) Conference, Denver, US.

"the word jumping triggers a memory of jumping hurdles at the Mock Olympics held at my elementary school…'he ran quickly' triggers an animated image of Dick from a first-grade reading book" (Grandin, 2006).

Introduction

People typically underestimate the complexity of word meanings and the flexibility required to use words appropriately, as people often assume each word refers to a clear-cut, fixed category (Gelman, 2003). Yet the most common words apply to highly complex categories of meanings (Lakoff, 1987; Murphy, 2002; Wittgenstein, 1953). For instance, the English word cap can refer to a bottle cap, pen cap, or mushroom cap; sorry can express a genuine apology, a polite means of excusing oneself, or an expression of sympathy. Word meanings are routinely extended as new situations arise (Christiansen & Chater, 2002; Elman, 2009; Mikolov et al., 2013). Both children and adults regularly select terms that are "good enough" to serve their intended purpose; for instance, a speaker may call a pencil a pen if the word pencil is temporarily inaccessible at the moment of speaking (Casasanto, 2015; Clark, 2023; Goldberg, 2019; Goldberg & Ferreira, 2022; Koranda et al., 2022). Given the need to use familiar words flexibly, we can predict that difficulties flexibly extending meanings will complicate communication.

This prompts our investigation into language and autism since autistic individuals tend to display greater attention to detail and a reduced tendency to generalize in comparison to individuals not diagnosed with autism (hereafter, neurotypicals or NTs). In particular, autistic individuals tend to display more veridical memory of instances, an observation primarily documented in perceptual tasks (Goldstein et al., 2001; Iarocci & McDonald, 2006; Kaplan-Kahn et al., 2021; Klinger & Dawson, 2001; Kopec et al., 2020; Mottron & Burack, 2001; Mottron et al., 2003; Mottron et al., 2006; Peck et al., 2021; Plaisted, 2000; Plaisted, 2001, although see Simmons & Todorova, 2018). For instance, autistic individuals are more likely to recognize visual entities that are highly similar

as distinct (Soulières et al., 2007), and tend to outperform NTs in discriminating phonetic distinctions as well (Eigsti & Fein, 2013, Remington and Fairnie, 2017).

Perception that is more veridical can be beneficial but may incur a cost when generalizing across instances is helpful, insofar as more detailed perceptions tend to be accompanied by a tendency to overlook similarities and relatedness (Happé & Booth, 2008; Happé & Frith, 2006; Mottron et al, 2013). For example, autistic individuals tend to be less accurate than NTs when asked to identify which of two dot patterns is more similar to a target pattern (Plaisted et al., 1998). When asked to compare two tones, NTs are influenced by an emergent category of tones witnessed across previous trials: the first of two tones being compared on a trial is treated by neurotypicals as if it were closer to the statistical average than it actually was; on the other hand, autistic individuals do not show evidence of forming the statistical average (Eigsti & Fein, 2013; Braida et al., 1984; Jaffe-Dax & Eigsti, 2020; Lieder et al., 2019). More generally, autistic individuals display a reduced tendency to form complex categories (Church et al., 2010; see Vanpaemel & Bayer, 2021 for review). Intriguingly, autistic children's receptive vocabulary has been found to correlate with their tendency to generalize in such non-linguistic tasks (Eigsti & Fein, 2013).

There is also evidence for reduced generalization outside the perceptual domain. In comparison with NTs, autistic adults are less prone to false memories that arise from generalizing beyond actual experience (Beversdorf et al., 2000; Hillier et al., 2007; Wojcik et al., 2018). Being able to generalize learned skills in appropriate new contexts is important for the skills to be used in daily life (Gunning et al., 2019), yet autistic individuals struggle to generalize successful strategies more than their NT peers do (de Marchena et al., 2011, de Marchena et al., 2015). Autistic children are also less likely to generalize a property from one member of a category to other instances of the category than their NT peers; for example, when shown an image and told "This black cat can see in the dark" and then shown a picture of another black cat in a different pose and asked, "Can this

black cat also see in the dark?" autistic children are less likely to say "yes" than NT children are (Naigles et al., 2013, Tecoulesco et al. 2021).

Yet the majority of work aimed at identifying communication challenges in autistic populations has overlooked a potential role for generalization differences. Instead, research has tended to focus on differences in social cognition (Anderson et al., 2007; Baron-Cohen, 1993; Carpenter & Tomasello, 2000; Ellis Weismer & Kover, 2015; Kuhl et al., 2005; Mundy et al., 1990; Osterling & Dawson, 1994; Paul et al., 2013; Sigman & McGovern, 2005; Tenenbaum et al., 2015) or differences in executive function (e.g., Ellis Weismer et al., 2018; Friedman & Sterling, 2019; Hill, 2004). Notable exceptions include the observation that autistic children are less likely than NT children to generalize word labels of concrete objects by generalizing their shape (Potrzeba et al., 2015; Tek et al., 2008; Tovar et al., 2020). Other relevant work has found that autistic children, aged 7-14, were as challenged by learning novel words assigned multiple related novel meanings (polysemes) as they were by learning novel words assigned multiple unrelated novel meanings (homonyms); NT children, on the other hand, display a marked advantage for learning polysemes over homonyms, seeming to spontaneously form a complex category of related meanings (Floyd & Goldberg, 2021; Floyd et al., 2021).

The current work extends these prior findings in important ways. First, the prior work on polysemes has relied on novel labels for novel objects. In order to determine whether autistic individuals find it challenging to extend the meanings of real words in realistic ways, the current study tests the ability of a large group of autistic individuals to extend familiar words to semantically related, familiar entities. The current meaning extensions rely on a variety of relationships including related functions, rather than exclusively focusing on shape or other perceptual features. In addition, prior work in this domain has focused almost exclusively on children. Since delays in language development are very common among autistic individuals, it

remains unclear whether verbal adults ultimately achieve parity with NTs. Therefore, the current experiment tests adults. Finally, the current work employs a second task, which differs primarily in the need for flexible extension; this allows us to compare autistic and neurotypical groups on the variable of interest as directly as possible.

The current preregistered study assesses how easily autistic adults assign familiar words to plausible new meanings in comparison to their NT peers. Specifically, after demonstrating familiarity with the conventional meanings of each target word, participants took part in a Flexible Meaning Extension (FME) task, where they were asked to select the most plausible extended meaning in a four-alternative forced choice (4AFC) task (Figure 1).

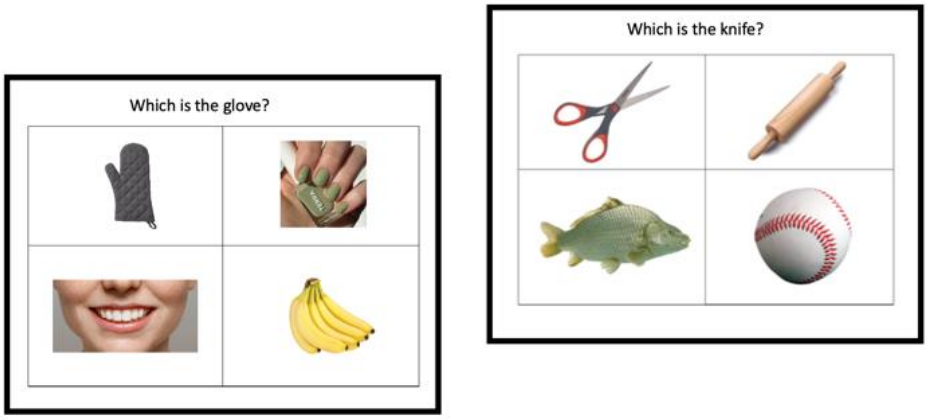


Figure 1: Two example trials used in the Flexible Meaning Extension task. On the left, participants were asked to choose which image was a glove, and on the right, which image was a knife.

The target meaning extensions were inspired by co-lexification patterns in languages other than English (e.g., the same word, tapa, is used to label both lids and caps in Spanish; Rzymski et al., 2020; see also Floyd et al., 2020). Fourteen pairs of common words and novel meaning extension images were selected based on preregistered norming criteria to ensure that each target word was a plausible, but not commonly used label for the extension image. The norming additionally

collected judgments about how similar in shape each target image was to the conventional meaning of each word. See SI.D for specifics about the norming and inclusion criteria.

Since brief online measures of executive function are unreliable (Camerota et al., 2020), in order to provide a way to assess focused attention, motivation, and skill in learning one-to-one mappings between labels and images, a Label Learning (LL) task tested participants' ability to learn eight one-to-one mappings between new words and novel objects. Like the FME task, LL was a 4AFC task: participants were required to choose which novel object matched the label that had been provided during exposure. Unlike the FME task, the LL task required no generalization.

We hypothesized that generalization challenges would impact even verbal autistic adults. Specifically, we predicted that in comparison to neurotypicals, autistic adults would find the FME task particularly challenging compared to the LL task. That is, we predicted an interaction, which would suggest that the difficulty autistic individuals face in generalization impacts their ability to interpret word meanings flexibly, while other aspects of word learning are more comparable between the two groups.

Methods

Design, sample sizes, exclusion criteria, and analyses were preregistered: https://researchbox.org/1192. Please see online Supplemental Information for a) details and links to the preregistrations, data, and analyses (SI.A); b) survey on terminological preference for our autistic participants (SI.B); c) more specifics on methods including images of all trials for both tasks (SI.C); d) specifics about the norming study (SI.D); e) full models of preregistered model and direct comparisons (SI.E) and exploratory analyses (SI.F); f) specifics of analyses testing a role for competition (SI.G).

Participants

80 autistic adults (28 female, 52 male; Mage = 31.7) were recruited via the Asperger/Autism Network and identified themselves as autistic. 80 NT adults (49 female, 31 male; Mage = 42.8) were recruited via Cloud Research (Litman & Robinson, 2020), and reported themselves to be non-autistic. Gender, proficiency in the Spanish language, and educational attainment were self-reported and subsequently included in exploratory models.

Procedure

All participants completed the flexible meaning extension (FME) and label learning (LL) tasks. The order of tasks was counterbalanced across participants in each group, and the order of trial presentation within each task was randomized for each participant. Both tasks were hosted on the online, Qualtrics platform and involved no participant-researcher interaction. No time constraints were imposed on responses.

Flexible Meaning Extension Task

Each participant saw six of 14 normed stimulus words (see SI.D for norming details). Each word was presented in two conventional meaning trials and one FME trial. Conventional meaning trials included a target image depicting a conventional meaning of the word; these trials were included to ensure all participants had the requisite prior knowledge of the conventional word meanings to be able to perform the FME task. All participants met the preregistered exclusion criterion (performance above 90% on conventional trials).

The critical FME trials required participants to assign a series of familiar words to plausibly related meaning extensions (Figure 2).



Figure 2. Fourteen familiar words and corresponding target images used in the Flexible Meaning Extension task. Norming ensured the images were plausibly related to the stimulus words but not commonly labeled by those words.

In each critical FME trial, four distinct options were presented along with the familiar label: the target image, two foil images, and a distractor image. The foils were unrelated to the label, while the distractor shared some characteristic or thematic relation with the label. The norming confirmed that all target images were preferred over the distractor image more than 90% of the time in a two alternative forced choice task (see SI.C for full set of stimuli used as targets, distractors, and foils, and SI.D for details of the norming study).

Label Learning Task

Novel objects and labels were selected from The Novel Object and Unusual Name (NOUN) Database (Horst & Hout 2016). Participants were initially familiarized with 24 novel objects, presented 4 at a time for 4 seconds, without labels, in random order (see Figure 3 [Left]). A written prompt: "Look at these!" appeared at the top of the screen.

Immediately after the familiarization trials, participants saw 8 novel objects, a unique novel label assigned to each, for 4 seconds apiece (two example exposure trials are provided in Figure 3 (right side).

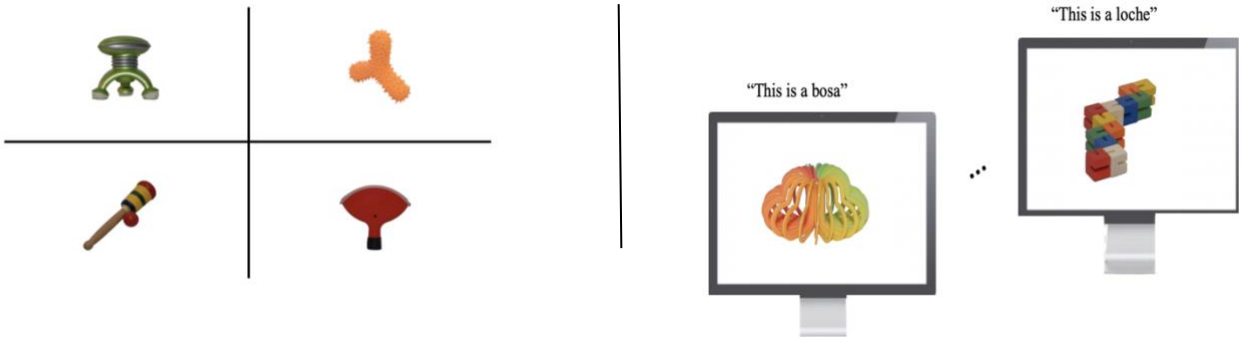


Figure 3: Example familiarization trial (left) and two examples of labelled novel objects witnessed in the exposure phrase (right) of the Label Learning task.

At test, participants were asked to assign each novel label to its correct target object in a 4AFC task. The four options always included the target (correct), a distractor object, and two foil objects. The distractor image had been assigned a different label than the one queried, and served as a target on a different trial. Foil images were witnessed during familiarization but unlabeled. The

LL task required no generalization, since each novel label named a single novel object. See SI.C for all stimuli.



Figure 4. Sample trial in Label Learning task. This task includes the target image (here, loche), two foils that had been witnessed but unlabeled during exposure, and a distractor image that was previously labeled (here, bosa).

Results

Accuracy on recognition of the conventional meanings of familiar words was very high, confirming that both groups had the requisite prior knowledge of the familiar words' meanings required to potentially perform the FME task accurately (M = 100% for NT, 97.8% for AS). Of interest was performance on the FME and LL trials (Figure 5).

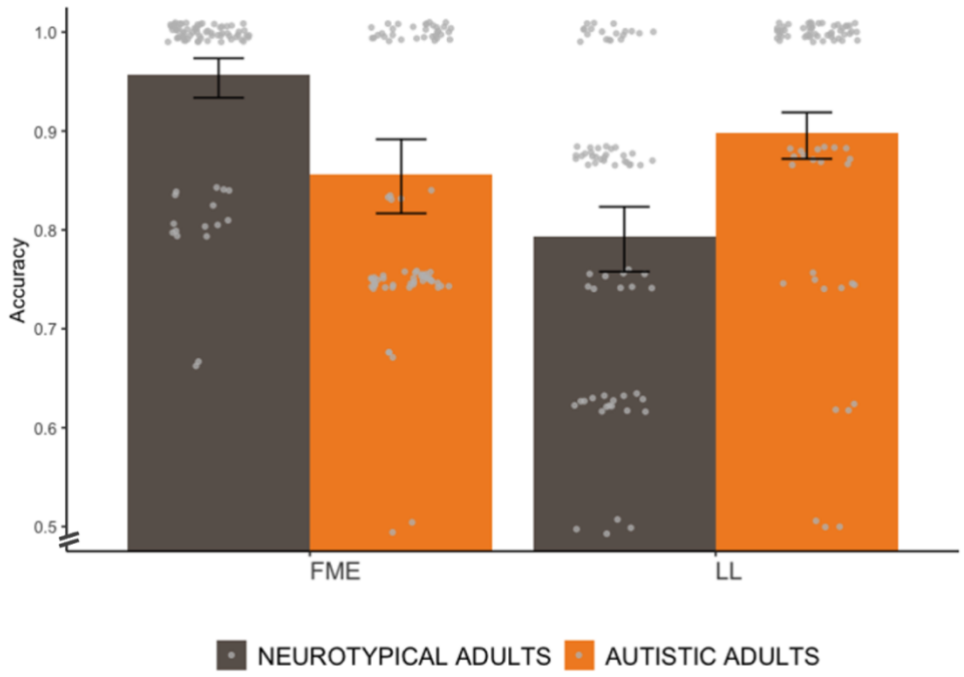


Figure 5. Accuracy on the Flexible Meaning Extension task (left) and the Label Learning task (right) for neurotypical (brown) and autistic adults (orange), with 95% confidence intervals. Grey points represent average accuracy of each participant (N=160).

Every participant scored at or above 50% accuracy on both tasks, where chance was 25%. Ceiling performance on the FME task was reached by 80% of NTs and 29% of AS participants, while ceiling performance on the LL task was met by 19% of NTs and 64% of the AS group. As planned, a generalized mixed effect model predicted accuracy on the basis of an interaction of group (AS vs NT) and trial type (FME or LL), with random slopes and intercepts for subjects and items. Fixed effects were sum coded. The predicted interaction was significant (β = 0.75, z = 3.81, p = 0.0001). Direct comparisons revealed that AS participants were less accurate than NT participants on the FME task (β = -1.62, z = -2.33, p = .02; 85.6% vs 95.8%), and more accurate on

the LL task (β = 1.49, z = 3.10 p = .002; 89.8% vs. 79.4%). Within group comparisons likewise revealed clearly distinct performance patterns: AS participants exhibited significantly higher accuracy on the LL task than the FME task (β = 1.83, z = 3.08, p = 0.002); in contrast, the NT participants performed significantly lower on the LL task than the FME task (β = -1.87, z = -3.33, p = 0.0009). See SI.E for full model results, and SI.F and SI.G for full exploratory models for results described below.

To explore whether the errors made by the autistic group in the FME task were attributable to extraneous factors, we performed a series of exploratory analyses, using generalized linear mixed models with the maximal effect structure that convergence allowed (See SI.F for full models). Six of the 14 FME items were inspired by co-lexification patterns in Spanish (Floyd et al., 2020), so we tested whether familiarity with Spanish influenced accuracy in this group on this task, and found no evidence that it did (β = -0.02, z = -0.10, p = 0.92); neither did we find any evidence for an effect of education level (β = -0.06, z = -0.73, p = 0.47); gender (β = 0.20, z = 0.33, p = 0.74); or age (β = 0.06, z = 0.82, p = 0.41). Given that autistic children are less likely to prioritize shape than neurotypicals, we used the norming data on mean similarity in shape between each word's conventional and extension images to predict accuracy. Similarity in shape (or lack thereof) did not predict accuracy either (β = 0.01, z = 1.15, p = 0.25).

Since executive function differences have been observed between AS and NT individuals, we considered that AS errors on FME trials might be due to the need to suppress a more conventional label for the target image: i.e., in order to successfully identify an image of a scissors as a knife, it may be necessary to suppress the competing word, scissors. To address this, we calculated the strength of competition from conventional labels by calculating Shannon H entropy scores, based on spontaneous labeling data from the norming data. A generalized linear mixed

models with subject and item as random effects failed to show any influence of competition (β = 0.81, z = 1.02, p = 0.31).

Discussion

The Flexible Meaning Extension task and Label Learning tasks are broadly comparable: both are 4AFC tasks and both require assigning words to object images in new ways. Results show that the autistic adults performed significantly better than the NTs on the LL task, which did not require the flexible extension of meanings (see also Norbury, Griffiths, & Nation, 2010). Critically, and as predicted by the idea that language should be affected by autistic individuals' generalization differences, autistic adults were significantly more challenged than the NTs on their ability to flexibly extend familiar words to related entities. Moreover, analyses within each group revealed that autistic individuals performed better on the LL task than the FME task, and the neurotypical adults displayed the opposite pattern.

Potential explanations for the current results that do not rely on generalization differences in the two groups are undermined by various aspects of the design or analyses. The autistic group's especially strong performance on the LL task undermines potential appeal to differences in executive function, given that the LL task requires focused attention and working memory, two key aspects of executive function. Moreover, the degree of competition from a more conventional label showed no influence on accuracy. Neither can the difference in performance be attributed to greater fatigue or distraction in one group on either task, since presentation of FME and LL tasks was counterbalanced across participants.

The group difference in performance on the FME task is not attributable to differences in prior knowledge, since both groups identified the conventional meanings of each of the familiar words at near ceiling levels. The effect cannot be attributed to a failure of the autistic adults to

understand the pragmatics of the task, since while they performed significantly lower than the NT group, they all performed well-above chance. Exploratory analyses revealed no evidence that the reduced performance on the FME task was predicted by education, age, gender, or familiarity with Spanish. Finally, the study took place entirely online, without any person-to-person interaction, eliminating the possibility that the social demands of a research setting influenced performance.

We had predicted autistic adults would underperform neurotypicals on the FME task and perform equivalently on the LL task. The fact that our autistic adults outperformed neurotypicals on the LL task was not anticipated. Since the autistic and neurotypical participants were recruited from two different platforms, the autistic participants' strong performance on the LL task may potentially be due to any of a number of factors including stronger motivation, attention, or IQ. A recent meta-analysis has found that autistic individuals recruited for online studies tend to be more educated and less likely to have intellectual disabilities than autistic individuals generally (Rødgaard et al., 2022). If our autistic participants outpaced our neurotypicals on any of these dimensions, however, it may explain their strong performance on the LL task, but it would make their underperformance on the FME task all the more remarkable.

Alternatively, it may be that strength in associating and retrieving labels with single meanings tends to be a particular area of strength for verbally able autistic individuals: To compensate for semantic memories that may be less clustered together and thereby more difficult to recall, verbally able autistic adults may rely more on episodic memory for language (recall the epigraph from Temple Grandin). While episodic memory retrieval is not considered an area of strength among autistic individuals generally, it has been argued to be at least comparable to neurotypicals when contextual support is provided (Norris & Maras, 2022). Moreover, it is possible that stronger memory recall is (or becomes) an area of strength among verbally able autistic adults. Future research is needed to investigate a potential relationship between memory and language to

determine whether stronger memory serves as a compensatory mechanism for the reduced tendency to flexibly generalize among verbally able autistic individuals.

Autism refers to a wide range of phenotypes and we do not expect all autistic individuals to be affected by challenges in extending word meanings, and certainly not to the same degree (Tager-Flusberg, 2004; McCormick et al., 2020). Indeed, while the current results demonstrate a significant group-level difference, 29% of autistic adults performed at ceiling on the FME task. We could not examine individual differences within each group because we did not collect supplementary metrics (e.g., diagnosis history, language history, vocabulary, IQ), although we aim to in future work. The fact that skill in extending word meanings is affected at the group level, even among verbally able autistic adults, raises the possibility that individuals with less verbal ability may be more impacted. The current FME task included only concrete words extended to new concrete entities; while this is a limitation of the current work, it also suggests that the implications of a difference in flexible meaning extension are potentially far reaching. In fact, autistic individuals' tendency to struggle with metaphorical extensions and sarcastic or ironic interpretations (Morsanyi et al., 2020) may stem from the same challenge identified here.

Insofar as new uses of familiar words are ubiquitous in natural language interactions, interventions aimed at increasing skill in this domain are worth exploring as a complement to interventions that emphasize social cognition and/or executive function (see also Naigles et al., 2013; Naigles & Tek, 2017). Future work is required to determine whether challenges in flexible meaning extension are relevant to children with developmental language disorders (Collison et al., 2015; Field et al., 2016; Jones, 2003). This possibility is suggested by the finding that children with DLD, like autistic children, demonstrate delayed prioritization of shape in early noun learning (Gladfelter & Barron, 2020; Perry et al., 2022).

At the same time, the current findings generalize prior work that has found that, in comparison to NTs, autistic children are less likely to appropriately prioritize shape when generalizing novel labels of concrete entities, (Collisson et al., 2014; Potrzeba et al., 2015; Tek et al., 2008; Tovar et al., 2020). That is, we find no evidence that the current effect results from a failure to prioritize the shape of objects. Instead, we suggest that both a reduced shape bias in autistic children and the current results reflect a broader difference in generalization, which continues to impact autistic adults at the group level. Given the complex and dynamic nature of word meanings in natural language, skill in extending meaningful categories in new ways merits close attention.

Other prior work had found that a group of autistic children showed no evidence of taking advantage of semantic relatedness among meanings when learning novel words, while neurotypical children did (Floyd et al., 2021). The current work demonstrates that even verbally able autistic adults are more challenged than neurotypicals in recognizing related plausible new meanings of familiar words. This therefore extends the impact of generalization differences well beyond childhood and beyond the realm of novel word learning to the domain of language comprehension. Because the semantic relatedness in the FME task did not depend on perceptual similarity, the current results extend language-relevant generalization differences among autistic individuals beyond visual or auditory perception.

The current work suggests an explanation for long-standing observations about unconventional aspects of autistic individuals' speech, namely that it often contains more repetitions and less productive extensions than neurotypicals' speech (for review see Luyster et al., 2022). To the extent that autistic individuals struggle to flexibly extend categories, including the complex categories of word meanings, their language can be expected to be less flexible and more rigid.

Persistent challenges in flexible generalization may help contextualize mixed results that extend beyond research on language. For example, scholars have claimed that autism is a prediction disorder (Sinha et al., 2014; Van de Cruys et al., 2014), although the evidence is mixed (Cannon et al., 2021; Prescott et al., 2022). Other studies have found autistic individuals rely less on priors in perceptual and social tasks than neurotypical individuals (e.g., Pellicano & Burr, 2012; Von Der Lühe et al., 2016), although again, a recent meta-study finds the evidence to be mixed (Chrysaitis & Seriès, 2023). We speculate that it may be useful to reanalyze previous results in terms of what is required in each case to create a prediction or make use of priors. Both require recognizing that a current event is relevantly similar to some prior event; without this, there would be no basis for a prediction, as priors would not be recognized to be relevant. That is, to appreciate that an event or stimuli, A, will be followed by another event or stimuli, one needs to recognize that the current situation or stimuli, A', is relevantly similar to A. The task may be more or less challenging, depending on how direct the relationship is between A and A', as well as on variability among autistic individuals.

Conclusion

The growing appreciation that word meanings must be routinely extended to apply in new contexts, combined with the observation that autistic individuals attend more to specifics than neurotypicals in domains outside of language, motivated the hypothesis tested in the current work. As predicted, the autistic group performed significantly less accurately on the task that required them to flexibly extend the meanings of familiar words in plausible but unconventional ways, while they significantly outperformed their neurotypical peers on the similarly demanding novel label learning task that did not require flexible extension. Exploratory analyses revealed no support for alternative explanations in terms of differences in prior knowledge of the familiar meanings, understanding of

task pragmatics, executive function or competition effects, education level, familiarity with plausible extensions from knowledge of Spanish, age, gender, or similarity (or lack of similarity) in shape of the items. Future work is required to determine whether the difference in flexible meaning extension applies to aspects of language beyond the word level. A deeper appreciation of the role of flexible extensions in language offers both a deeper understanding of natural language and potentially a novel way to understand communication challenges faced by autistic individuals.

Data availability Data, analyses, and preregistrations are available here: https://researchbox.org/1192

Supplementary Information is uploaded separately and includes a) details and links to the preregistrations, data, and analyses (SI.A); b) results of survey on terminological preferences for our autistic participants (SI.B); c) images of all trials for both tasks (SI.C); d) the norming study e) full models of preregistered model and direct comparisons (SI.E); f) full models for all exploratory analyses (SI.F); g) specifics of several analyses testing a role for competition (SI.G).

Supporting Information

Cuneo, Floyd, & Goldberg "Word meaning is complex: language-related generalization differences in autistic adults"

SI.A. Preregistration: https://researchbox.org/1192

Table SI.1 Availability of data

type	section	description	file name
Pre-Registration	Main Study Pre-Registration	AsPredicted #97387	Main Study Pre-Registration - AsPredicted 97387.pdf
Data	Norming Data File (for supplementary analysis)	csv	Norming Data File for supplementary analysis.csv
Codebook	Norming Data File (for supplementary analysis)	csv	Norming Data File for supplementary analysis.csv___CODEBOOK.csv
Pre-Registration	Stimuli Norming Pre-Registration	AsPredicted #104803	Stimuli Norming Pre-Registration - AsPredicted 104803.pdf
Code	Total Rscript	R Code	Total Rscript.r
Data	Total Study Data File	csv	Total Study Data File.csv
Codebook	Total Study Data File	csv	Total Study Data File.csv___CODEBOOK.csv

SI.B. Terminological preference of participants

In an effort to respect our autistic participants' preferred terminology, we sent a survey to all autistic participants who completed the study.

Instructions: "We appreciate that people prefer different terms, and we would very much like to hear from you about your preferences. We would greatly appreciate it if you could let us know

your reactions to the descriptions listed below. These choices were taken from an adult terminology preference study and do not reflect the language or opinions of the researchers in this study."

Participants were provided a slider initially set at 0 which was labelled, Strongly Dislike. The other end of the scale was labelled, Strongly Like (100), as in Figure SI.1. Participants in both groups indicated no strong dispreference for any term, but both groups displayed a numerical preference for autistic individuals. Therefore, this is the term we predominantly use in the text.

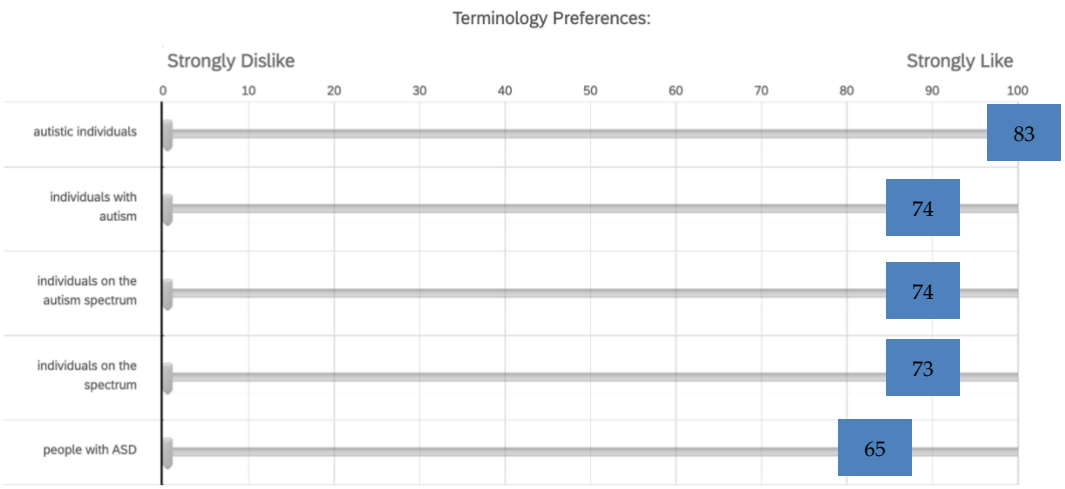


Figure SI.1: Adult autistic participants' preferences on terminology

SI.C. Specifics of Methods

Stimuli in Flexible Meaning Extension (FME) task

Stimuli comprised 14 common words paired with a novel but plausible novel meaning extension, inspired by the CLiCS database of cross-linguistic polysemy: https://clics.clld.org. In order to be included in the FME task, each stimuli had to meet the following criteria in the Norming study (ResearchBox #1192): (1) To ensure that the FME task required an extension of the target word's conventional meanings, the target image must not spontaneously elicit the target word more than 5% of the time; (2) To ensure that each extension was plausibly related to its target word, the extension image must elicit the target word in the two-alternative forced-choice task more than 90% of the time. We also collected judgments on the extent to which each word's extended meaning was related to its conventional meanings on the basis of shape (Table SI.2).

The full set of FME trials is in Figure SI.2: the target (most similar) image is in the top left quadrant and the distractor image (less similar but not unrelated) in the top right quadrant, and foil images are on bottom row. In the actual trials, the positions of target, distractor and foils were randomly positioned in quadrants on each trial.

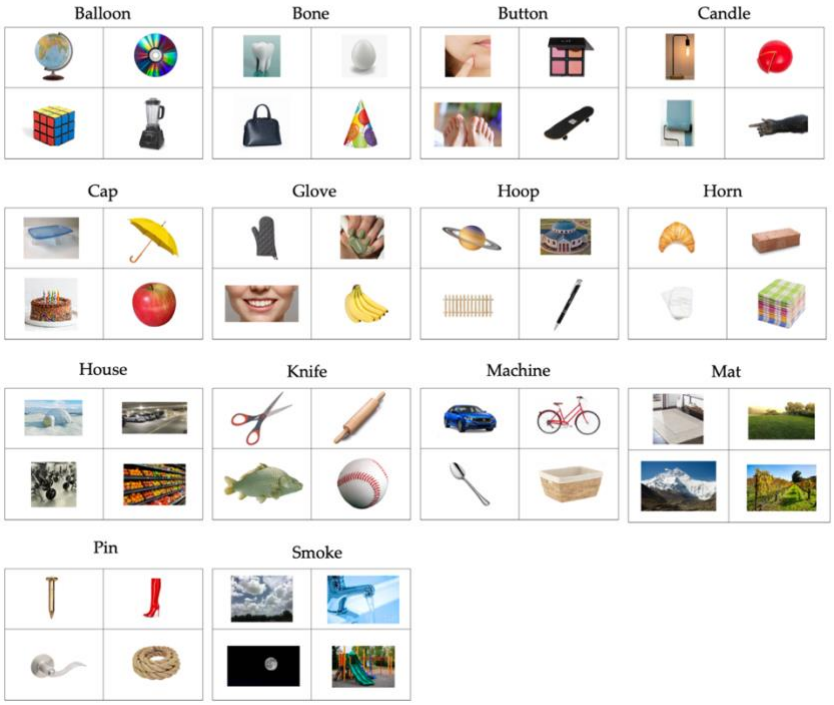


Figure SI.2: Full set of FME trials

Stimuli in Label Learning (LL) task

Two sets of labels were counterbalanced, across participants. All of the novel objects and alternate labels are shown in Figure SI.3. The full set of LL trials is shown in Figure SI.4

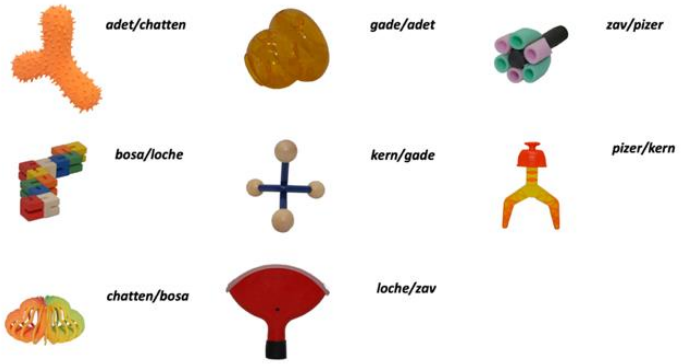


Figure SI.3: novel objects used in Label Learning task along with novel labels (counterbalanced across participants) from Horst & Hout (2016).

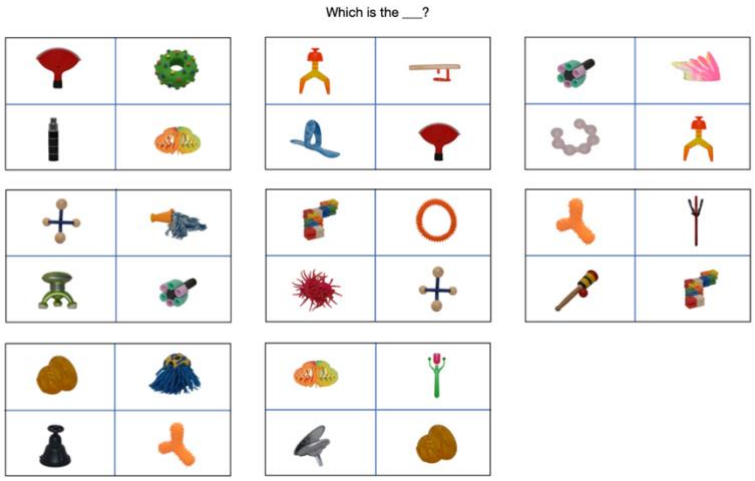


Figure SI.4 Full set of 8 label learning test trials (see Figure SI.3 for labels)

SI.D. Norming Study

28 extensions of familiar words to images were initially normed for use in the current FME task. The norming involved 3 tasks: free labeling of images, a 2AFC version of the FME task (which was a 4AFC task in the experiment), and judgments on how similar in shape each target image was to the conventional meaning of each word. Each participant was randomly assigned to one of 4 lists. No item was repeated across any of the three tasks, for any given participant.

Participants

148 neurotypicals were recruited through the Cloud Research platform which prescreens AMT participants for reliability (62 female, 80 male, 2 non-binary, 4 preferred not to say; Mage = 40.0). We had preregistered 144 participants and include all participants who took part.

The 14 target labels and image pairs used in the FME task were chosen based on the preregistered criteria described below:

Free Labeling

In the free labeling task, participants were simply asked to label each image. As preregistered, to be included in the FME task, the target image could not be labelled by the target label spontaneously by more than 5% of participants. This ensured that the task required participants to extend the familiar words. Typos were corrected before processing the data. Plural and singular terms were considered the same.

2AFC FME task

Participants were given a two alternative forced choice task and asked to select the best image for each provided target word from a choice of the target image and a "lure" image. The lure image was intended to be somewhat related to the word's conventional meaning, but less related than the target image. Our preregistered criteria required that the target image be chosen over the lure 90% of the time.

Similarity in Shape

We also asked participants in the norming study to decide how similar each target meaning extension image was from the target words' conventional meanings. "How similar in shape is the object below to those above?" A slider was provided and preset to the middle (scaled between 0 and 100). Table SI.2 provides the mean similarity-in-shape meanings for each meaning extension.

Table SI.2: Mean similarity in shape ratings for each stimulus word and target image

Familiar word (target image)	average similarity judgment(shape)	Familiar word (target image)	average similarity judgment (shape)
bone (tooth)	29.94	hoop (saturn ring)	71.35
machine (car)	30.55	glove (oven mitt)	78.89
candle (light)	32.00	house (igloo)	80.54
cap (lid)	37.44	button (pimple)	82.82
knife (scissors)	46.15	smoke (clouds)	82.96
mat (rug)	61.90	pin (nail)	84.50
horn (croissant)	64.22	balloon (globe)	85.52

Shannon Entropy

To test whether competition from a more familiar label was a factor in the autistic individuals' errors in the FME task, we calculated the strength of competitor labels for each image used in the FME task. The strength of competition was determined by calculating Shannon entropy scores, based on the Free Labeling data collected as part of the norming, from neurotypical participants. We subsequently collected data a separate group of 80 autistic adults to see whether their entropy scores might predict errors.

Lower entropy indicates more agreement across participants on a single label, which could presumably make that label a stronger competitor with the label provided. Higher entropy would imply that many different labels could label a particular image, with less agreement across

participants. To test whether low entropy led to more errors in the FME task for the autistic group, Shannon entropy was calculated as follows.

The number of distinct names (n): the number of distinct labels used to label a given target image, by the set of participants who took part in the norming task. All participants labeled the image of a scissors, scissor(s) so n = 1 for that item. The number of distinct names is expected to correlate with entropy, so that fewer distinct labels may predict more competition and therefore more errors.

Percentage agreement on a shared label: (pi) the percentage of participants who agreed on the most commonly used label for each item, i. (For instance, the image of clouds was labelled cloud or clouds by 45 % of participants, so its percentage agreement score was 45). Higher percentage agreement should also correlate inversely with entropy, so that higher agreement should mean stronger competition and therefore more errors.

Shannon H entropy combines these factors with the standard formula in (1). n is the number of unique labels assigned to each image; {p1…..pn} is the probability of each label being produced.

(1) $H(X) = -\sum_{i=1}^{n} p_i log_2 p_i$

SI.E. Full results of preregistered model and direct comparisons

In all models, the optimizer, optimx, was included and categorical variables AS and trialtype were sum contrast coded. An attention check was included in each task, and only participants who correctly answered attention checks were included in analyses. As preregistered, data was collected until we collected 80 AS and 80 NT participants in each group.

Table SI.3: Pre-registered model reveals predicted interaction between group (AS vs NT) and trial type (FME vs LL).

glmer(accuracy~trialtype*AS +(1 + trialtype|subject) + (1 + AS |item), binomial("logit"), optimizer, data)

Random effects:

Groups	Name	Variance	Std.Dev	Corr
subject	(Intercept)	0.00	0.02	
	trialtypeLL	2.23	1.49	
item	(Intercept)	1.46	1.21	
	AS1	2.85	1.69	-0.72

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.93	0.20	14.98	< 0.0001 ***
trialtype1	0.13	0.20	0.67	0.51
AS1	-0.01	0.20	-0.06	0.95
trialtype1:AS1	0.75	0.20	3.81	0.0001 ***

Pairwise comparisons between the two groups on each task (Flexible Meaning Extension and Label Learning) are provided in Tables SI.4 and SI.6.

Table SI.4: AS vs NT on FME trials

glmer(accuracy ~ AS + (1 |subject) + (1 + AS|item), binomial("logit"), optimizer, data_FME)

Random effects:

Groups	Name	Variance	Std.Dev
subject	(Intercept)	0.00	0.00
item	(Intercept)	2.17	1.47

	AS1	4.28	2.07	-0.78

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	4.00	0.54	7.39	< 0.0001 ***
AS1	-1.62	0.70	-2.33	0.02 *

Accuracy on individual items for both groups are shown in Figure SI.5.

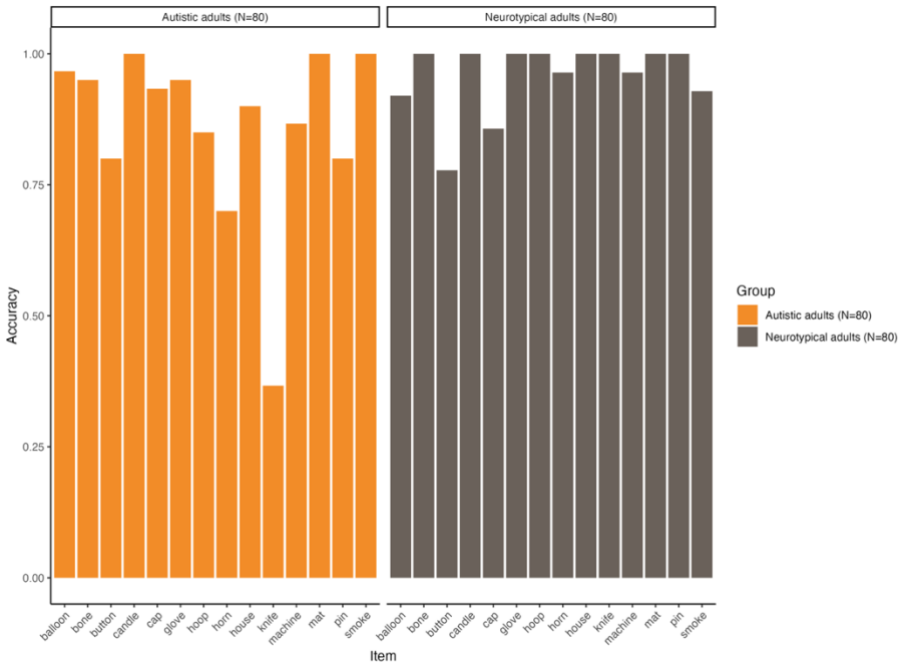


Figure SI.5: Mean accuracy in FME task, per target label for autistic adults (left, in orange) neurotypical adults (right, in grey)

Autistic participants displayed particular difficulty on the “knife” extension, so we re-ran the analysis without this item to ensure the effects were not driven by a single extension. Below is the modified model, excluding scissors. The results remain significant.

Table SI.5: Pre-registered model without “knife” extension still reveals the predicted interaction between group (AS vs NT) and trial type (FME vs LL).

glmer(accuracy~trialtype*AS +(1 + trialtype|subject) + (1 + AS |item), data_withoutknife)

Random effects:				
Groups	Name	Variance	Std.Dev	Corr
subject	(Intercept)	0.03	0.17	
	trialtypeLL	1.70	1.31	1.00
item	(Intercept)	1.41	1.19	
	AS1	1.94	1.39	-0.72

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.92	0.20	14.68	< 0.0001 ***
trialtype1	0.21	0.20	1.06	0.29
AS1	-0.08	0.19	-0.45	0.65
trialtype1:AS1	0.65	0.18	3.61	0.0003 ***

The comparison between groups on the Label Learning task is shown in Table SI.6.

Table SI.6: The AS group performed significantly more accurately on the LL trials than the NT group.

glmer(accuracy ~ AS + (1 |subject) + (1 + AS |item), binomial("logit"), optimizer, data_LL)

Random effects:				
Groups	Name	Variance	Std.Dev	Corr
subject	(Intercept)	2.18	1.48	
item	(Intercept)	1.32	1.15	

	AS1	2.07	1.44	-0.69

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	1.99	0.36	5.59	<.0001 ***
AS1	1.49	0.48	3.10	0.002 **

We also ran within-group comparisons on the two tasks, Flexible Meaning Extension and Label Learning, to determine whether each group differed in their performance on the two tasks. Results are provided in Tables SI.7 and SI.8.

Table SI.7 AS participants performed significantly better on the LL task than on the FME task.

glmer(accuracy ~ trialtype + (1+trialtype|subject) + (1 |item), binomial("logit"), optimizer, ASdata_only)

Random effects:

Groups	Name	Variance	Std.Dev	Corr
subject	(Intercept)	0.00	0.02	
	trialtypeLL	5.12	2.26	1.00
item	(Intercept)	1.73	1.31	
	trialtypeLL	0.12	0.35	-0.50

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.38	0.41	5.83	< 0.0001 ***
trialtypeLL	1.83	0.59	3.08	0.002 **

Table SI.8 The NT participants performed significantly worse on the LL task than on the FME task.

glmer(accuracy ~ trialtype + (1+trialtype|subject) + (1 |item) , binomial("logit"), optimizer, NTdata_only

Random effects:				
Groups	Name	Variance	Std.Dev	Corr
subject	(Intercept)	0.01	0.09	
	trialtypeLL	1.46	1.21	-1.00
item	(Intercept)	1.30	1.14	

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	3.75	0.45	9.36	<.0001 ***
trialtypeLL	-1.87	0.56	-3.33	0.0009 **

SI.F. Exploratory Models

It is difficult to explain the fact that the autistic group performed less well on the FME task but more accurately on the LL task without appealing to the key difference between the tasks, namely that only the FME task required flexible extensions of meaning. However, exploratory models were created to test whether familiarity with Spanish (SI.9), education level (Table SI.10), gender (SI.11), age (SI.12) or influence or lack of influence of shape (SI.13) may have predicted the lower performance by the autistic group on the FME task. No significant effects were revealed.

Table SI.9: Familiarity with Spanish did not predict accuracy on the FME task

glmer(accuracy ~ spanish + (1 |subject) + (1 |item), binomial("logit"), optimizer, data_FME_AS)

Random effects:			
Groups	Name	Variance	Std.Dev
subject	(Intercept)	3.89 e-17	6.24 e-09
item	(Intercept)	1.72	1.31

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.42	0.58	4.19	<.0001 ***
Spanish	-0.02	0.19	-0.10	0.92

Table SI.10. Education level did not predict accuracy on the FME task

glmer(accuracy ~ education + (1 |subject) + (1 |item), binomial("logit"), optimizer, data_FME_AS)

Random effects:

Groups	Name	Variance	Std.Dev
subject	(Intercept)	8.85 e-19	9.41 e-10
item	(Intercept)	2.23	1.49

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.81	1.03	2.72	< 0.01 **
Education	-0.06	0.08	-0.73	0.47

Table SI.11: Gender did not predict accuracy on the FME task

glmer(accuracy ~ Gender + (1 |subject) + (1 |item), binomial("logit"), optimizer, data_FME_AS)

Random effects:

Groups	Name	Variance	Std.Dev	Corr
subject	(Intercept)	1.66 e-18	1.29 e-09	
item	(Intercept)	0.52	0.72	

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	1.99	0.64	3.11	0.0019 **
GenderMale	0.20	0.62	0.33	0.74

Table SI.12: Age as a predictor of accuracy on the FME task (the full model failed to converge, despite the optimizer; item intercepts as a random effect also failed to converge; therefore included only random intercepts for subjects).

glmer(accuracy ~ age + (1 |subject) , binomial("logit"), optimizer, data_FME_AS)

Random effects:				
Groups	Name	Variance	Std.Dev	
subject	(Intercept)	1.23e-32	1.11e-16	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	0.20	2.13	0.10	0.92
age	0.06	0.70	0.82	0.41

Given reported differences in evidence of the shape bias in the autism developmental literature, we performed an exploratory analysis to test whether similarity of shape predicted accuracy on the FME task for autistic individuals. (Table SI.13).

SI.13 Similarity did not predict accuracy in FME task (the full model failed to converge, despite the optimizer, so random subjects and random items were included in separately models.)

glmer(accuracy ~ NT_shape_similarity + (1 |subject), binomial("logit"), optimizer, norming_data)

Random effects:				
Groups	Name	Variance	Std.Dev	
subject	(Intercept)	0.00	0.00	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	1.29	0.44	2.94	0.003 *
NT_shape_ similarity	0.01	0.01	1.15	0.25

glmer(accuracy ~ NT_shape_similarity + (1 |item), binomial("logit"), optimizer, norming_data)

Random effects:

Groups	Name	Variance	Std.Dev	
item	(Intercept)	1.71	1.31	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.25	1.26	1.78	0.07
NT_shape_ similarity	0.00	0.02	0.10	0.92

SI.G. Testing Competition

In further exploratory analyses, we tested a potential role for competition from familiar labels on accuracy in the FME task. Shannon Entropy is related to two other measures: the number of distinct labels used by for each item and the percentage of agreement among participants on the labels produced. As expected, all three measures were strongly correlated with one another, as shown in Table S.14.

Table SI.14: Pearson correlations between entropy measures based on norming provided by NTs

	r	r2
Shannon entropy ~ number of distinct labels	.93	.86
Shannon H entropy ~ % agreement on a shared label	- .96	.92
number of distinct names ~ % agreement on a shared label	-.79	.62

As reported in the main text, Shannon Entropy did not predict accuracy (Table SI.15).

Table S.15 Shannon H entropy score (based on NT norming) did not predict AS accuracy, glmer(accuracy ~ NT_Shannon_H + (1 |subject) + (1 |item), binomial("logit"), optimizer, norming_data)

Random effects:

Groups	Name	Variance	Std.Dev
subject	(Intercept)	0.00	0.00
item	(Intercept)	1.54	1.24

Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	1.97	0.54	3.64	< 0.001 **
NT_Shannon_H	0.81	0.79	1.02	0.31

Neither did other ways of measuring competition explain performance on the FME task: the percent agreement in labeling among participants (Table SI.16), nor the number of distinct names used by participants (Table SI.17)

Table SI.16: Percent agreement on alternative label did not predict AS accuracy glmer(accuracy ~ NT_percent_agreement + (1 |subject) + (1 |item), binomial("logit"), optimizer, norming_data)

Random effects:

Groups	Name	Variance	Std.Dev
subject	(Intercept)	3.38 e-19	5.81 e-10
item	(Intercept)	1.64	1.23

Fixed effects:	Estimate	Std.Error	Z value	p value

(intercept)	3.88	3.03	1.28	0.20
NT_ percent_agreement	-1.69	3.36	-0.50	0.61

The raw number of names produced by participants in the norming study had a marginal influence(without correcting for multiple comparisons); however, it trends in the opposite of the expected direction: the more distinct names produced for a given image, the marginally more accurate were the AS group's choices on that item (Table SI.17).

Table SI.17: Number of names as a predictor of AS accuracy, based on NT norming glmer(accuracy ~ NT_number_of_names + (1 |subject) + (1 |item), binomial("logit"), optimizer, norming_data)

Random effects:				
Groups	Name	Variance	Std.Dev	
subject	(Intercept)	3.85 e-20	1.96 e-10	
item	(Intercept)	1.28	1.13	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	1.23	0.69	1.80	0.07
NT_number_of_names	0.48	0.27	1.80	0.07

Testing all three entropy measures on autistic labeling data

Recognizing that measures of entropy based on labels produced by neurotypicals may not be the best metric to predict entropy in an autistic group, we also conducted the same spontaneous labeling task with a new group of 80 autistic individuals, recruited the via the Asperger/Autism Network (49 female, 31 male; M age = 28.83). None of the autistic participants previously saw any

of the items in the task. As expected, the three ways of calculating entropy in the AS group correlated with one another (Table SI.18).

Table SI.18 Correlations among entropy measures based on labeling data from AS participants

	r	r2
Shannon entropy ~ number of distinct labels	.94	.88
Shannon H entropy ~ % agreement on a shared label	- .93	.96
number of distinct names ~ % agreement on a shared label	-.77	.59

None of the entropy measures based on AS norming predicted AS accuracy on the FME task (see Tables SI.19-SI.21 for full models).

Table SI.19 Shannon H entropy score did not predict accuracy, based on AS norming

glmer(accuracy ~ AS_Shannon_H + (1 |subject) + (1 |item), binomial("logit"), norming_data)

Random effects:				
Groups	Name	Variance	Std.Dev	
subject	(Intercept)	4.58 e-17	6.77 e-09	
item	(Intercept)	1.55	1.25	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	1.86	0.74	2.50	< 0.01 *
AS_Shannon_H	0.34	0.43	0.78	0.43

Table SI.20: Number of names did not predict accuracy, based on AS norming

glmer(accuracy ~ AS_number_of_names + (1 |subject) + (1 |item), binomial("logit"), norming_data)

Random effects:				
Groups	Name	Variance	Std.Dev	
subject	(Intercept)	8.12 e-19	9.00 e-10	
item	(Intercept)	1.67	1.29	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	2.19	0.77	2.84	< 0.01 **
AS_number_of_names	0.04	0.14	0.28	0.78

Table SI.21. Percent agreement among participants did not predict accuracy, based on AS norming

glmer(accuracy ~ AS_percent_agreement + (1 |subject) + (1 |item), binomial("logit"), norming_data)

Random effects:				
Groups	Name	Variance	Std.Dev	
subject	(Intercept)	2.00 e-17	4.48 e-09	
item	(Intercept)	1.51	1.21	
Fixed effects:	Estimate	Std.Error	Z value	p value
(intercept)	3.45	1.15	2.99	< 0.01 **
AS_percent_agreement	-1.76	1.73	-1.02	0.31

Chapter 3: Taken from Cuneo, N. & Goldberg A.E (2025). Extending familiar constructions: How autistic and non-autistic adults fill in the blanks. *Proceedings of Linguistic Society of America.*

This work was presented at the following places:

Cuneo, N (2025, Princeton) Beyond Accessibility: Crafting Digestible and Engaging Content for Neurodiverse Audiences. Talk presented at the Princeton UX Research Group & OIT Department. Princeton, New Jersey.

Cuneo, N (2025, Princeton) Neurodiversity in Design: How Language Research informs Digital Accessibility. To present at the CPACC Training Workshop. Princeton, New Jersey.

Cuneo, N, & Goldberg, A. (2025, Philadelphia) Flexible Language and Meaning Extension: A Constructionist Approach to Autism. Poster accepted at the 2025 at the Linguistic Society of America (LSA), Philadelphia, Pennsylvania.

Cuneo, N (2024, Philadelphia) Flexible Language and Meaning Extension; A Constructionist Approach to Autism. Talk presented at the AJ Drexel Autism Institute. Philadelphia, Pennsylvania.

Cuneo, N, & Goldberg, A. (2024, Durham) The impact of generalization differences on multi-word constructions. Poster accepted at the 2024 Meeting of Language and Autism (MOLA), Durham, North Carolina.

Abstract

Autistic individuals show group level differences in categorization tasks compared to non-autistic individuals, exhibiting a strength in detecting differences and a reduced tendency to flexibly generalize. The current work indicates that autistic individuals are challenged by a task that require extensions of familiar constructions in relatively novel ways, a challenge previously documented at the level of individual words. Study 1 provides a series of phrases that each contain a single blank slot, and participants are asked to choose which of four words best fits the slot. In key Flexible Extension trials, the target word only infrequently occurs in the phrase in corpus data, but it is more suitable than the other options. Results indicate that AS adults find it more challenging to flexibly extend familiar phrases in new ways than their non-AS peers, when performance is matched on trials that do not require flexible extensions.

A second study tests the extent to which autistic and non-autistic adults converge on the same prototype for familiar multi-word phrases by asking them to generate words to fill open slots. Results suggest that AS participants show less convergence (greater entropy) in the generation of fillers for open slots, when matched with non-autistic participants on education level and verbal fluency. Current results suggest that categorization differences are a subtle yet persistent difference that is relevant for phrasal patterns as well as words.

Keywords. Language; communication; autistic adults; usage-based approach; linguistics

Introduction

Autistic individuals are recognized to display certain differences in categorization tasks that require flexible extensions or generalizations. They tend to display a preference for sameness (American

Psychiatric Association, 1994). Behaviorally, this manifests as a propensity for routine, special interests, and lower tolerance for uncertainty (for review see Petrolini et al., 2023). Perceptually, heightened attention to distinctions results in enhanced visual and auditory discrimination (Mottron et al., 2006; Eigsti & Fein, 2013), improved performance on visual search tasks (Dakin & Frith, 2005), and a tendency to perceive instances of a category to be more distinct rather than similar (Soulières et al., 2007).

The usage-based approach to language suggests the possibility that categorization differences may help explain certain challenges with language that are common among autistic individuals. The approach treats all linguistic categories, like other categories, as including prototypical and less prototypical instances and being flexibly extended in new contexts as the need arises (Jackendoff, 1983; Lakoff, 1987; Tomasello, 2003; Goldberg, 2003, 2006; Bybee, 2010). Because new information is related to prior information (e.g., Bayes, 1763; Vygotsky, 1986), linguistic categories are viewed as emerging from clusters memories within a dynamic ConstructionNet (e.g., Goldberg et al., 2004). That is, language involves flexible dynamic categories rather than rigid rules (Weissweiler et al., 2025). The usage based approach argues that we learn language by using it, gathering statistical information from our linguistic encounters and interpretations in context (Tomasello, 2003; Goldberg, 2003, 2006, 2019; Bybee, 2010; Kapatsinski, 2014; Diessel, 2019).

Evidence that categorization differences between autistic and non-autistic individuals exist at the level of words is reviewed in the following section.

REDUCED GENERALIZATION AND FLEXIBILITY AT THE LEVEL OF VOCABULARY AMONG AUTISTIC INDIVIDUALS. When provided with lists of words, autistic individuals have

been found less likely to attend to semantic relationships among instances. For instance, Tager-Flusberg (1991) found that autistic and non-autistic participants recalled lists of unrelated words as well as lists of unrelated words, while non-autistics showed improved recall when the listed words were semantically related to one another. Another type of evidence for a difference in the formation of word-level categorization has been found in "false memory" tasks, in which participants hear a list of related words (e.g., bed, rest, pillow, awake, etc.), all associates of a `gist' word that is not presented (here, sleep). Non-autistics are very likely to falsely believe they had witnessed the gist word (Roediger & McDermott, 1995), presumably because activation spread from the related words to the gist word, making it feel familiar. Yet autistic individuals are less likely to fall prey to false memories; instead, they tend to accurately recognize that the gist word as new (Beversdorf et al., 2000, Hiller et al, 2006, Wojcik et al 2018, Griego et al, 2019).

Recent work has also found that autistic individuals are less likely to attend to semantic relationships among multiple meanings of a single word. That is, most commonly used words in each language are associated with semantically distinct but related meanings. Such polysemous meanings can be distinguished from homonymous meanings of a word, which are unrelated semantically and far more rare. Non-autistic children and adults find it easier to learn polysemy than homonymy, an advantage that persists even a week after exposure (Floyd & Goldberg, 2021).

Yet when groups of autistic and non-autistic children were exposed to several novel homonyms and several novel polysemous words, the two groups performed similarly on the homonyms, but only the non-autistic children displayed markedly better learning of polysemous words (Floyd et al., 2021). That is, the autistic group essentially treated homonyms and polysemous words alike, as if they did not recognize the intended relationships among the meanings of the novel polysemous words. This is not simply a developmental delay nor is it due to a lack of exposure, because related results hold for adults when required to extend the meanings of

familiar words. In particular, Cuneo et al. (2024) compared 80 autistic adults with 80 non-autistic adults in a four-alternative choice paradigm (4AFC). Results showed that the autistic adults were less inclined to flexibly extend familiar words in new ways than the non-autistic participants, while the same group outperformed the non-autistics on novel word learning task that did not require flexible meaning extensions.

To summarize, prior work suggests that autistic individuals find it more challenging to recognize or make use of relationships among word meanings: they are less prone to false memories formed from generalizing across a set of related words; less advantaged by semantic relationships among word lists in memory tasks or by related meanings of a single word during learning; and less likely to extend familiar words in new ways. In each case, the autistic group's performance on another language task that did not involve semantic relatedness or generalization matched or exceeded the performance of the non-autistic group. Categorization differences in language tasks have been documented at the word level, but language involves more than just words. Learning and using language involves learning phrasal patterns that include lexically fixed idioms and more abstract constructions as well. The current work seeks to determine whether differences in flexible extensions (Study 1) and generalization (Study 2) are evident at the level of phrasal expressions.

IDIOMS AND GRAMMATICAL CONSTRUCTIONS. The idiom bite the bullet conveys a meaning that is different from the meanings of its individual words, as it means "to do something you've been avoiding." This particular idiom is lexically fixed insofar as near synonyms cannot be substituted, as illustrated by examples (1)-(2):

(1) ? Chew the bullet

(2) ? Bite the ammunition

Other constructions are more abstract and flexible, rather than fixed, although they tend to have prototypical instances. For instance, consider the English "double object" (DO) construction (as in examples (3)-(5):

(3) She gave him something.

(4) She kicked them the ball.

(5) He baked her a cake.

Many distinct verbs can and do appear in the DO construction (Levin, 1993). At the same time, the verb, give is particularly prototypical, as it accounts for 40-50% of all instances, with other verbs occurring far less frequently (Casenhiser & Goldberg, 2004; Goldberg et al., 2004). Relatedly, the meaning "give" is evoked by the DO construction, insofar as the construction generally implies realized, intended or metaphorical giving between an animate agent and an animate recipient (Green, 1974; Pinker 1989; Goldberg, 1995). That is, the DO construction is associated with "giving" even when used with verbs that don't necessarily imply transfer on their own, such as the verbs kick or slip (e.g., kick him something; slip him something). Another example is provided in (6a). She got him something implies that she procured something that she intends to give him, yet the verb get does not imply intended "giving" when appearing in any other "argument structure" construction (see 6b-f):

(6a) She got him something.

(6b) She got something.

(6c) She got him into the car.

(6d) She got him to do something.

(6e) She got sick.

(6f) She got going.

Thus, the DO construction, and other argument structure constructions help determine "who did what to whom" (e.g., Goldberg, 1995; 2015). Non-autistic people are implicitly aware of the verb give's special role in the DO construction insofar as they tend to respond with give when asked what a nonsense verb (moop) means in the DO construction (She mooped him something) (Ahrens, 1995; Goldberg, 1995; Johnson & Goldberg, 2013). The usage based constructionist perspective argues lossy instances of similar utterances to cluster together in memory, giving rise to a category that includes prototypical instances and a range of conventional extensions (Goldberg, 1995, 2019; Ninio, 1999; Tomasello, 2003).

Motivating the current studies. A considerable body of research has found that autistic individuals face certain challenges in language learning and use. Much work has focused on metaphorical, sarcastic, or other non-literal aspects of language, which we leave aside here (for reviews see e.g., Morsanyi et al., 2020; Lampri et al., 2024). Other work reports that autistic individuals are more likely to rely on memorized, verbatim utterances than non-autistic individuals (Prizant & Rydell, 1984; Dobbinson et al., 2003; Karmali et al., 2005; Perkins et al., 2006; Stribling et al., 2007; Valentino et al., 2012). To the extent that fixed phrases are relied upon, the fewer novel utterances we can expect.

Here we ask why autistic individuals are more prone to repeating verbatim phrases than non-autistic individuals. Building on work that has highlighted difficulties in flexibly extending words in novel ways (Tek et al., 2008; Wilson & Bishop 2020; Floyd et al., 2021; Didnar et al,

2023; Cuneo et al, 2024) here we examine group differences in how autistic and non-autistic adults use flexible grammatical constructions. We hypothesize that autistic adults will find it more challenging to extend familiar constructions in new ways, while matching non-autistics on accuracy of fixed phrases that do not require flexible extensions. Thus, Study 1 compares how easily autistic and non-autistic adults extend familiar grammatical constructions.

Study 2 tests the degree to which autistic and non-autistic individuals spontaneously generate the same consensus filler-word for familiar constructions (e.g., She __ him something). We hypothesized that verbal autistic adults would be less likely to converge on the same target word than non-autistic adults (e.g., give for the DO construction), thereby displaying more entropy on generated fillers at the group level. We reasoned that if autistic individuals form implicit clusters of verbs in argument structure constructions atypically or not at all, they will show less consensus when asked to provide a filler word for grammatical constructions.

PREREGISTRATION AND SUPPLEMENTAL INFORMATION.

Design, sample sizes, exclusion criteria, and intended analyses were preregistered: https://researchbox.org/3809&PEER_REVIEW_passcode=SQRINZ. Please see Supplemental Information for a) details and links to the preregistrations, data and analyses (online resource 1); b) survey on terminological preference for our autistic participants (online resource 2); c) full models of preregistered model (online resource 3 and 5); d) and exploratory analyses (online resource 4 and 6).

Study 1: Flexible Meaning Extensions of Constructions.

Study 1 directly tests the hypothesis that autistic individuals find it more challenging to flexibly extend familiar grammatical constructions in new ways. In a four-alternative forced choice task (4AFC), we asked participants to select which word best fills the constrained open slot in each of a series of phrasal constructions, presented one at a time. Four types of 4AFC trials were presented in randomized order for each participant.

Flexible Extension Trials. Flexible Extension trials are the key experimental condition. Participants are asked to select which word "fit best" in the open slot of a provided phrase. Table 1 displays the stimulus phrases, along with a low frequency but plausible target choice, and three unacceptable/implausible foil options. Options were presented to participants in randomized order. In order to select the target word, participants needed to essentially flexibly extend a familiar construction in a way that is plausible but unlikely to have been previously witnessed frequently, if at all. We hypothesized that autistic adults would find Flexible (low frequency) Extension trials more challenging than their non-autistic peers.

Stimulus phrase	Flexible (low frequency) extension	Foils (unacceptable/implausible)
She ___ him something	knit	did, divided, caused
It's ___ of you to say that	noble	tall, new, first
He ___ his way to the front	muscled	glided, weighted, stopped
She ___ it on the table	propped	caused, affected, figured
She drove him ___	batty	glad, happy, irritated

She ___ at him	blinked	watched, lagged, excited
She ___ the night away	dreamed	attempted, looked, thanked
How big of a ___ is it?	win	freedom, beauty, agreement
He ___ them into doing something	bribed	told, promised, felt

Table 1. Stimuli phrases, target filler and foils used in Flexible Extension (low frequency) trials.

Three other types of 4AFC trials were randomly interspersed: High-Frequency trials, intended to ensure familiarity with the phrases provided; Collocation trials, to ensure familiarity with collocations that do not require flexible extensions, and 'catch' trials, used to insure sustained attention to the task. Each is described below.

High Frequency (HF) (Control) Trials. The same nine stimuli phrases used in the Flexible Extension (low frequency) trials were repeated in High Frequency trials, now with four new fillers including a filler word that appears with high frequency in the phrase. Because participants cannot be expected to flexibly extend a construction that they are unfamiliar with, Flexible Extension LF trials are only included in the analysis when the same participant responded correctly to the corresponding HF trial. Thus, HF trials were included to confirm familiarity with the constructions used in the key Flexible Extension trials.

Stimulus phrase	Target	Foils
She ___ him something	gave	snapped, skated, bent
It's ___ of you to say that	nice	short, sunny, glad
He ___ his way to the front	made	went, walked, stood
She ___ it on the table	put	caught, portioned, figured

She drove him ___	crazy	small, smothered, married
She ___ at him	looked	spoke, created, connected
She ___ the night away	slept	adapted, liked, checked
How big of a ___ is it?	deal	blue, happy, pact
He ___ them into doing something	tricked	realized, passed, changed

Table 2. High-Frequency stimuli used to ensure participants' familiarity with each construction. For each phrase, the target word occurred with high frequency as a filler (according to COCA, Davies, 2008); foil options were all less acceptable or implausible.

Collocation Trials. Ten collocation trials included common phrases that prefer a particular filler word. For instance, the phrase Once ___ a time is nearly always filled by the target word, upon (98% of instances in the COCA corpus, Davies, [2008]); each of the three foil words on each trial were implausible or unacceptable (in this case: on, atop, above).

Catch Trials. Five catch trials were randomly interspersed, requiring participants to match a pattern provided: e.g., for the pattern one, two, three, four, __, six, where the target choice was five.

Methods

Participants. A total of 105 autistic (AS) adult participants, aged 18–69 and living independently, were recruited from the SPARK database (SFARI Base). As planned, participants were excluded if they did not self-identify as autistic (n = 15); accurate diagnosis was further indicated by a requirement that participants score 6 or above on the AQ-10, a standard assessment used to recommend further screening (n = 13); also excluded were participants who failed to respond correctly to at least 4 of the 5 catch trials (n = 3). This resulted in 74 AS participants' data to be

analyzed (M = 31.5 years). Gender estimates, based on database proportions, are 49 participants identified as female and 25 as male. Participants identified their race/ethnicity as Asian (n = 1), Black (n = 3), White (n = 52), or mixed race (n = 8); 10 participants opted not to disclose their race/ethnicity.

We collected 74 non-autistic (non-AS) similarly (M = 44.4 years). A larger group of 89 participants were consented from Prolific and excluded if they self-identified as autistic (n = 11), scored above 6 on the AQ-10 (n = 3), or failed to respond correctly to at least 4 out of the 5 catch trials (n = 1). We estimated the gender of participants using Prolific (41 identified as female; 31 as male, 1 prefer not to say); participants identified as Asian (n = 1), Black (n = 1), white (n = 58), mixed race (n = 12), or opted out (n = 2).

Procedure. Each participant responded to 33 trials in randomized order: 9 Flexible (low frequency) Extensions (Table 1), 9 High Frequency (HF) trials, 10 Collocation trials and 5 catch trials. As illustrated in Figure 1, each trial began with the question: "Which word fits best in the following blank? <stimulus>," followed by four randomly ordered sentences, each containing a different filler of the missing word. No time limit was imposed.

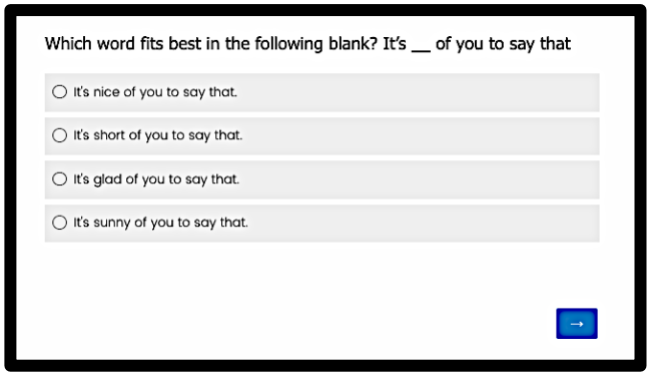


Figure 1: Example High Frequency trial (nice is the target, short, glad and sunny are considered incorrect).

Results.

High Frequency Trial Accuracy

Recall participants needed to respond correctly on the HF trial in order for their corresponding low-frequency (LF) trial accuracy to be included in the analysis. As shown in Table 4, more trials needed to be eliminated for AS participants than non-AS participants ($\beta = -2.57$, $z = -3.54$, $p < .001$). We return to this aspect of the data in study 2.

# of Trials Correct	# of AS participants	# of non-AS participants
2	1	0
3	0	0
4	1	0
5	2	0
6	6	0
7	9	1
8	5	7
9	50	66
Total	74	74

Table 4. Number of HF trials correctly responded to by participants in each group (ranging from 2 to 9 out of 9).

Pre-registered analysis. We predicted that AS adults would perform less accurately on Flexible Extension trials than the non-AS adults, while performing at least as well on Collocation trials. We first use the preregistered model to analyze the full data set (n = 74 AS; 74 non-AS). As planned, a generalized linear mixed effect model was created with accuracy as the output variable; AS status interacting with Trial Type (Flexible or Collocation), and education as fixed effects. Random intercepts and slopes were included for subjects and items. This model failed to converge (see SI for specifics), so we simplified to include only intercepts and slopes for AS status on items. Results are shown in Figure 2. AS participants were significantly less accurate than non-AS participants ($\beta = -1.94$, $z = -4.63$, $p < 0.001$); Flexible (LF) Extension trials also negatively impacted performance ($\beta = -1.80$, $z = -2.49$ $p = 0.01$). The predicted interaction approached significance in the predicted direction ($\beta = 0.79$, $z = 1.91$, $p = 0.06$). In the AS group, 32% scored at ceiling on Flexible extension trials (24/74), while 61% of the non-AS did (45/74). Educational attainment positively predicted accuracy ($\beta = 0.10$, $z = 4.00$, $p < .001$), although there was no significant difference in years of schooling between groups (M = 14.7 years for non-AS; M = 14.1 years for AS).

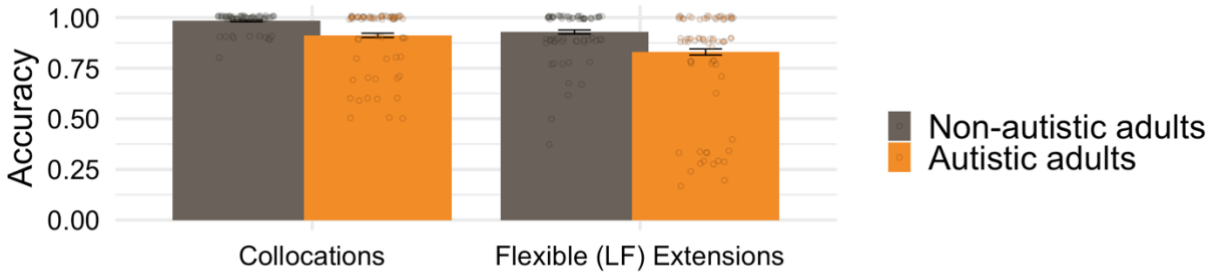


Figure 2: Performance of all participants (n = 74 AS; n= 74 non-AS) on Collocations and Flexible (Low Frequency) trials in study 1. The autistic group is represented by orange bars. Points represent individual participants' mean accuracy

Exploratory analyses: Matching collocation accuracy. Given the overall lower performance of the AS group, the marginal interaction and the unanticipated effect of education level on accuracy, in an exploratory analysis, we matched groups on familiarity with collocations in order to take a closer look at performance in the Flexible (LF) extension condition. The lowest cutoff yielding nonsignificant group differences on the collocations ($p > 0.05$) was 0.71, so we excluded participants who scored below this threshold to compare performance on Flexible (LF) extensions between the two groups, when matched on all criteria available to us.

Matched participants. The resulting sample consisted of 61 AS participants and all 74 non-AS participants. This sample was better matched insofar as there were no longer significantly more HF trials that needed to be eliminated for AS than non-AS participants ($\beta = -0.55$, $z = -0.43$, $p = 0.67$), and no longer any influence of education on accuracy ($\beta = -0.01$, $z = -0.05$, $p = 0.96$) in the generalized linear mixed-effects model with Flexible (LF) Trials as an outcome, autism status and years of education as fixed effects. The model includes random intercepts for subjects and random intercepts and slopes (AS status) for items. Given the differences in sample sizes, we weighted the influence of participants rather than excluding any additional data, with weights of 1.82 for non-AS and 2.21 for AS. In this better-matched subgroup, the AS group displayed significantly lower accuracy on the Fixed (LF) extension trials than their non-AS peers ($\beta = -1.01$, $z = -2.01$, $p = 0.04$).

Discussion of study 1. We hypothesized that AS adults would find Flexible (LF) extension trials particularly difficult and the exploratory analysis indicates that they do. At the same time, a good deal of individual varation is evident in our full samples. A sizable proportion of autistic individuals showed good skill in flexibly extending the familiar constructions, with 32% scoring at ceiling on Flexible extension trials. At the same time, nearly twice as many non-AS partcipants performed at ceiling on these trials (61%).

The full AS group performed less accurately overall. They made more errors in the High Frequency condition than the non-AS group. And our pre-registered analysis showed autistic adults underperformed on both Collocations and Flexible (LF) Extensions. Results also demonstrated that education positively predicted accuracy across the board. A marginal interaction suggested the AS group performed especially poorly on the Flexible Extensions, as predicted. This led us to better match the two groups in an exploratory analysis on a subsample of participants that did not differ significantly on their performance on collocations. We then ran the same analysis on all remaining participants.

This subset of 61 AS participants better matched the full non-AS group in two ways beyond their performance on collocations. They no longer made more errors on the High Frequency fillers and there was no longer any effect of education on accuracy (while the two groups remained matched on education level).

As planned, for Flexible extension trials to be included in the analyses, we required that the same participant provided an accurate response on the corresponding high-frequency trial, to ensure that participants were familiar with the constructions that needed to be extended.

Results on the better matched groups, showed the AS participants performed less accurately on Flexible (low frequency) extensions. This was hypothesized, since Flexible Extension trails required participants to flexibly extend familiar expressions in order to identify a plausible but low-

frequency filler word in a four-alternative-forced choice task. Thus, the exploratory analysis is consistent with the hypothesis that autistic individuals find it more challenging to extend familiar linguistic constructions than their non-autistic peers, when matched on accuracy on collocations, familiarity with the constructions, and education level. It thus extends previous work that had focused on autistic adults' ability to flexibly extend word meanings (Cuneo et al., 2024), as current evidence indicates that autistic participants find it more challenging than well-matched non-autistic peers to extend familiar phrasal patterns in new ways.

Motivation for study 2. Challenges generalizing or flexibly extending linguistic categories may stem from several sources. It could be that categories are represented the same way among AS and non-AS adults, and that autistic individuals are less inclined to use language in novel ways due to a general avoidance of novelty. As aspect of the results in the full sample of AS participants in study 1 leads us to an alternative hypothesis. Recall that the full group of AS participants found it more challenging to accurately choose the high-frequency target word from among unacceptable or implausible foil options than their non-AS peers. Although this effect was eliminated in the better-matched subset of participants used in the exploratory analysis, it is possible that the 4AFC task used in study 1 facilitated performance by reducing accessibility demands: participants in study 1 only needed to recognize the best option in a 4AFC task.

In study 2, we ask participants to generate fillers for open slots. Of particular interest is whether AS and non-AS participants spontaneously converge on the same first word when filling in a blank (e.g., "She ___ him something"). Groups were matched and binned by education level. We also include a measure of verbal fluency to determine whether any differences are due to general fluency effects rather than an ability to generate prototypical fillers. If AS adults are less likely than their non-AS peers to generate the same filler word while showing equivalent (or

stronger) verbal fluency, it will be taken to indicate that the two groups may represent categories differently. In particular, insofar as the generation of prototypical instances of categories indicates a "center of gravity" among exemplars, we hypothesize that a reduced tendency to access and produce the most prototypical filler word would indicate that categories that are less tightly clustered around prototypical instances.

Support for the idea that prototypical instances may be less accessible to autistic individuals comes from the domain of conceptual and perceptual categories. Autistic children have been found less likely to produce prototypical exemplars when asked to name instances of a category (Dunn et al., 1996). Similar effects have been extensively studied in the visual domain (for review, see Vanpaemel et al, 2021). Thus, we predict that autistic participants will show a reduced tendency to spontaneously produce prototypical fillers of grammatical constructions in comparison to their non-autistic peers, when matched on education level and verbal fluency.

Study 2: Accessibility Of Prototypical Instances.

Study 2 asks participants to generate slot-fillers for eight instances of familiar, semantically constrained constructions (see Table 5).

She __ him something.
It's __ of you to say that.
He __ his way to the front.
She __ it on the table.
She drove him __.
She __ at him.
She __ the night away.
He __ them into doing something.

Table 5: Stimuli used in Study 2.

It investigates whether autistic adults are as likely as non-autistic adults to converge on the same filler words for each phrase. We reasoned that if autistic individuals form implicit clusters atypically or not at all when representing a category of key words appearing in a construction, they will show less consensus on the first filler word they produce, since the first word tends to be semantically prototypical and highly frequent. We therefore analyzed the extent that each group, binned by education level, converged on same word, for each construction; we also used the more sensitive measure of entropy (variability) among first choices in both groups. Finally, we analyzed whether the highest consensus words appeared among the top three words produced by both groups, to determine whether both groups are implicitly aware that the most prototypical filler was

appropriate, even if one group was less likely to produce it as the first filler. Given the findings of educational attainment in Study 1, participants were grouped and recruited at different education levels as a rough proxy for exposure to written language. A phonological verbal fluency task served as an additional metric of verbal fluency.

Study 2 Methods

Participants A new group of 80 AS adults (between 18 to 69 years old: M = 37.6) were recruited through the SPARK database and prescreened as for study 1: they had to have been diagnosed with autism be living independently; and score 6 or above on the AQ-10, a standard assessment used to recommend further screening. Twenty of the autistic adults had education up to high school (hereafter, HS); 30 attended 1-4 years of college (College); and another 30 had earned a master's degree or higher (Masters). The gender of participants is estimated to be 54 identifying as female; 26, as male, based on proportions in our database of SPARK participants (a coding error prevented us from collecting this information). Autistic participants reported their race as Asian (3), Black or African American (3), White (61), Mixed Race (9), or Other (4).

We also recruited 80 non-autistic participants on Prolific in the same age range (M = 42.1), after exclusions for a diagnosis of autism or scores of 6 or higher on the AQ-10. Non-autistic participants were prescreened in order to match the education level bins of the autistic group using criteria supplied by Prolific: 20 HS; 30 College; 30 Masters. Forty-eight identified as female, 32, as male. Non-autistic participants reported their race as Asian (4), Black or African American (13), Hawaiian or Pacific Islander (1), white (60), and mixed race (2).

Stimuli

Experimental stimuli are provided in Table 5. The consensus fillers for each stimuli were determined by AS status, further divided by (three) education levels each, for a total of 6 groups.

Procedure

The experimental task and phonological fluency measure were presented in counterbalanced order across participants, in each group, to avoid differences based on potential fatigue effects. In the experimental task, participants were presented with 8 phrases, each containing a missing key word (see Table 5), one at a time in randomized order. For each, participants were asked to generate as many words as possible to fill in the blank appropriately. Participants who produced fewer than 3 filler words per phrase were excluded, as a way of ensuring that we included only participants who were familiar with the phrase as an instance of a productive pattern, rather than an idiomatic exemplar.

The phonological verbal fluency measure simply asked participants to name as many words that began with the sound /s/ or /l/ as possible in one minute.

Results

Verbal fluency. Verbal fluency was analyzed with a linear mixed model in which the number of words generated was the outcome, group and education, as interacting fixed effects, and random intercepts for participants. The intermediate level (College) was the reference level for education in all analyses. There was no effect of Autism status on verbal fluency (ß = -0.73, z = 1.24, p= 0.22). Participants with at most a HS education were marginally lower than those with some College (ß = -1.13, z = -1.72, p = 0.087). There was no difference in verbal fluency between those with some College or Masters (ß = 0.67, z = 1.12, p = 0.27).

Consensus on participants' top choice was measured in three related ways. As preregistered, we first simply consider whether each group, divided into bins by education level, tended to produce the same consensus word, for each stimulus. We separately analyze each group by item, and then by proportion of items for which each participant provided the consensus word. Finally, we use a more sensitive analysis of entropy (disorder), which can only be calculated at the group level.

Consensus reached across items, for each group subdivided by education level. To predict the extent to which subgroups chose the same most common word in their subgroup (the consensus word). Subgroups were determined by autism status and education bin: As described in the Participant section, bins included participants with at most a High School education (n = 20 AS; n = 20 non-AS), some College (n = 30 AS; n = 30 non-AS), and master's or above (n = 30 AS; 30 non-AS). As planned, a linear mixed effect model was created with the proportion of consensus across items as the outcome variable. Group (AS or non-AS) and education level were fixed factors, and random intercepts and slopes were included for items. This analysis revealed that HS education showed a marginally negative effect on consensus (ß = -0.07, t = -1.91, p = 0.06), (see SI for full model), but no effect of autism (ß = -0.05, t = -1.31, p = 0.20).

Given the influence of HS education on verbal fluency and on consensus, we next performed exploratory analyses with the HS group excluded. The same linear mixed effect models were run on the remaining 60 autistic adults and 60 non-autistic adults, who all had at least some college education. This shows significantly lower degree of consensus for the autistic group (ß = -0.05, t = -2.47, p = 0.02) and no effect of education bin (College vs Masters) (ß = 0.01, t = 0.58, p = 0.57). The difference in consensus by item is depicted in Figure 3.

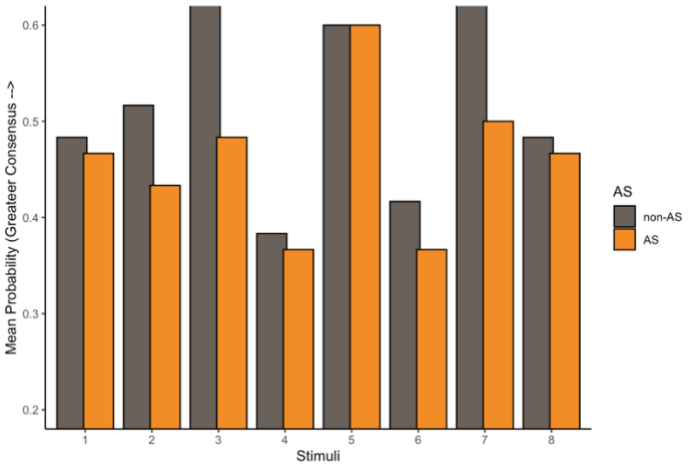


Figure 3: Comparison of non-autistic (brown) and autistic (orange) groups in probability of choosing the consensus word on each stimuli (x-axis) for all participants with at least some college education.

Entropy. Entropy scores were normalized to facilitate comparison across items so that entropy ranged from [0, 1]. To predict the entropy of the first word produced, a linear mixed effect model was created with group (AS or non-AS) and education bin as interacting fixed factors, along with random intercepts and slopes (for group) on items.[1] As in study 1 and in the consensus analysis of study 2, we see a main effect of education level: participants with education up to HS had higher entropy (more disordered responses) than the rest of the sample: (ß = 0.06, t = 2.07, $p < 0.05$). There was no main effect of autism status (ß = 0.03, t = 1.00, p = 0.32). We next performed an exploratory analyses with the HS group excluded. The same linear mixed effect model was run on

[1] Each subgroup of participants tended to produce the same word most frequently, for each construction, with the exception that autistic participants favored *nice* and non-autistic participants favored *kind* in *It's __ of you to say that.* Both adjectives are highly frequent options in corpus data (Davies, 2008) and are near synonyms. Since *nice* and *kind* were the top two most frequent words in all groups, we do not consider this difference meaningful.

the remaining 60 autistic adults and 60 non-autistic adults, who all had at least some college education, divided into subgroups by education level and autism status. This analysis revealed marginally higher entropy for the autistic participants compared to their non-autistic peers (ß = 0.03, t = 1.83, p = 0.08).

Proportion of consensus for participants, across items. The analysis just described calculated consensus at the group level, so it did not allow us to look at the data by participant. We therefore also tested the proportion of agreement as a binary factor on whether the consensus word was produced across items, for each of the 120 participants with above HS education. A generalized linear model was used to predict proportion of participant consensus, with fixed effects of group and education level. This analysis allows us to treat education as a gradient factor. Random intercepts were included for subjects and items. Gradient education level was not predictive (ß = -0.01, z = -0.18, p = 0.86). The model shows a marginally lower degree of consensus for autistic participants (ß = -0.29, z = -1.75, p = 0.08).

Analysis of top three words. The previous analyses focused on the first word produced by each participant for each item. We additionally analyzed the first three words produced by each participant to see whether the consensus word was produced among participants' top three words, including only participants with at least high school education. To this end, we applied the same models—consensus by participant and entropy (by group). Neither of the models showed a significant influence of autism status. A linear mixed-effects model at the group level assessed entropy: (β = -0.01, t = -1.33, p = 0.20). A generalized linear mixed effect model at the participant level assessed consensus (β = -0.04, z = -0.48, p = 0.63).

Discussion of study 2.

We hypothesized that the autistic individuals' categories may be less tightly clustered around prototypical instances in comparison to non-autistic adults. This predicted that groups of autistic individuals would be less likely to spontaneously produce the most prototypical fillers for familiar constructions. The preregistered analyses tested a binary factor for choosing the highest consensus word on each item for both groups, subdivided into three levels of education. We also ran a group analysis using entropy scores as a more sensitive measure of the degree of variation (higher entropy) in first responses at the group level. No difference in consensus or entropy between AS and non-AS groups were detected when the full set of 160 participants was considered. Results did show a general influence of education level, with those with at most HS education displaying less consensus in their productions of slot-fillers and correspondingly marginally higher entropy than participants with more years of education. This group is likely to have had less experience with written language, which would afford them less opportunity to learn conventional formulations (see also Dabrowska, 2004). Also relevant is this subgroup's marginally lower verbal fluency, which may have made it somewhat more challenging for them to access the most conventional fillers in the experimental context (Goldberg & Ferreira, 2022). The HS groups (20 AS and 20 non-AS) were also smaller in size than College (30 AS; 30 non-AS) or Master's (30 AS; 30 non-AS), which may have made consensus harder to detect.

Because of these differences, we conducted exploratory analyses on the 120 participants who had at least some college education. Here the autistic group showed significantly less consensus on their top choices than their non-autistic peers and a related marginal increase in entropy. That is, in this subset, matched autistic participants were less likely to produce the same word first, and their responses overall were correspondingly marginally more variable in comparison to their non-autistic peers. We see a similar marginal effect of autism when consensus

was determined at the individual level, which allowed us to include random intercepts for participants, and education as a gradient factor. These exploratory analyses conceptually replicate the finding in Study 1, where the autistic group as a whole made more errors on the four alternative forced choice task involving High Frequency fillers (recall Table 1). Taken together, these results underscore modest but consistent challenges in accessing the prototype across both forced-choice and free-response tasks.

The difference is not likely to stem from a lack of understanding that the consensus word was appropriate in the provided expressions, since the analyses of the top three words generated showed no differences between groups. Verbal fluency was also not different between the groups in the final analysis. If, as hypothesized, autistic participants do not attend to semantic relatedness to the same extent as non-autistics, the categories that autistic individuals use to access the most prototypical filler may be less tightly connected and therefore less easily accessible. At the same time, we recognize that the difference is only evident when the HS participants were excluded.

General Discussion and Conclusion.

The current two studies are the first to experimentally test whether autistic adults differ from non-autistic adults in their ability to generalize and extend language patterns beyond the level of word meanings. In both studies, when relatively large groups of participants are well-matched (on collocations in study 1) and verbal fluency and education (study 2), the predicted influences are evident: autistic individuals were challenged when required to flexibly extend familiar constructions (study 1) and were also somewhat more challenged in identifying prototypical instances of familiar constructions (studies 1 and 2).

Study 1 was designed to compare autistic and non-autistic adults' skill on flexible extensions of grammatical constructions. We reasoned that the low-frequency fillers would

generally require flexible extensions, predicting that autistic participants would struggle when only a low-frequency filler was offered, along with three options that were inappropriate. Our planned analysis revealed that autistic groups performed worse across the board, with more years of education resulting in better performance and only marginally weaker performance on the low-frequency extensions.

Because groups did not differ significantly on years of education, we decided to anchor performance on collocations with the goal of exploring the marginal interaction and potentially eliminating the influence of education on accuracy. The resulting groups were better matched: there was no longer a difference in identifying the high frequency fillers and no influence of education on performance.

In this subgroup of participants, autistic adults were significantly less accurate on the Flexible (LF) extension trials than the non-autistic adults. That is, autistic participants demonstrated greater difficulty with flexible extensions, when well-matched with non-autistic peers. This extends prior research that had identified difficulties in novel meaning extensions at the word level (Cuneo et al., 2024), by testing whether autistic adults have difficulty extending meaning grammatical constructions as well as words, even in four alternative forced choice tasks which restrict potential options to a limited set.

Study 2 was motivated by the unanticipated finding in study 1 that the full sample of autistic adults was less accurate in identifying prototypical (high frequency) instances of familiar patterns in the four alternative forced choice task. While this effect was eliminated in the subgroup that was better-matched, we reasoned that the four alternative forced choice task may obscure potential subtle differences between groups. Study 2 therefore used a free-response task to examine the extent to which subgroups of autistic and non-autistic groups, binned by education level, converged on the same first words when supplying filler words for grammatical constructions. We

emphasize that the difference in accessing consensus fillers of familiar constructions is indeed fragile: lower education level (and/or verbal fluency differences) obscured any difference in the autistic group in study 2. Only when groups were matched on having attended some college in an exploratory analysis did we see the predicted effect on group consensus: autistic individuals were less likely to converge on the same consensus word than non-autistic peers; in this group there was no difference in verbal fluency. We also note that the consensus word was just as likely to be included in participants' top three responses by autistic and non-autistic adults alike. We take the combination of results to suggest that the most prototypical fillers of constructions are available to autistic adults but may be less accessible.

The current findings are consistent with our hypothesis that autistic adults face subtle but persistent challenges in generalizing phrasal constructions: flexible extensions of grammatical constructions seem to be particularly challenging, and the prototypical instances of constructions appear to be less accessible. But this is just a first step toward better understanding the nature of generalizations of grammatical constructions by autistic individuals. It is important and relevant because language is composed of more than individual, isolated words: grammatical constructions play a crucial role in language and require generalizations and flexible extensions. While much of the autistic language literature focuses on individual words and concepts, the current work focuses on language beyond the level of individual words.

To be sure, not all autistic adults showed evidence of finding either task challenging. In our samples of autistic individuals who live independently, nearly a third performed at ceiling in study 1 when required to flexibly extending familiar constructions, and a comparable proportion selected the consensus word first, for each phrase, in study 2. Further work is required to look at individual differences. We were limited in our ability to do so here, because different groups of people participated in the two studies. Nonetheless, group-level differences are detected when education

level is matched, shows no influence, and is in fact quite high (including at least some amount of college).

Any differences in generalization or flexible extensions carry implications for everyday communication, where generalization and flexible language processing is essential. Language use demands flexibility, particularly in "good-enough" production and comprehension: Speakers rely on listeners' inferential skills to interpret incomplete or imprecise expressions (Ferreira et al., 2002; Goldberg & Ferreira, 2022; Ferreira & Patson, 2007). In this process, both speaker and listener must adaptively navigate meaning, bridging the gap between what is said and what is intended. For instance, imagine you're at a lunch, and someone says, Please pass the cup, but only coffee mugs are on the table. To accurately understand the request, the listener must rely on the speaker's intention (they want the mug) rather than focusing on the less precise word choice, cup. In fact, people often speak in a "good-enough" manner, sometimes prioritizing ease of word retrieval over precision (Koranda et al., 2022). In other words, people may select words that are more accessible, even if slightly less accurate, influenced by factors such as priming or frequency. This tendency affects both individual words and grammatical constructions.

From a constructionist perspective, language is learned through usage and shaped by flexible patterns rather than rigid rules. Speakers must adapt as they encounter and interpret new contexts and new meanings. The framework encourages us to consider how language flexibility interacts with autistic traits, especially in tasks that require extending or reinterpreting meaning. Challenges with flexible extensions may impact overall language proficiency in the autistic community, given that language frequently involves subregularities that allow flexible generalizations. Closer examination of strengths and weaknesses in language among autistic individuals could hardly be more critical. Language development is usually delayed in autistic

children (e.g., Reindal et al., 2023; Clarke et al., 2024) and communication skill remains an ongoing challenge for many autistic adults (LeGrand et al., 2021).

While non-autistic individuals are recognized to cluster similar instances of constructions together in overlapping memory traces (e.g., Goldberg, 2019), verbal autistic individuals may cluster instances less tightly and instead rely more on individual memories of specific instances. In a paper documenting autistic adults' reflections on their language skills, one autistic adult shared, "I think I am fortunate that I've memorized so many idioms and metaphors that I'm able to do an instant translation in my head" (Cummins et al., 2020), suggesting that memorization may serve as a compensatory strategy. For individuals with more diffuse clustering patterns, as indicated among autistic adults in the current studies, "good-enough" language processing may present particular challenges, especially in aligning with non-autistic conversational expectations.

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Author Contributions

Both C and G contributed equally to the Conceptualization, Data Curation, Formal Analysis, Methodology, Visualization, and Writing–Review and Editing. C wrote the first draft of the manuscript, while C and G authors discussed the results and collaborated on the final manuscript.

Compliance with Ethical Standards

This study was approved by the Princeton University Institutional Review Board (IRB #4951). All participants provided informed consent prior to participation. There are no conflicts of interest related to this study.

Chapter 4: De Marchena, A., Cuneo, N., Gurbuz, E., Brown, M., Trujillo, J., and Bergstrom, J. (to appear). Communication in Autistic Adults: An Action-Focused Review. *Current Psychiatry Reports*

Purpose of review: This review focuses on recent research (primarily published between 2020-2024) describing unique aspects of communication in autistic adults. We review research on communication-related outcomes, as well as four communication topics frequently cited as important to autistic people (literal and non-literal language, augmentative and alternative communication, nonverbal communication, and double empathy).

Recent findings: A substantial proportion of autistic adults do not develop fluent language by adulthood. Autistic adults frequently experience communication barriers impacting relationships, employment, and health. These barriers arise from multiple sources (e.g., language, nonverbal communication, and unaccommodating environments and communication partners). Thus, it is essential to take a multifaceted approach to supporting autistic adults to ensure their communication success.

Summary: We conclude that it's vital for clinicians and researchers to understand how autistic traits commonly manifest in adults and to accept and accommodate communication differences as they arise. To that end, we offer specific recommendations to help clinicians and researchers strengthen their interactions with the autistic people in their lives.

Introduction

Effective communication – including both sending and receiving messages from others – is essential for human survival and life quality. Broadly speaking, communication encompasses social behaviors, emotional responses, and cognitive and linguistic skills. When we use "communication" in this paper, we mean all modes of communication, not just spoken or signed language, including nonverbal communication such as gestures, facial expressions, body language, and the use of augmentative and alternative communication (AAC) systems. Autism spectrum disorder (hereafter, 'autism'[1]) is characterized by differences and difficulties in "social communication" (described in more detail below); thus, a strong understanding of autistic communication is essential for clinicians and researchers working with this population.

A brief history of communication in the DSM

Communication skills and behaviors are central to the clinical conception of autism. Overall, the DSM autism criteria have evolved from viewing communication as a standalone domain to viewing it as inextricable from social interaction. The DSM-III (APA, 1980) – the first edition to include autism as an independent diagnostic category – emphasized gross language deficits and atypical speech patterns, such as echolalia and pronoun reversal. The DSM-III-R (APA, 1987) expanded communication criteria to include verbal and nonverbal communication differences, including atypical eye contact and difficulty in sustaining conversations. By DSM-IV (APA, 1994) and DSM-IV-TR (APA, 2000), the criteria evolved to include delayed language development and repetitive language use.

However, the most substantial change occurred with DSM-5 (APA, 2013), where communication and social interaction merged into a single domain, "Social Communication,"

which requires persistent difficulties with social-emotional reciprocity, nonverbal communication, and relationships.

Outcomes

Characterizing a "good" communication outcome is difficult to define and measure. However, by any definition, communication outcomes in autistic adults are highly heterogeneous. Terminology used to describe autism and associated ability/disability is a hotly debated topic. Because there is heterogeneity in terms of how adults on the autism spectrum preferred to be referred (Bottema-Beutel et al, 2021), we use a range of terminology in this manuscript. In our empirical work, we ask all of our autistic participants for their preferred terminology, and use the most common selection in our publications (Cuneo et al, 2024) . Our guiding philosophy for thinking and writing about autistic communication is to not make assumptions that differences are necessarily deficits (although sometimes they can be (Kapp et al 2013). For guidance on avoiding ableist language and non-pathologizing frameworks, please see (Bottema-Beutel et al, 2021). We briefly note our own positionality: AdM is a non-autistic licensed clinical psychologist and autism researcher. She enjoys many close relationships with autistic adults, and caregivers of autistic adults, primarily through research collaborations and participatory methods. NC is a non-autistic researcher and ally investigating communication differences to promote better language practices and enhance accessibility guidelines. EG is a non- autistic autism researcher and autism ally working with autistic community to understand support needs in higher education and employment. MB is a neurodivergent, gender diverse autism researcher in training committed to research that prioritizes autistic lived expertise. They study how gender diversity, autism and communication interact to shape daily experiences and impact access to opportunities and critical support. JPT is an autistic communication researcher. He tries to understand communication through the lens of

neurodiversity, and engages with autistic researchers and advisory groups to better situate his research. JB is a SLP and AAC specialist working within autistic community by supporting effective communication strategies across the lifespan.

Language and Communication Skills

Longitudinal studies of adults followed since early life diagnosis may provide the best data on communication outcomes; they are less prone to sample biases that exclude participants with intellectual disabilities (Russell et al, 2019). One proxy for language fluency is to examine rates of Autism Diagnostic Observation Schedule module administration (ADOS; 10), as modules are tailored to examinees' verbal status. Module 1 applies to examinees who do not use phrase speech indicative of minimally verbal status. According to recent results from longitudinal cohorts, 35% (Lord et al, 2016) - 46% (Sterrett et al, 20124) of examinees received Module 1, demonstrating high rates of minimally- speaking status for adults diagnosed in childhood.

Beyond basic language fluency (i.e., as measured by the ADOS), as few as 25% of autistic adults diagnosed in childhood score in the average or above-average range when measuring communication as an adaptive behavior skill (Sterrett et al, 2024). Even among adults with enough language fluency to self-report, our team found high rates of positive screening for developmental language disorder (46%; Sterrett et al, 2024). Taken together, these studies suggest high rates of heterogeneity and high rates of communication disability among autistic adults.

Lived Experience

The outcomes described above rely primarily on outsider report or observation. But what about the opinions of autistic adults themselves? Communication involves both observable behavior (e.g. noticing someone's large vocabulary or expressive face) and internal experiences (e.g., the subjective feeling of struggling to express one's point,). Thus, it is vital to characterize the experience of communicating while autistic. Cummins and colleagues (Cummins et al, 2020) asked autistic adults to report on their perspectives of communication, including communication preferences, perceived strengths and weaknesses, and desired support. Thematic analysis revealed

that autistic adults with communication difficulties experienced feelings of vulnerability and withdrawal from society.

Relationship to Quality of Life

Communication ability in adulthood, while an outcome in itself, also impacts quality-of-life and functional outcomes across domains. Building on outcome frameworks from the World Health Organization (WHO, 2001), Autistic Self Advocacy Network (ASAN, 2019), and mothers of adults with Intellectual Disability (Lee McIntyre, 2004), McCauley and colleagues (McCauley et al, 2020) proposed a framework including autonomy, social relationships, and purpose, which could be measured across adults with higher and lower IQs.

Verbal IQ was a strong and reliable predictor of positive outcomes, demonstrating the strong relationship between verbal reasoning and outcomes across the IQ spectrum. In a longitudinal study of 84 autistic adults, Friedman and colleagues (Friedman et al, 2019) assessed conversational skills through open-ended interview questions. They found that vocabulary diversity, an indicator of structural language, was significantly associated with vocational independence; adults with a robust vocabulary were more likely to hold a job or advance their education. Additionally, maintaining conversation topics, a pragmatic language skill, was linked to friendships-- effective social communication is crucial for establishing and maintaining social connections.

The Current Review

The vast majority of autism research focuses on samples without significant cognitive (and thus, communication-related) disability (Russell et al, 2019), a significant limitation of the field. In an effort to balance recent research and include varying levels of baseline communication abilities, we

have focused our review on four essential topics: (1) literal and non-literal language, (2) augmentative and alternative communication (AAC), (3) multimodality, and (4) allyship and the double empathy problem. With the exception of AAC - chosen for its relevance to minimally-speaking adults - we selected topics that autistic adults themselves often reference as central to their communication successes and failures. Throughout all sections, we note specific samples in included studies, a practice we encourage other researchers to adopt.

Literal and Non-Literal Language

Language is flexible; the meaning of a word often changes depending on the situation (Lakoff, 1987; Murphy 2002). For example, the word dish can mean a plate, a meal, the act of serving food, or even gossiping. About 80% of English words have multiple related meanings. These words make communication flexible, but speakers and writers must share enough context for listeners and readers to pinpoint the intended meaning in the moment (Piantoadosi, Tily & Gibson, 20212).

Many people assume that words have simple, fixed meanings, but even the most common words represent complex and nuanced ideas shaped by context (Lakoff, 1987; Murphy 2002; Gelman, 2003). The same holds true for phrases. Consider the expression spill the beans, which means "to reveal a secret," rather than literally dropping beans. The ability to discern context is particularly challenging for autistic people. Importantly, this difficulty persists even when controlling for general language ability (Schaeffer, 2023).

When matched on age, education, or performance tasks, autistic adults perform comparably to or better than non-autistic adults on structured language tasks, including memorizing new words (Cuneo, Floyd, & Goldberg, 2024), context-independent vocabulary tests (27), and overall lexical knowledge (Schaeffer, 2023). However, when tasks require extending word meanings in novel ways (Cuneo, Floyd & Goldberg, 2024), making normative judgments on new stimuli (Wilson & Bishop, 2020), interpreting implied or non-literal meanings (Didnar et al, 2023, Wilson & Bishop 2020), or integrating thematic elements (e.g., in storytelling; Wilson & Bishop 2020), autistic adults tend to struggle.

These patterns suggest that autistic adults often excel in structured, rule-based language tasks, but face greater challenges in more flexible, interpretive contexts that rely on extending or abstracting meaning. One notable factor underlying these challenges is a preference for literal interpretations of language (for a review, see Lampri, Peristeri, Marinis & Andreou, 2024). This tendency presents challenges in tasks like metaphor processing, which requires understanding non-literal language. Such difficulties are frequently linked to broader language impairments; verbal ability is a key predictor of success in metaphor comprehension (for a review, see Geelhand et al, 2020). Literal interpretation may create miscommunication, and autistic adults may compensate by relying heavily on memory. One autistic individual shared, "I wish people were more mindful of things that are ambiguous in communication. I'm fortunate to have memorized so many idioms and metaphors that I can instantly translate them in my head" (Cummins et al, 2020).

Despite these challenges, a preference for literal interpretation has advantages in specific contexts, including technical or legal writing, where clarity and precision are critical. Autistic individuals may also demonstrate less conventional but highly effective language use, characterized by precision and creativity (Luyster, Zane & Wisman, 2022).

Augmentative and Alternative Communication (AAC)

Augmentative and alternative communication (AAC) refers to tools and strategies that support individuals with complex communication needs. These range from low-tech options such as paper based, picture communication (Figure 1A) to high-tech solutions such as speech- generating devices (SGDs; Geelhand et al 2020, Lampri et al, 2024; Figure 1B). AAC systems enhance communication, foster independence, and improve quality of life by supporting the AAC user in important, everyday life activities (Ganz et al, 2023). The studies reviewed in this section primarily include minimally speaking adults.

For autistic adolescents and adults, AAC access reduces challenging behavior, and improves functional, social communication and engagement (Holyfield, Drager, Kremkow & Light, 2017). Additionally, AAC positively impacts employment outcomes for non-speaking autistic adults by enhancing employee and employer satisfaction (Hedley et al, 2017; Richardson, McCoy & McNaughton, 2019; Morgan & Schultz, 2012). For autistic adults with significant communication challenges, AAC tools are essential for social interaction and self-expression (Light & McNaughton, 2012). However, much existing literature focuses on AAC use in children. This gap highlights the need to better understand AAC's role across the lifespan, particularly in supporting autistic adults (Ganz et al, 2023; Andzik & Chung, 2022).

Recent advancements in AAC technology, such as just-in-time (JIT) programming and visual scene displays (VSDs; Figure 1C), are transforming communication for individuals with high communication needs. These tools enable users to instantly capture real-world scenes and access context-specific vocabulary (Babb et al, 2019; Babb et al 2020; Drager et al, 2019; Schlosser et al, 2016). Innovations like AI-generated vocabulary from photographs further enables devices' ability

to meet user's 'in-the-moment' communication needs (Babb et al, 2020; Yu et al, 2024). These technologies support participation in complex social situations and address sensory and anxiety-related difficulties that arise when verbal speech is inaccessible (Donaldson, Corbin & McCoy, 2021; Zisk & Dalton, 2019).

Successful AAC implementation requires careful planning, training, and support from communication partners, including family members, friends, community members, educators, and employers (Ganz et al, 2023). Individuals familiar with symbolic communication adapt more easily to this role, while AAC newcomers require more intensive training. Training models like the Communication Partner Instruction (CPI) framework equip partners with the skills to integrate AAC use to everyday contexts, improving communication for users with severe disabilities (Ogletree, Bartholomew, & Price, 2020).

The continued evolution of AAC technology requires ongoing research to ensure these goals and strategies remain effective, accessible, and adaptable to autistic people's wide-ranging communication needs. AAC tools and systems not only enable communication but also promote inclusion, independence, and opportunities for meaningful engagement.

Figure 1. Examples of low- and high-tech AAC displays.

**REVIEWER NOTE: we are in the process of seeking permission to re-print these images, so the exact images may change slightly, but they will reflect the same content.

Figure 1A. Example of a lite/low-tech paper based AAC option using both orthographic and picture symbols to support communication.

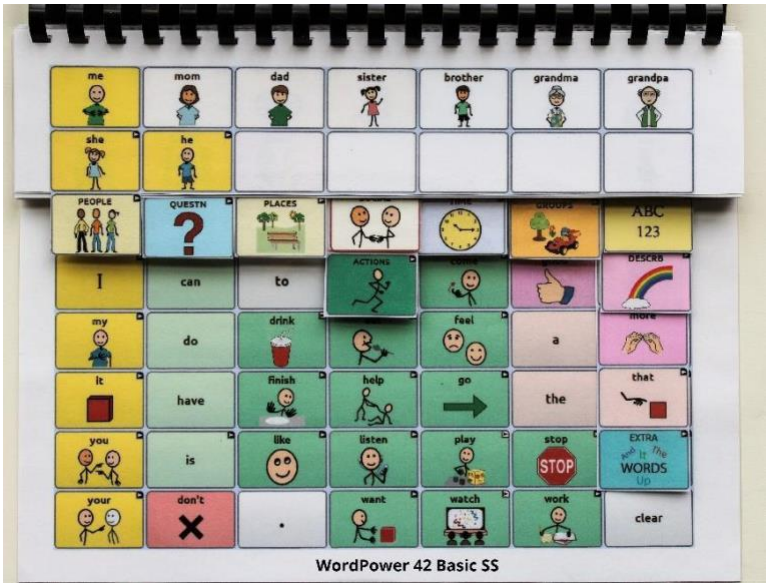
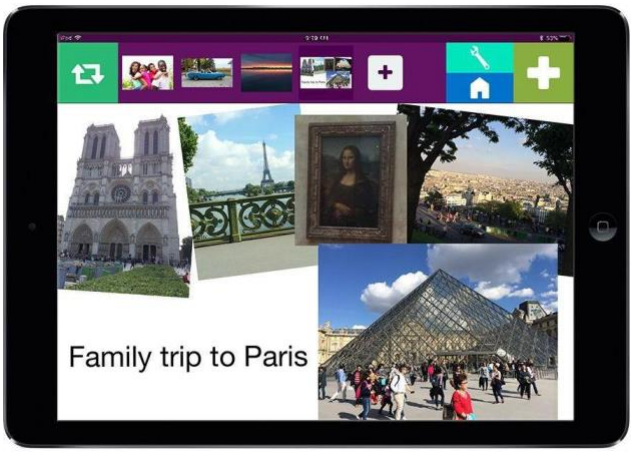


Figure 1B. Example of high-tech AAC option, Proloqou2go application for an IOS device. AAC software with a grid display and synthetic speech output.



Figure 1C. Example of Just in Time (JIT) programming using a Visual Scene Display (VSD). Contextual personal photographs are uploaded to the GoVisual application. Photos contain hotspots programmed with messages for communicating with others about a recent family trip.



Nonverbal Communication

Nonverbal communication (sometimes referred to as "multimodal language") refers to the integration of the many modalities of our communicative system: we can speak (the vocal modality), but we also use facial expressions, manual gestures, and posture (the visual modality). Not everyone uses all possible signals or modalities all the time (see also the section on AAC), but nonverbal communication is ubiquitous, particularly in face-to-face communication. We note that all studies in this section include only verbally fluent autistic adults, due to limitations in the available research literature.

Nonverbal communication serves a wide range of functions. Different modalities are often co-expressive: information conveyed via language may be redundant with other modalities or communicate entirely new information (Goldin-Meadow, 2014). Often, interpreting meaning requires integrating multiple modalities. Consider the exclamation, "look!" Its meaning may depend on tone — is it spoken in awe or alarm? – or on whether the speaker is pointing (i.e., gesturing) toward a cardinal hiding in a tree or a car running a red light. Nonverbal communication thus links speech and the environment. As such, it often plays a critical role in revealing speakers' intentions (Kelly, 2001). Multimodal communication also serves interactive functions such as grammatical marking, emphasis, and regulation of turn-taking (Bavelas et al, 1992).

Several studies now demonstrate that autistic adults benefit from nonverbal communication similar to the ways that non-autistic adults do (Cairney et al, 2024; Trujillo et al, 2021). For example, when speech is hard to hear, gestures can support comprehension (Matyjek et al 2024; Mazzini, Seijdel & Drijvers, 2024), and especially important finding given that auditory barriers are reported as highly

influential on autistic adults' ability to participate in conversations (Caldwell- Harris, 2024; Cummins et al, 2020; Stromber et al 2022). Recent studies show little to no evidence for overall group differences in facial emotion recognition (Hendriks et al, 2021; Keating, Ichijo & Cook, 2023; Keating, Fraser, Sowden & Cook, 2022; Keating, Sowden & Cook, 2022); however, alexithymia (i.e., difficulty expressing, experiencing, or identifying emotions) traits seem to modulate the intensity (Keating, Fraser, Sowden & Cook, 2022) and accuracy of perceived emotions (Gehdu et al, 2023). These findings show the importance of considering how co-occurring conditions can shape traits related to the traditional autism phenotype.

Among speaking autistic adults, differences in nonverbal communication relate to differences in processing or executing contextual cues, a pattern observed across behavioral (Trujillo et al, 2021) and neuroimaging data (gesture: (Matyjek et al 2024; Trujillo et al, 2022); facial expressions: (Gehdu et al, 2023), prosody: (Haigh et al, 2022), and autistic adults' own descriptions of their experiences (Radford, Reidinger, Kapp & de Marchena, in preparation). Importantly, even when there are no differences behaviorally, neuroimaging studies suggest that autistic individuals may have a different way of processing information than non-autistic adults (Matjek et al, 2024; Trujillo et al, 2022). These processing differences could impact the interpretation of others' nonverbal behaviors, or the time or effort required for processing.

The nonverbals autistic people produce also differ from control groups, for example, they are more likely to be unilateral (de Marchena et al, 2019) and to show greater temporal segmentation through the use of brief pauses in movement (Trujillo et al, 2021). Such differences may impact the way others interpret the autistic individuals' nonverbal behavior. Autistic adults appear to rely heavily on multimodal communication (specifically, hand gestures) to support conversational turn-

taking, supporting social benefits to autistic speakers (de Marchena et al, 2019). In the vocal modality, the backchannels (e.g., ‘ums’ or ‘uhs’ within conversational pauses that cue states such as confusion, attention, and needing more time) that autistic adults produce during conversation may also differ prosodically (Grice et al, 2023). This likely impacts mutual understanding.

Autistic adults are aware of the different ways they use and understand multimodal communication, and the negative impacts these differences can have on their lives. For example, autistic adults describe negative impacts when others assume they are being dishonest when their facial expression does not “match” their verbal language. Autistic adults also describe how it’s often easy to interpret emotional extremes, but challenging to interpret more subtle expressions (Kurumada, Rivera, Allen & Bennetto, 2024). Many autistic adults describe how their greatest challenges with multimodality involve processing differences such as needing more time to process and/or integrate multiple signals. One contributor to Radford and colleagues’ (Radford, Reidinger, Kapp & de Marchena, in preperation) study stated, “it's not so much a case of ‘can/cannot’ read body language, so much as a different way of doing it which has a much higher cognitive load, so is much more tiring.”

Double Empathy

Traditional autism literature focuses on social and cognitive difficulties in the autistic child or adult. Accordingly, it often concludes that observed interaction difficulties arise due to the autistic person's deficits (Baron-Cohen Alan & Frith, 1985; Simpson, 1991). A newer theory, the "Double Empathy Problem" (DEP), emphasizes the bidirectional nature of forming and maintaining social relationships (Milton, 2012). Originally described and developed, in large part, by autistic scholars, the DEP shows how interactions between autistic and non-autistic partners sometimes break down because non- autistic people may not understand different communication styles, akin to cultural differences that can hinder mutual understanding.

Empirical evidence supporting this theory has accumulated over more than a decade of study (Milton, 2022). For example, non-autistic people struggle to understand the mental states of autistic people (Shepard et al, 2016) which might lead them to less favorable impression. Social dynamics often associated with autism (e.g., low rapport) improve when measured during interactions exclusively among autistic people (Crompton et al. 2020). Behavioral indicators of rapport differ between autistic and non-autistic pairs. While mutual gaze and backchanneling lead to higher rapport in non-autistic pairs, less use of these signals predicts higher rapport in autistic pairs (Rifai et al, 2022), demonstrating how a difference – but not a deficit – in nonverbal communication can hinder social connectedness across – but not within – neurotypes.

Even when communication is measured in a way that minimizes social effects, communication experiences improve when autistic people interact with each other. For example, information transfer is similar within autistic-autistic and neurotypical-neurotypical dyads, but declines in

autistic-neurotypical pairings (Crompton et al, 2020). These effects are possibly related to autistic adults being less likely to follow neurotypical language conventions (Cummins, Pellicano & Crane,2020; Stromberg et al, 2022; Luyster, Zane, & Wisman), though this relationship requires further investigation. Importantly, future research should examine why autistic-autistic pairs are often more successful than mixed neurotype dyads; these findings will give direction to specific changes non-autistic partners can make to help support positive interactions with autistic people in their lives.

The DEP emphasizes differences in autistic culture that may drive more positive interactions between autistic people, relative to across neurotypes. For example, among autistic people, it is often considered polite to ask questions of a communication partner to confirm mutual understanding. However, non-autistic people often misinterpret this same behavior as rude, difficult, dominant, or challenging authority. Non-autistic people could learn to respect autistic social norms/etiquette, rather than placing the sole burden on autistic people to conform to non-autistic expectations.

Misunderstandings due to differences in interaction styles across neurotypes have implications for autistic people in critical life domains, including education (Lim et al, 2023), employment (Szechy, Turk, & O'Donnell, 2024), and healthcare (Nicolaidis et al, 2015). The shift in focus from autistic deficits to neurodivergent misalignment is essential for advancing our understanding of contextual communication. It suggests that non- autistic people can improve communication with autistic people by adapting their own expectations and behaviors. Below, we make suggestions for those who are looking to do just that.

Recommendations

Autistic adults are encouraged to learn self-advocacy skills to communicate their needs and preferences (Schena, Rosales & Rowe, 2023). It is equally important that non-autistic people, including teachers, parents, carers, and clinicians, advocate for the rights and needs of neurodivergent people and learn skills themselves to promote and support autistic communication. Given the many barriers neurodivergent people face and the danger of self-advocacy fatigue or burnout, neurodivergent people need allies (Moss, 2024; Wolbring & Lillywhite, 2023). Psychiatrists can be allies by educating themselves and their colleagues about autistic communication differences and how to support those differences to enhance mutual understanding.

Clinical Implications and Recommendations

Autistic adults experience communication difficulties as arising from both internal and external factors, and suggest that communication supports should focus on building skills for both autistic people and society at large (Cummins, Pellicano & Crane, 2020). For example, difficulty communicating with providers is a barrier to healthcare for autistic adults (Raymaker et al, 2017), who have significantly shorter lifespans compared to the general population (Hirvikoski et al, 2016). Autistic patients identify both their own communication skills and their providers' communication skills (e.g., use of accessible language) as major factors influencing healthcare interactions (Nicolaidis et al, 2015; Raymaker et al, 2017). With respect to mental health specifically, Maddox and colleagues (Maddox et al, 2020) explored the challenges in community mental health services for autistic adults, identifying barriers at the clinician, client, and systemic levels. Clinicians lack training and confidence in working with autistic clients, while communication differences make it difficult for autistic adults to express their needs or navigate the

healthcare system. Systemic issues, such as poor coordination between mental health and disability services, often result in denied care or referral to inappropriate services (Maddox et al, 2020).

In addition to needed systemic changes, individual clinicians can improve their patients' health outcomes by adjusting their own communication practices. Table 1 includes examples of specific communication differences often observed in or reported by autistic people, and recommendations for clinicians for how to manage them. Critically, communication differences vary widely among autistic and neurodivergent people in general. Thus, clinicians who want to be better communication partners with their autistic and neurodivergent patients should make fewer assumptions about what patients can and cannot do, while also self-educating about common communication differences.

In addition to general adaptations and communication practices, there is now a growing evidence base for mental health interventions that have been tailored to and tested with autistic patients. Increasingly, autistic researchers and community partners have helped develop or adapt these programs, reflecting best practices. As one example, take the problem of suicide. Autistic individuals have a heightened risk of suicide—recent studies suggest a two to eightfold increase—compared to the general population. Prevalence studies estimate that 34% of autistic individuals experience suicidal ideation, with 24% reporting suicide attempts (Brown et al, 2024). The CBT-DAY model, a co-created neurodiversity-affirming group intervention, has demonstrated effectiveness in reducing depressive symptoms and targeting key factors linked to suicidal behaviors. Scaling these interventions and reforming systemic shortcomings are critical to mitigating the heightened suicide risk faced by autistic individuals and improving their mental health outcomes (Schwartzman et al, 2024).

Lastly, an autistic person cannot be fully understood in isolation from other constructs such as their race, gender, sexuality, class, etc. These multiplying identities create diverse experiences and can create additional barriers to interaction (Mallipeddi & VanDaalen, 2022). Again, we advocate for personalized care based on each individual patient's multiple identities and referring problems. Overall, anticipating and responding to – not only understanding – the diverse experiences and needs of autistic people is the best way to ensure they thrive in society, education, and employment.

Recommendations for Research and Researchers

As recommended to clinicians, we also encourage researchers to anticipate communication differences and pay attention to how their own communication styles and preferences may create barriers to communicating with autistic research participants. As described in the introduction, research in general is limited in autistic adult samples, thus we strongly encourage researchers and funders to increase their research portfolios to focus on adults in addition to children. Some progress has been made on research showing how non-autistic adults can change their own communication practices to be better interaction partners for autistic people (Jones, DeBrabander & Sasson, 2021); this is a critical research area in need of more work.

As research tends to focus on autistic samples with low support needs, we recommend increasing inclusivity and access to research for autistic adults with higher support needs. In our own work, for example, we implemented a range of strategies to make participation accessible to as many people as possible. Participants may complete our studies independently, with a trusted support person, with support from our study team, or, in the case of adults who cannot self-report we permit participation by proxy. Occasionally, ethical dilemmas present themselves while trying to enhance fair subject selection and inclusivity while balancing rigorous data collection. We recently discussed some of these tradeoffs with respect to online data collection with autistic adults (Carey, McClean & Chvasta, 2024).

Communication is a priority for autistic adults. At a 2019 summit, the Autistic Self-Advocacy Network identified the question, “how can we help autistic people communicate?” as a key research concern (ASAN, 2019). Autistic adults advocate for research that characterizes autistic communication and improves accessibility, yet most funding remains concentrated on biomedical

and genetic studies rather than everyday communication solutions that respect autistic agency (IACC, 2019; Roche, Adams. & Clark, 2021). Additionally, autistic adults want a greater investment in AAC, nonverbal communication interventions, and accommodations for sensory and cognitive differences (95,96). Participatory approaches and the removal of research barriers, including exclusionary criteria, deficit-based models, and inaccessible methods, are necessary to align autism research with autistic priorities and improve communication support (ASAN, 2019; ASAN, 2023; Nicolaidis et al, 2015).

We support efforts to include autistic adults, not only as research participants, but as part of the research team. Doing so ensures both that research questions are relevant to the autism community, and that research practices are as accessible as possible. For example, AASPIRE, a longstanding community academic collaborative, has published guidelines on how to engage autistic community members as research partners, guidelines on engaging autistic community partners as co-researchers (Nicolaidis et al, 2019), and guidelines for conducting accessible research based on the work of their partnership (Nicolaidis et al, 2020).

Conclusions

Research on autistic adults, especially non-speaking populations, is limited and requires focused effort. Improved communication is associated with improved outcomes including autonomy, social relationships, and purpose, at all IQ levels. Critically, because communication is bilateral, improving communication for autistic adults requires adaptation and change by non-autistic communication partners. Important but understudied areas of research and clinical practice include communication partner training for both speaking (Albin, Chawrun, & Tint, 2024) and minimally speaking adults (Olgree, Bartholomew & Price, 2020). Clinicians should prioritize understanding communication differences and nonverbal cues in their interactions, while minimizing assumptions that may be based on non-autistic behaviors, or assumptions about a patient just because they are autistic. Allyship, intersectionality, and understanding autism as a culture will support impactful research and practice. Psychiatrists can be allies not only by supporting their own patients but also by educating colleagues and the next generation of clinicians.

Table 1

Common communication differences reported by or observed in autistic adults, and recommendations for clinician adaptations

Goal: Lower cognitive and emotional demands	
Communication Difference	Differences in processing and response time
Example(s)	Patient responds more slowly than expected
Clinical adaptations (general)	Slow down speaking pace. Allow time for processing without assuming disengagement. Reduce expectations of immediate backchanneling.
Adaptation examples and scripts	Count to ten before prompting again. Use explicit pauses instead of filling silence. Allow an opportunity for the patient to ask questions before moving onto another subject, "Do you have any other questions before we talk about something else?" Provide a written summary of the discussion and clear action points for care plan.
Communication Difference	Cognitive/emotional overload
Example(s)	Patient becomes overwhelmed when asked multiple complex questions. Patient-clinician communication goes well, but patient fatigues quickly.
Clinical adaptations (general)	Use a predictable and consistent structure during appointments, so that patient knows what to expect. Pace the session by asking one question at a time, allowing the patient to fully answer before moving on. Offer pauses or breaks if signs of overload are noticed.

	May need to offer multiple, shorter appointments to minimize fatigue.
Adaptation examples and scripts	"First I want to hear about how you've been this week, and then I will ask you about medication side effects." "Once you're ready, we can talk more about what happened."
Goal: Reduce Bias and Assumptions	
Communication Difference	Differences in nonverbal expression (e.g., eye contact, facial expression, vocal tone)
Example(s)	Patient looks away, makes minimal eye contact, or has a neutral facial expression. Patient's facial expressions do not "match" expected emotional cues based on their verbal language.

Clinical adaptations (general)	Recognize multiple valid ways of expressing engagement. Focus on explicit communication over inferred meaning. Use verbal check-ins rather than relying on assumed meanings of nonverbal expressions.
Adaptation examples and scripts	Instead of assuming disengagement, focus on what the patient is saying. Instead of inferring patient's emotional state based on nonverbal cues, ask: "How do you feel about that?" or "How are you feeling right now?"
Goal: Accommodate Language Preferences	

Communication Difference	Preference for precise, literal language
Example(s)	Patient interprets figurative language (e.g., “Let’s unpack this”; “where are we on that goal?”) literally (e.g., shows confusion about what to unpack or gives a physical location in response to a question intended to be about progress toward goals).
Clinical adaptations (general)	Use direct and concrete language. Be on the lookout for idioms and metaphors that are part of your automatic communication style. Rephrase statements in a way that prioritizes clarity.
Adaptation examples and scripts	Instead of “Let’s unpack this,” say “Can you describe that in more detail?”
Communication Difference	Preference for alternative communication methods
Example(s)	Patient prefers writing to speaking.
Clinical adaptations (general)	Offer multiple ways to communicate. Allow for written, typed, or asynchronous communication options.
Adaptation examples and scripts	“You can always email me after the session if there’s something else you’d like me to know. You can also email me any questions you have now or later.”
Communication Difference	Differences in expressing emotional or other internal states.
Example(s)	Patient does not express emotional states in expected ways.

	Clinical adaptations (general)	Checking in, validating, and reducing clinician assumptions Check in about communication preferences instead of making assumptions.

		Explicitly confirm understanding and preferences Check in to ensure what you have communicated is understood and you interpreted the patient correctly.
	Adaptation examples and scripts	“Is my speaking pace okay for you?” or “Would you like me to slow down?” "Is this a correct interpretation of [how you interpreted patient]?" “I want to make sure I’ve explained everything clearly...”

Chapter 5: How can we help autistic adults communicate?

When I first began this dissertation, I was driven by a fundamental question- one posed in 2019 by the Autism Self Advocacy Network: How can we help autistic adults communicate?

It is well established that autistic individuals exhibit a preference for sameness, often characterized by routine-seeking, focused interests, and lower tolerance for uncertainty (see Chapter 1). In fact, this preference is a core diagnostic feature. At the same time, the usage-based approach to language observes that language use regularly requires flexibility: Language is learned through usage, shaped by patterns, and deeply context-dependent, The contrast between the rigidity often associated with autism and the flexibility often required by language use raises the question: Do autistic individuals display challenges or differences when faced with flexibly extended meanings of a word or construction or the need to flexibly extend a meaning themselves?

This dissertation directly engages with this question through a novel, linguistically informed approach: Flexibility and Meaning Extension (FLAME) in autistic language use. Across three empirical studies with a combined sample of 480 participants, I have examined how verbally able autistic adults navigate language—uncovering not only challenges but also unique strengths in their use of the English language. Understanding these nuanced differences is key to designing more effective communication strategies and interventions with the goal of helping autistic adults communicate. To pinpoint the nature of language flexibility challenges, we examined language at three levels: words, phrases, and category structures.

Word-Level Flexibility (Chapter 2) We first investigated whether autistic adults struggle with meaning extensions at the level of individual words. In a study with 160 participants (80 autistic, 80 non-autistic), autistic adults showed significantly more difficulty when required to flexibly

extend familiar word meanings compared to their non-autistic peers. At the same time, the autistic group excelled in a novel word-learning task where flexibility demands were minimal (Cuneo et al., 2024). This suggests that difficulties arise not from language per se, but in skill flexibly extending familiar words in new ways.

Phrase-Level Flexibility (Chapter 3a) Language is more than just words- phrases also carry meaning. We extended our investigation to multi-word constructions, comparing performance on flexible, variable phrases to fixed, memorized chunks. Among 135 participants (61 autistic, 74 non-autistic), autistic adults again showed greater difficulty when constructions had to be extended in new ways, when matched with the non-autistic group on familiar instances (Cuneo & Goldberg, submitted). Taken together, Chapters 2 and 3 reveal a subtle but pervasive difficulty with flexible extensions—from the word level to the phrase level. The implications for real-world communication, particularly in conversational settings, are profound. I will return to this point in 5.3.

Categorization and Consensus (Chapter 3b) Finally, we explored how autistic adults complete partially filled-in sentences by analyzing the responses they provided. We then examined how much agreement, or consensus, emerged across the two groups for each blank. Among 120 participants (60 autistic, 60 non-autistic), non-autistic adults showed greater agreement in recalling prototypical words, while autistic adults demonstrated more individual variation, suggesting the possibility of more individual variation in their linguistic categories (Cuneo & Goldberg, submitted).

Together, the three studies challenge the notion that autistic language differences necessarily stem from a general linguistic deficit. Instead, they suggest that a core challenge lies in language

flexibility. The FLAME Hypothesis provides a new framework for understanding where autistic strengths lie—namely, in structured, contextually stable language tasks—and where challenges arise, particularly in contexts requiring flexible interpretation or productive extensions.

By isolating a specific type of linguistic difference, this research moves us closer to answering the question that inspired this dissertation: How can we help autistic adults communicate? The answer lies not in viewing autistic language use as entirely deficient, but in recognizing the ways in which linguistic flexibility interacts with autistic traits- and using this knowledge to create communication systems that empower rather than constrain.

Recommendations and Lived Experiences (Chapter 4) Chapter 4 provides a comprehensive review of the past five years of research on autistic adult communication, conducted in collaboration with autistic and non-autistic researchers. It prioritizes lived experiences by centering topics frequently highlighted by autistic adults themselves: (1) literal and non-literal language, (2) augmentative and alternative communication (AAC), (3) multimodality, and (4) allyship and the double empathy problem. Recognizing the field's tendency to focus on autistic individuals with lower support needs, this review emphasized the necessity of inclusive research that accounts for diverse communication profiles.

This chapter underscores the real-world impact of communication barriers, from healthcare access to mental health disparities, urging clinicians to adopt neurodiversity-affirming practices, and providing them with the tools to do so in everyday practice. It also calls for researchers to engage autistic adults not only as participants but as collaborators, ensuring that studies reflect their lived realities. By advocating for more inclusive methodologies and systemic changes, this review

aims to shift the field toward a deeper, more representative understanding of autistic communication.

Lastly, this chapter complements Chapters 2-3b by highlighting instances where non-autistic adults contribute to communication breakdowns with autistic individuals. While Chapters 2-3b focused on differences in autistic adults—emphasizing both challenges and strengths—these studies were conducted in isolation. This allowed for the examination of language alone, minimizing the influence of social anxiety, external pressures, or variations in communication partners. However, a limitation is that the studies do not capture the ways in which non-autistic individuals may contribute to communication difficulties. This discussion aligns with the framework of the double empathy problem, an essential perspective for advancing this work (Chapter 4).

5.1. Implications and Significance:

Much of the intended impact of this work has already been outlined, including that it may help lead to the advancement of more effective communication strategies, improved outcomes for autistic adults, and the promotion of neuroaffirming practices. A key contribution of this research is its linguistic perspective, which allows for the isolation of language differences from other aspects of autism, providing a more precise understanding of the role language plays in shaping autistic communication experiences.

The significance of language is hard to overstate. Language is not merely a tool for interaction- it is the foundation of social connection and community. It shapes cultural norms, structures beliefs, and reinforces shared identities (White, 2012). As White (2012) aptly notes, "life itself can be described as a life of language," underscoring its fundamental role in human existence. Empirical research further highlights the profound link between language use and well-being (Griffiths et al 2021; Jelen et al, 2023; Nook et al, 2025; Valdivia-Moreno et al 2025), demonstrating that strong social networks and conversational engagement are critical predictors of both physical health and subjective well-being (Helliwell & Wang, 2011; Ren, 1997; van der Horst & Coffe, 2012). In contrast, social isolation—often exacerbated by communication barriers—has been linked to increased mortality risk (Hunt-Lundstad, Smith, & Layton, 2010).

Beyond its social and psychological implications, language holds significant political power. As Weinreich famously stated, "A language is a dialect with an army and a navy," highlighting the ways in which languages can help inform national identities and shape geopolitical landscapes. The ability to communicate effectively is not only a matter of personal connection but also a determinant of societal participation and influence. Empowering a community to communicate more effectively is essential.

This research extends beyond its immediate applications in autistic communication. It also provides critical insights into the usage-based approach to language, which emphasizes flexibility and adaptation. By examining a population often characterized by linguistic rigidity, this work underscores the importance of flexibility in language learning and use, offering a unique lens through which to evaluate core theoretical frameworks in linguistics. Ultimately, this study not only supports autistic individuals in achieving more effective communication but also deepens our broader understanding of language itself.

5.2: Limitations & Future Directions

This research opens several promising avenues for future study, particularly in understanding the real-world impact of challenges with language generalization, exploring cross-domain connections, and investigating the developmental origins of flexibility in autistic language processing.

Impact on Daily Communication Measuring the cumulative burden of language generalization difficulties in autistic adults is essential. A limitation of this study series is that it isolates each level of language, to measure the impact of flexibility, which while helpful in understanding impacts, is not the way language works in real time conversations.

While this research finds an average 10% difference in performance among the verbally able autistic adults tested, that difference is expected to compound across multiple levels - word meanings, phrase meanings, and the larger discourse. In real-world conversations, layered challenges may lead to significant communication barriers or place a disproportionate cognitive load on autistic individuals. Future work should examine whether and how these difficulties compound and what the effect this may have in everyday life.

*Educational and Clinical Application*s Applying these findings to educational and clinical settings is a critical next step. By leveraging autistic individuals' strengths in structured language tasks, researchers and practitioners can develop targeted interventions. Strategies that introduce controlled flexibility- while aligning with autistic cognitive processing- may enhance generalization skills in a way that feels natural and supportive. Future studies should explore how such interventions can be optimized for different learning and communication styles.

Supplementing this, a crucial question remains: When do these generalization difficulties emerge? Do they originate in the early stages of language learning due to differences in attention and interpretation? Or do they develop later, influenced by how knowledge of language is stored and retrieved? A limitation of this work is that our data captures single points in time. Longitudinal

studies are needed to clarify whether the differences identified here are present from the beginning of language learning or whether they emerge over time, as this is key to providing insights for early intervention and support.

Cross-Domain Connections Rigidity in language generalization is unlikely to exist in isolation. Similar patterns of inflexibility and distinct categorization have been observed in motor planning, social cognition, and sensory processing (for review see chapter 1.1). There has also been early work done investigating neuro and cognitive-inflexibility (Geurts, Cobrett & Solo,on, 2017; Sigar et al 2025; Harlalka et al, 2019). Investigating whether language rigidity correlates with challenges in these non-linguistic domains could deepen our understanding of autistic cognition more broadly. Future research should examine whether increasing flexibility in one domain influences adaptability across others, offering potential insights into broader intervention strategies.

Expanding the Scope This dissertation focused on a subset of autistic adults to control for cognitive and linguistic ability, but this approach inherently excludes a significant portion of the autism spectrum. It is vital to extend this type of research to autistic individuals with higher support needs to gain a more comprehensive understanding of communication across different verbal ability levels. Future studies are needed to prioritize more inclusive methodologies, ensuring that research reflects the full diversity of autistic experiences.

Centering Autistic Adults Exploring these questions will not only advance our understanding of language flexibility in autism but will also drive practical applications in education, clinical practice, and accessibility initiatives. As discussed in Chapter 4, meaningful progress requires allyship and intersectionality. Future research must center autistic voices, ensuring that findings translate into real-world benefits for the community.

5.3: Concluding Remarks

This dissertation challenges conventional assumptions about autistic language use, demonstrating that communication differences in autism are not merely deficits but reflections of a unique cognitive and linguistic profile. By centering flexibility as a key factor in language processing, the FLAME Hypothesis provides a new framework for understanding both the challenges and strengths of autistic communication. This work shows a deep appreciation for the usage-based approach to language, an incredibly useful framework for future adult autism research. Through empirical evidence and a linguistically focused approach, it highlights the importance of recognizing and accommodating these differences- not only in research but in real-world interactions. Moving forward, meaningful progress in accessibility and inclusivity will require a shift from deficit-based models to approaches that embrace and support the diverse ways autistic individuals engage with language.