4-24-2014

Uh, Um, and Autism: Filler Disfluencies in Children with Optimal Outcomes from Autism Spectrum Disorder

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B.A., Whitman College, 2008

A Thesis

Submitted in Partial Fulfillment of the

Requirements for the Degree of

Master of Arts

at the

University of Connecticut

2014

APPROVAL PAGE

Master of Arts Thesis

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2014

Acknowledgements

This project would not have been possible without the support and encouragement of my many research and clinical mentors. First, thank you to my advisor and research mentor, Inge-Marie Eigsti, for wholeheartedly fostering my growth as a researcher. Her intellect, curiosity, and enthusiasm are truly an inspiration to me. Thank you also to Deborah Fein, for her sincerity, kindness, and encouragement throughout this process. I would also like to thank Heather Bortfeld, for her willingness to devote her time, effort, and support to my project.

In addition to my committee, I would like to thank many others with whom I have had the pleasure of working with at UConn. First, thank you to Marianne Barton, for her continual kindness, assurance, and support. I would like to thank members of the Optimal Outcome Lab: Molly Helt, Michael Rosenthal, Eva Troyb, Katherine Tyson, Alyssa Orenstein, and Joyce Suh, for all of their hard work recruiting participants and collecting data. Thank you also to our undergraduate research assistants, Allison Fitch and Bonnie Stas, for their careful help with transcription. I would also like to thank the Developmental Cognitive Neuroscience team: Jessica Mayo, Allison Canfield, Brian Castelluccio, and Joshua Green, for their constant good humor and moral support. Many thanks also to my cohort for their encouragement over the years. And of course, thank you to my family, especially Matteo, who has been unwaveringly beside me at every step of this process.

I am truly grateful to the participants and their families who have volunteered their time and efforts to participate in this research. This work would be impossible without their generosity.

Finally, we acknowledge the generous support of a National Institutes of Mental Health grant R01MH076189 to Deborah Fein.

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Abstract

Spontaneous speech is marked by the presence of frequent disfluencies, including fillers like *um* and *uh*, which are thought to serve distinct social-communicative functions (Clark & Fox Tree, 2002). People with autism spectrum disorder (ASD) struggle with social communication. The current study examines a) the production of fillers in spontaneous speech among children and adolescents with ASD as well as individuals who have achieved "optimal outcomes" (OO) from ASD, and b) the association between filler rate and autism symptom severity versus general cognitive factors, in order to illuminate the processes implicated in filler production. Speech samples from 64 individuals ages 8-21 with ASD, OO, and typical development (TD) were analyzed for *um* and *uh* production. While *uh* rate did not differ, participants with ASD produced *um* less frequently than OO and TD peers; OO and TD groups did not differ. *Um* rate was also inversely correlated with autism symptom severity within the ASD group, but was not associated with cognitive abilities. The finding that reduced *um* production is associated with ASD, and further, that ASD severity is linked to *um* frequency, highlights the uniquely social-communicative function of *um*. These findings may also clarify why, despite findings of atypical prosody in only 50% of individuals, there is a general clinical impression of odd speech quality in ASD. Finally, the typical production of this pragmatic marker among OO individuals substantiates the normalization of social-communicative abilities in OO and the possibility of behavioral recovery from ASD.

Keywords: autism, optimal outcome, pragmatic language, disfluencies, fillers

Introduction

Autism Spectrum Disorder (ASD) is characterized by social-communication deficits. Although speech oddity is observed clinically in ASD, prior studies have failed to consistently capture the qualitative signatures of this idiosyncratic speech. In the current study, we investigate an often-overlooked aspect of speech – filler disfluencies – in the context of the social-communication deficits of high functioning autism (HFA), and whether such disfluencies are apparent even in individuals who otherwise have achieved "optimal outcomes" (OO) and no longer show symptoms of ASD. Given the known pragmatic deficits seen in ASD, the current study will also shed light on the social-communicative meaning and function of fillers in typical development.

Disfluencies

When the Nixon transcripts were published, people were not only shocked by the content, but also the irregularity of spoken language (as cited in Pinker, 1995, p. 224). Naturalistic speech is characteristically halting and uneven, filled with repeated words, pauses, and speech errors; one study estimates that for every 100 words, speakers produce six to ten disfluencies (Fox Tree, 1995). Disfluencies include self-repetitions (e.g., *She ate the—she ate the apple*), repairs (e.g., *She ate the orange—the apple*), silent pauses (e.g., *She ate the—apple*), and filled pauses or "fillers" (e.g., *She ate thee—uh—apple*). They occur more frequently when there is time pressure or a temporary bottleneck in language production, due to difficulty with semantic content, lexical retrieval, or formulating phrase structure.

Disfluencies reflect cognitive load. Speech is more disfluent when planning demands are greater. Many studies have elicited and measured disfluencies as participants jointly work to complete a structured task, such as a puzzle. Using this methodology, Bortfeld, Leon, Bloom, Schober, and Brennan (2001) found that people are more disfluent when describing unfamiliar images (which were more difficult to describe) than familiar images. Both Oviatt (1995) and E. E. Shriberg (1996) found that longer utterances (which contain more lexical and grammatical content, thereby creating greater planning demand) contain more disfluencies than shorter utterances. Disfluencies are more likely to occur before uncommon (low-frequency) words (Arnold, Hudson Kam, & Tanenhaus, 2007), or words that are new to the discourse (Arnold, Tanenhaus, Altmann, & Fagnano, 2004) and are more common near the beginnings of utterances, where planning load is likely greater (Clark & Fox Tree, 2002).

There is a growing literature demonstrating that disfluencies are associated with executive processes. Engelhardt, Nigg, and Ferreira (2013) found that among typically developing adults, better inhibitory control is associated with fewer repair disfluencies. Adults with ADHD produce more repair disfluencies (Engelhardt, Corley, Nigg, & Ferreira, 2010), as well as more repetitions and unfilled pauses (Engelhardt, Ferreira, & Nigg, 2011).

Fillers, however, appear to be different. In contrast to other disfluencies, Engelhardt et al. (2010; 2011; 2013) found no association between executive functions and filler rate in the spontaneous speech of typically developing adults and those with ADHD. Moreover, although disfluencies in general are more common in longer sentences, some studies report no association between *fillers* and sentence length (E. E. Shriberg, 1996). Interestingly, one study reported that alcohol consumption, which reduces planning and self-monitoring abilities, actually decreases *um* production specifically (Christenfeld & Creager, 1996). These studies suggest that fillers may have a special status among disfluencies, one that reflects a more direct link to cognitive control or executive functions.

Why do we fill our pauses? Saying *uh* or *um* enables a momentary halt in speech, offering time for speech planning and production. This momentary delay, however, could otherwise be achieved with a silent pause. Why, then, do speakers fill pauses with *uhs* and *ums*? For one thing, filled pauses may serve a self-regulatory function (e.g. priming the language production system). They also, however, seem to serve a pragmatic function, conveying mental-state information between speakers and listeners. For example, speakers may produce filled pauses to "announce" momentary delays in speech (Clark & Fox Tree, 2002) in order to hold the conversational floor or communicate metacognitive information, such as difficulty accessing a word or deciding what to say next.

Fillers are cross-linguistic pragmatic cues. Although fillers vary phonologically across languages (i.e., they are produced with distinct sound patterns), most fillers tend to correspond with the vowels that are most frequent in that language's lexicon (see E. E. Shriberg, 1994), as is true in English *um* and *uh*. Speakers also typically produce two distinct fillers, which may serve to distinguish one type of pause from another (Clark & Fox Tree, 2002). In addition, fillers share prosodic characteristics across languages. English-speaking listeners are able to identify fillers in fluent German and Mandarin speech (Lai, Gorman, Yuan, & Liberman, 2007), suggesting that fillers have a prosodic "signature," even across tonal and non-tonal languages. Fillers seem to display common properties and functions across languages and cultures.

Fillers serve a social-communicative function. When people speak with an interlocutor over the telephone, they produce more fillers (counted as total disfluencies) than when speaking face-to-face (Oviatt, 1995). This finding suggests that when nonverbal cues such as gesture and eye contact are unavailable, speakers rely more heavily on disfluencies to coordinate discourse.

Studies contrasting dialogue with human versus machine partners have yielded interesting results. Oviatt (1995) found that when participants were speaking with a machine audience (i.e. voice recognition software) disfluency rates were lower. E. E. Shriberg (1996) also reported lower filler rates for machine-directed speech. The presence of a "mindful" or conscious audience seems to promote filler production, suggesting that fillers are at least in part listener-oriented.

Bortfeld et al. (2001) found that fillers serve a uniquely interpersonal function. In their experiment, participants were placed in male-female pairs, and each person was assigned a "director" or "matcher" role. They were then given identical sets of cards with a) unfamiliar abstract images (tangrams) or b) familiar images (children's faces), and were asked to put the cards in the same order. The director and the matcher could communicate verbally but not visually. Participants in the director role produced more repetition and repair disfluencies than those in the matcher role, but only for unusually long conversational turns (>30 words). During average-length turns, directors and matchers did not differ in disfluencies, with one exception: regardless of turn length, directors produced more fillers than matchers, suggesting that conversational role can uniquely influence filler production. Interestingly, although participants produced more overall disfluencies when describing unfamiliar items (tangrams), the opposite was true for fillers: directors and matchers used more fillers when describing the familiar items (faces). This increase, however, was attributable entirely to *male* participants. The authors posited that male speakers might believe that female partners have more expertise with children's faces, and produce *uhs* and *ums* to signal their own uncertainty.

Fillers improve interpersonal coordination and communication. Fillers are produced in a variety of conversational contexts, and carry a variety of contextually dependent "meanings." For example, fillers may help people in conversation to manage turn taking, align their mental states, and anticipate upcoming speech content. In other words, fillers are instrumental for interpersonal coordination, serving a variety of functions, which we review now.

Fillers help coordinate interactions. Fillers may help listeners determine a speaker's intentions. Unlike silent pauses, filled pauses seem to indicate that the speaker intends to hold the floor, as first proposed by Maclay and Osgood (1959).

Fillers communicate metacognitive information. Fillers signal other kinds of mental-state information, including hesitation, uncertainty, planning difficulty, and speech errors. In response to questions, fillers are produced more often when a speaker is uncertain of the answer (Brennan & Williams, 1995). Fillers are more frequent when speakers are having difficulty formulating a response. For example, when speakers were asked to communicate information about which they were "confident" versus "unconfident," 95 percent of the unconfident statements contained fillers; none of the confident statements did (Barr, 2003). Chrisenfeld and Craeger (1996) found that people who report more self-consciousness produce more fillers.

Although *uhs* and *ums* might seem to disrupt speech comprehension, evidence suggests that hearing these fillers may actually *improve* it. Fox Tree (2001), for example, found that listeners more quickly identify target words after hearing *uh* during speech — a finding that was consistent in both English and Dutch. Fillers can also help listeners more efficiently disregard erroneous spoken information. In Brennan and Schober (2001), participants first listened to instructions with a mid-word repair and then selected the target object. Listeners who heard a filler prior to the mid-word correction (e.g. *Move to the yel—uh, purple square*) selected the target object more quickly than listeners who heard the instructions without a filler, or with a silent pause of equal length. In this case, fillers may alert listeners to errors in speech and allow them to make inferences about the speaker's mental state.

Fillers signal lexical access difficulty. Fillers seem to improve comprehension. Listeners interpret fillers as signals of word-finding difficulty (Goodwin & Goodwin, 1986). For example, they can help listeners attend more carefully to complex upcoming referents. Fillers are more likely to precede phrases that require more time to plan or words that are more difficult to retrieve from the lexicon (Arnold et al., 2007; Arnold et al., 2004). The literature suggests that fillers lead listeners to anticipate two kinds of referents: those that are *new* to the discourse, and those that are *difficult to describe*. In Arnold, Fagnano, and Tanenhaus (2003), participants viewed four objects on a screen and used a cursor to respond to auditory instructions. Some of the trials were fluent (e.g. *Put the grapes above the candle*), and some contained a filler (e.g. *Put the grapes above the—uh, candle*); eye tracking was used to follow listeners' fixations. After hearing a filler, participants fixated more on discourse-new referents (referents that had not yet been mentioned). Similarly, a Japanese language study found that listeners were quicker to anticipate reference to complex shapes (e.g. a triangle with two arrows attached) — instead of simple shapes (e.g. a triangle) — after hearing a description with a filler (as compared to descriptions that contained no disfluency or contained a silent pause), providing cross-linguistic evidence that fillers lead listeners to anticipate syntactically complex descriptions (Watanabe, Den, Minematsu, & Hirose, 2008). This kind of discourse processing appears to arise early in development. While the literature is scarce, one study reported that two-year-olds begin to anticipate novel referents after hearing a filler (Kidd, White, & Aslin, 2011). Indeed, the orientation to pragmatic cues such as fillers may aid in early word-learning by placing a "spotlight" on relevant referents (Yu & Ballard, 2007).

Although listeners appear to use perspective-taking when they interpret fillers to anticipate novel or difficult-to-describe referents, there is a plausible alternative explanation. Listeners may simply rely on distributional statistics to learn that fillers are more likely to precede novel referents, using the same statistical learning mechanisms proposed to underlie the learning of word boundaries (Saffran, Aslin, & Newport, 1996), morphology (Mintz, 2013), and grammatical categories (Gómez & Lakusta, 2004; Mintz, 2003).

To test these competing alternatives, Arnold et al. (2007) employed the eye tracking paradigm described above (Arnold et al., 2003) and found that fillers help listeners to anticipate novel referents. When listeners were told, however, that the speaker had impaired object recognition, hearing a filler no longer led to anticipation of novel referents. Similarly, Barr and Seyfeddinipur (2010) found that when the speaker's gender changed immediately before a target trial, fillers no longer led listeners to anticipate discourse-new objects. These findings suggest extensive top-down influence, such that listeners account for contextual information while interpreting fillers. In contrast, however, when the speaker ostensibly heard a distracting noise, immediately prior to their filler production, listeners *still* anticipated the novel referent, suggesting that the alternative explanation for the speaker's filler use (e.g. hearing a distracting noise) did not interfere with the typical anticipation effect (Arnold et al., 2007). Therefore, the evidence for perspective-taking versus distributional learning is equivocal.

These equivocal findings leave open the possibility of these two competing accounts. The current study provides a test of these two competing hypotheses. People with ASD struggle with theory of mind and perspective-taking (Happé & Frith, 1996); however, they also seem to have intact distributional learning (Eigsti & Mayo, 2011). Therefore, reduced filler production in ASD would suggest that fillers function via perspective-taking, whereas intact filler production in ASD would suggest that fillers function via distributional-learning.

***Uh* versus *um*.** While *uh* and *um* might appear interchangeable, they are used in different contexts and may carry different meanings. For example, although both fillers signal upcoming delays in speech, *uh* typically precedes shorter delays, while *um* typically precedes longer ones (Clark & Fox Tree, 2002; Smith & Clark, 1993). In addition, *uh* occurs more within utterances, whereas *um* is produced more at utterance boundaries (Clark & Fox Tree, 2002; Swerts, 1998). Relatedly, *um* — a "full" syllable — has a more marked phonological construction than *uh*, which is produced with a "reduced" schwa (see Clark & Fox Tree, 2002), suggesting that *um* is more specialized than *uh*.

If *uh* and *um* appear in complementary distribution, speakers may produce them to convey distinct information: *uh* appears to serve a self-directive, inward-oriented function, whereas *um* serves a communicative, listener-oriented function. O'Connell and Kowal (2005) analyzed speech corpora of public speakers and reported a higher *uh:um* ratio compared to typical adult participants (e.g. Clark & Fox Tree, 2002), and proposed that public speakers are better able to suppress listener-focused *ums*, but have more difficulty suppressing inward-focused *uhs*. Contradictory findings, however, come from Fox Tree (2001), who found that *uh* helped listeners recognize words in upcoming speech but *um* did not. It is still an open question whether *um* serves a specifically social-communicative function.

Children as young as age two produce *uh* and *um* in spontaneous speech. However, although 5 and 6 year-old children pause longer after *um* (as do adults), three and four-year old children do not pause differentially for *um* versus *uh* (Arnold et al., 2007; Van Der Wege &

Ragatz, 2004). Interestingly, children begin to pass false belief tasks, which indicate the emergence of theory of mind, around the ages three to four (Wellman & Cross, 2001). Consistent with the social-communicative account of fillers, these findings suggest that theory of mind is a prerequisite to the effective use of fillers in spontaneous speech.

Summary. The literature to date provides evidence that speakers and listeners implicitly interpret fillers as conveying metacognitive pragmatic context-dependent information. Like prosody, co-speech gesture, and other pragmatic cues, fillers play an important role in helping people manage discourse and coordinate interpersonal communication. Although *uhs* and *ums* may appear to be no different than other speech disfluencies, the presence of these filled pauses in speech reflects sophisticated interpersonal coordination and theory of mind: they require the listener's understanding of the speaker's perspective, as well as the speaker's understanding of the listener's understanding of the speaker's perspective. Because social-communicative deficits are central to ASD, filler production in this population is of particular relevance, providing a window into their pragmatic functioning. Furthermore, studying filler production by individuals who have achieved OO following early ASD diagnosis will be particularly informative, as the degree of "normalization" of subtle social-communicative functions in OO is an open question. Finally, data on filler production in ASD will help to adjudicate between perspective-taking versus distributional learning accounts of filler production, given the unique profile of strengths and weaknesses in ASD.

Autism Spectrum Disorder and Optimal Outcomes

Autism Spectrum Disorder is a neurodevelopmental disorder marked by deficits in reciprocal social interaction and communication, and the presence of restricted interests and repetitive behaviors (American Psychiatric Association, 2000). Although ASD was previously considered a lifelong condition, a small but growing body of literature indicates that some children diagnosed with ASD in early childhood make significant gains over the course of development, or even lose their ASD diagnosis (Fein, Dixon, Paul, & Levin, 2005; Kelley, Naigles, & Fein, 2010; Kelley, Paul, Fein, & Naigles, 2006; Lovaas, 1987; Perry, Cohen, & DeCarlo, 1995; Sallows & Graupner, 2005; Sutera et al., 2007; for a review of optimal outcome studies, see Helt et al., 2008).

Recent studies of OO have settled on an operational definition of OO (Fein et al., 2013; Kelley et al., 2010; Sallows & Graupner, 2005; Sutera et al., 2007). An individual must no longer meet diagnostic criteria for an ASD, attend a mainstream classroom, have a full scale IQ greater than 77, receive no more than one hour per week of speech, occupational, or educational services, and have had a diagnosis before age five from an experienced clinician, documented by written report.

Utilizing these stringent criteria, several studies have compared OO, high functioning autism (HFA), and typically developing (TD) individuals, matched for chronological age, gender and nonverbal IQ, to explore whether children who have achieved OO exhibit residual deficits or persistent subtle, subclinical features of ASD. Although OO individuals demonstrate normative functioning in many domains, studies have reported residual deficits including attention problems (Fein et al., 2005; Sallows & Graupner, 2005; Zappella, 2010), impulsivity (Fein et al., 2005; Zappella, 2010), anxiety (Sallows & Graupner, 2005), tics (Zappella, 2010), mild perseverative behaviors and interests (Piven, Harper, Palmer, & Arndt, 1996), and subtle language deficits (Kelley et al., 2006; Naigles, Kelley, Troyb, & Fein, 2013).

Language in ASD and OO. Language impairments are common among people with ASD, although the severity of these impairments is heterogeneous. Approximately one third of people diagnosed with ASD never develop functional language (Tager-Flusberg et al., 2005). People with ASD who do develop functional speech reach language milestones later than their typically developing peers (Howlin, 2003; Mayo, Chlebowski, Fein, & Eigsti, 2013). Children with HFA often show delays in vocabulary and grammar (Eigsti, Bennetto, & Dadlani, 2007; Rapin, Dunn, Allen, Stevens, & Fein, 2009). These skills are, however, generally on par with TD peers later in development – at least in terms of performance on standardized language measures (Eigsti & Bennetto, 2009; Tager-Flusberg, 2001).

Evidence suggests that OO children and adolescents also have generally intact grammatical and lexical abilities (Kelley et al., 2010; Kelley et al., 2006). A study of individuals ages 8-21, which included participants from a rigorously defined OO sample (see Fein et al., 2013), found that the OO and TD groups were indistinguishable on most measures of core language skills and verbal memory (Tyson et al., 2014).

It is important to note, however, that intact performance on standardized language measures does not necessarily reflect language skills that are indistinguishable from peers. In fact, although Eigsti et al. (2007) found that children with HFA were indistinguishable from their TD peers on a standardized vocabulary measure, their spontaneous speech during a free-play session was meaningfully less complex than NVIQ-matched TD children, *and* to NVIQ-matched children with developmental delay. This discrepancy highlights the limitations of standardized language measures in capturing certain language problems, which are frequently more apparent in open-ended spontaneous speech; quantifying the latter, however, requires careful analysis.

Pragmatic language in HFA. Pragmatic language, which involves the use of language for communicating in a social context, is broadly impaired among people with HFA. Speech in ASD, for example, is often marked by atypical prosody, such as less appropriate stress patterns, nasal resonance qualities, and slower phrasing (L. D. Shriberg et al., 2001); however, these authors found that these abnormal prosodic qualities were only present in 50% of ASD subjects tested. People with ASD also use affective and grammatical prosodic cues differently than TD peers (Eigsti, Schuh, Mencl, Schultz, & Paul, 2012) and have more difficulty using these cues to resolve syntactic ambiguities (Diehl, Bennetto, Watson, Gunlogson, & McDonough, 2008). Moreover, although people with ASD tend to gesture at a normative rate (Attwood, Frith, & Hermelin, 1988; Capps, Kehres, & Sigman, 1998), these gestures are poorly synchronized with speech (de Marchena & Eigsti, 2010). Importantly, these equivocal findings highlight a broader challenge within this line of research: the quantification of pragmatic language often fails to fully capture more subtle interpersonal qualities. Indeed, abilities in ASD often appear more normalized in conditions of high structure relative to spontaneous production.

Perspective-taking in HFA. It is clinically well understood that people with HFA have difficulty accounting for their interlocutors' mental states during conversation and narrative production; the literature corroborates these clinical observations. Capps et al. (1998), for example, found that children with ASD had a number of difficulties coordinating conversation, as they more often failed to respond to questions and comments, offered fewer relevant contributions to the conversation, and produced fewer descriptions of personal experience than their TD peers. Similarly, Ozonoff and Miller (1996) found that adults with ASD performed more poorly than TD adults on measures of understanding humor, inference, and indirect requests. Paul, Orlovski, Marcinko, and Volkmar (2009) analyzed ADOS interviews and found that children with ASD have more difficulty than TD children managing conversational topics, conversational reciprocity, and gaze during conversation.

Studies have also found that people with ASD are more likely to produce ambiguous pronouns during narrative production, providing evidence of difficulty accounting for their listeners' perspective during conversation (Colle, Baron-Cohen, Wheelwright, & van der Lely, 2008). In general, people with ASD often have often have trouble with theory of mind, metacognition, and accounting for others' mental states (Happé & Frith, 1996). Relatedly, some studies have found that people with ASD tend to produce fewer mental state verbs during narrative production (Tager-Flusberg & Hale, 2005).

Pragmatic language in OO. A growing literature on individuals with OO has found that, along with other deficits, pragmatic language and social-communication deficits largely abate in OO, although some subtle deficits may remain. While Kelley et al. (2006) found that OO children ages 5-9 had poor narrative production, Suh et al. (2014) found that, later in development, these OO individuals do not differ from TD peers in general narrative structure, such as inclusion of central narrative elements. Kelley et al. (2006) also found that OO children ages 5-9 produced fewer mental state verbs during narrative production; however, follow-up studies found that by late childhood or early adolescence, these OO individuals produce mental state verbs at typical rates (Kelley et al., 2010). This normalization of mental state verb production remained consistent into adolescence (Suh et al., 2014). The authors also found that these OO adolescents did not differ from their TD peers in rates of ambiguous pronoun production (Suh et al., 2014).

A recent study revealed subtle pragmatic deficits that may linger in OO. Suh et al. (2014) found that, similar to adolescents with ASD ((Rapin & Dunn, 2003), adolescents with OO remain more likely than TD peers to use idiosyncratic or unconventional language. It was also observed that in their narrative production, ASD *and* OO individuals identified fewer goals and motivations of characters, had fewer causal explanations, and were more likely to misinterpret story events. Therefore, some residual social-communicative deficits, particularly those with more complex listener-oriented functions, appear to persist in OO.

In sum, although research finds that people with OO function in the normative range of language, social, and pragmatic abilities, early evidence suggests that some subtle areas of pragmatic language difficulty may persist despite recovery. Understanding filler production in OO may serve as a helpful marker of metacognitive abilities during discourse.

Disfluency in HFA and OO. During spontaneous speech, people with HFA are generally more disfluent than their TD peers. Plexico, Cleary, McAlpine, and Plumb (2010) found that children with ASD tend to use more "atypical" disfluencies, such as final sound repetitions (e.g. *animal—mal*) and within-word breaks (e.g. *op—e—n*), that are generally not used by TD children. Adults with HFA produce more repetitions (L. D. Shriberg et al., 2001) and silent pauses (Lake, Humphreys, & Cardy, 2011). Similarly, Suh et al. (2014) found that children and adolescents with HFA produce more repetitions and self-corrections relative to TD peers. OO individuals, however, do not produce more repetitions, though they produce more self-corrections than their TD peers.

In general, repetitions and self-corrections are thought to reflect difficulty with organizing or timing language output. As previously reported, non-filler disfluencies, such as repairs, repetitions, and unfilled pauses appear to reflect poor inhibitory control and other executive dysfunction (Engelhard et al., 2010; 2011; 2013). Studies have shown that people with ASD have poorer executive skills than their TD peers (Ozonoff, Pennington, & Rogers, 1991). It is possible, then, that executive dysfunction partially underlies the disfluent speech seen in HFA.

Fillers in HFA and OO. Although people with ASD are generally more disfluent than their TD peers, due to the unique social-pragmatic function of fillers, it follows that HFA individuals may use fillers *less* frequently than TD individuals. To date, the two studies addressing this question have yielded mixed results. Lake et al. (2011) assessed speech corpora from TD and HFA adults and found that, unlike other disfluencies, adults with HFA produced significantly fewer fillers (*um* and *uh,* which were not analyzed separately) than TD adults. This finding is consistent with evidence of broader social-pragmatic deficits common in HFA. Suh et al. (2014), however, found that neither OO nor HFA participants produced fewer fillers than TD participants during narrative production, although filler rates among the groups trended in the predicted direction.

An important open question remains: what are the mechanisms underlying reduced filler production in HFA? While social deficits may underlie this phenomenon, it is also possible that secondary factors, such as executive functions (EF), verbal fluency, or general language abilities, play an important role as well. Pragmatic language is generally contingent upon mentalizing abilities and attunement to nonverbal social cues; however, these skills are also associated with executive functions, which are also impaired in HFA (for a review, see Eigsti, de Marchena, Schuh, & Kelley, 2011). In the case of filler production, EF deficits could contribute to difficulties anticipating upcoming delays in speech, thereby hindering the use of fillers to signal these delays. Therefore, if filler production is reduced in HFA, this may be the result of executive dysfunction rather than ASD symptomology *per se*. Of note, Engelhard et al. (2010; 2011; 2013) found no association between executive functions and filler rate in either direction. Nonetheless, this question warrants additional investigation.

It is also possible that reduced filler production is associated with verbal disfluency or general language deficits, which, as discussed previously, are common among people with HFA. In the current study, we will directly examine these possible contributing factors in order to shed light on the mechanism underlying this filler underproduction.

Current Study

In the current study, we sought to examine filler production among children, adolescents, and young adults with HFA during a spontaneous speech sample under time constraint and cognitive load. Given findings that speakers produce more fillers when choosing from a larger range of expressive options (Schachter, Christenfeld, & Ravina, 1991), we used an open-ended picture description task to elicit filler production.

Due to mixed findings regarding filler production in ASD, and to help elucidate whether subtle pragmatic deficits persist among OO individuals, we examined filler differences by group. In light of evidence from the TD literature suggesting differential functions of *um* and *uh*, where *um* serves a listener-oriented function, we were particularly interested in examining the relative rates of these fillers among HFA, OO, and TD groups. Secondly, to explore underlying cognitive factors associated with filler production, we examined the associations between filler production and autism-specific social deficits (i.e. ASD symptomatology) as well as executive function, verbal fluency, and general language ability, which are also implicated in, but not unique to, HFA.

Methods

Participants

Participants included individuals between ages 8 and 21 years with a history of ASD who have achieved Optimal Outcomes (OO; $n = 24$), high-functioning individuals with a current ASD diagnosis (HFA; *n* = 24), and typically developing peers (TD; *n* = 16). The groups did not differ on age, gender, or nonverbal IQ (NVIQ), though there was a difference in verbal IQ (VIQ), with the OO and TD groups having a VIQ about 9 points higher than the HFA group. Participant data are shown in Table 1. Participants were part of a larger study of recovery from ASDs (described in Fein et al., 2013).

Table 1. *Characteristics of High-functioning Autism (HFA), Optimal Outcome (OO), and Typically Developing (TD) groups.*

	HFA	OO	TD	*F*/□^{2}	*p*	Post-Hoc	Cohen's *d*
N	24	24	16				
Sex (M:F)	21:3	19:5	14:2	□^{2} = 0.79	0.67		
Age	12.9 (2.0)	13.5 (3.6)	13.4 (1.5)	0.30	0.74		
VIQ	103.5 (13.8)	111.6 (15.0)	113.2 (12.9)	2.96	0.06	HFA < OO, TD	HFA/OO: 0.56
	81-133	80-137	99-136				HFA/TD: 0.73
NVIQ	111.1 (14.7)	110.6 (13.8)	115.1 (12.2)	0.59	0.56		
	78-147	87-134	89-139				
ADOS[a]	10.4 (3.2)	1.4 (1.6)	0.9 (1.1)	123.49	0.001	HFA < OO, TD	HFA/OO: 3.56
	7-19	0-4	0-4				HFA/TD: 3.97
SCQ, Lifetime	23.1 (6.0)	17.1 (6.1)	1.27 (1.3)	78.92	0.001	TD < OO < HFA	TD/OO: 3.59
	10-31	7-28	0-4				HFA/TD: 5.03
							OO/HFA: 0.99
BRIEF, Global EF	66.5 (9.3)	51.1 (8.4)	40.9 (6.2)	43.90	0.001	TD < OO < HFA	TD/OO: 1.38
	49-82	38-68	32-54				HFA/TD: 3.24
							OO/HFA: 0.99
D-KEFS, Cat. Flu.	10.58 (4.2)	12.9 (3.7)	11.6 (3.7)	2.14	0.13		
	3-19	7-19	7-19				
CELF, Core Lang.	99.9 (14.1)	109.9 (11.9)	119.3 (7.8)	12.0	0.001	HFA < OO < TD	HFA/OO: 0.77
	70-124	79-126	109-132				HFA/TD: 1.70
							OO/TD: 0.93

Table reports means (SDs) followed ranges
[a]ADOS : Summed social and communicative domain scores from the ADOS.

All participants had verbal, nonverbal, and full-scale IQ scores at or above the average range (SS > 77) as measured by the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999). Inclusion criteria for each group were as follows:

HFA group. Participants met current diagnostic criteria for ASD based on expert clinical judgment using DSM-IV criteria (American Psychiatric Association, 2000), confirmed using gold-standard clinical tools: the Autism Diagnostic Observation Schedule (Lord, Rutter, DiLavore, & Risi, 2002), the Autism Diagnostic Interview-Revised (Rutter, Le Couteur, & Lord, 2003), and the Social Communication Questionnaire, Lifetime Version (Rutter, Bailey, & Lord, 2003).

TD group. Participants did not meet criteria for any ASD as assessed by the ADOS, parent report on the SCQ, or clinical judgment. Participants had scores on the Communication and Socialization domains of the Vineland Adaptive Behavior Scales, Second Edition (Sparrow, Cicchetti, & Balla, 2005) that were within the normal range (SS > 77). Participants had no first-degree relatives with an ASD diagnosis. In order to avoid a hyper-normative group, however, TD children were not excluded for other learning or psychiatric disorders.

OO group. All participants were part of a larger study of Optimal Outcomes in ASD, for which children from across the U.S. and Canada were recruited in order to better understand the phenomenology of possible resolution of ASD symptoms following early intervention. Participants had to have received a diagnosis early in life (prior to age five years) from a specialist in the field of autism, focusing directly on the ASD diagnosis, and verified in a written report covering the period prior to age five. Participants in the OO group could not exhibit *current* ASD symptomatology on the basis of the ADOS or by clinical judgment. Additionally, OO participants were required to demonstrate full-scale, verbal, and performance IQ scores of 78 or above (within 1.5 SD of average), the presence of age-appropriate social and communicative skills (validated using relevant measures: Vineland-II, Clinical Evaluation of Language Fundamentals (Semel, Wiig, & Secord, 2003), Test of Language Competence (Wiig & Secord, 1989)), and participation in a regular education class without assistance.

Exclusion criteria. Participants were excluded from all groups if they exhibited symptoms of major psychopathology, severe visual or hearing impairments that would impede study participation, history of seizure disorder, Fragile X Syndrome, and significant head trauma with loss of consciousness. Two TD and 2 HFA participants were excluded due to possible seizure disorder.

Measures

As part of the larger study, participants completed a comprehensive assessment of ASD symptom severity, IQ, executive functions, and language ability. Several measures were of relevance to the current study.

Autism Diagnostic Observation Schedule (ADOS). The ADOS (Lord et al., 2002) is a semi-structured play-based assessment, and is the "gold-standard" tool for assessing and diagnosing ASD. Participants completed either Module 3 or Module 4. Trained and research reliable graduate student clinicians administered and scored the ADOS. Assessments were video recorded for review by expert clinicians.

Social Communication Questionnaire, Lifetime Version (SCQ). The SCQ (Rutter, Bailey, et al., 2003) is a 40-item parent questionnaire that screens for ASD symptoms across the lifespan rather than current ASD symptoms specifically. Higher scores indicate more severe ASD symptomatology, and scores at or above 15 suggest clinically significant ASD symptoms.

Wechsler Abbreviated Scale of Intelligence (WASI). The WASI (Wechsler, 1999) is a brief measure of verbal and nonverbal intelligence; it was used to assess cognitive abilities.

Clinical Evaluation of Language Fundamentals (CELF). The CELF (Semel et al., 2003) is a clinical measure of general language abilities. The Core Language score, which provides a composite score across all subscales, was used in the current study.

Delis-Kaplan Executive Function System (D-KEFS). The D-KEFS (Delis, Kaplan, & Kramer, 2001) is a neuropsychological test battery for assessing executive functions. The Category Fluency subtest, a speeded test of word generation, was used in the current study as a measure of verbal fluency.

Behavior Rating Inventory of Executive Function (BRIEF). The BRIEF (Gioia, Isquith, Guy, & Kenworthy, 2000) is a parent questionnaire assessing executive functions. The Global Executive Composite, which provides composite score across subscales, served as the primary measure.

Experimental task. Participants were administered a computerized dual-task paradigm. During the task, participants were instructed to tap the spacebar with their right or left index finger as rapidly as possible. The tapping hand was randomized and counterbalanced such that each participant tapped an equal number of trials with each hand. Participants completed "baseline" (tapping only) and "dual task" trails. Only the dual task trails are relevant to the current study. Participants completed a total of 6 dual task trials. Each trial was 10 seconds in length. Trial start and stop times were indicated on a computer screen with the words "Go" and "Stop." During the dual task trials, participants were instructed to describe an image presented on the computer display while tapping with an index finger. Images were oil paintings, including two portraits of individuals, two landscape scenes including humans, and two distant scenes without any individual people. Trials were videotaped for transcription and further analysis.

Procedures

All participants were tested in a quiet room at the University of Connecticut or at their homes. The University of Connecticut Institutional Review Board approved all procedures, and written consent and assent were obtained from parents and participants.

A graduate student and trained research assistants, all naïve to diagnosis, transcribed the spontaneous verbal painting descriptions. All words including fillers were transcribed. Transcribers specifically differentiated between the fillers *um* and *uh*.

Total word count (including *um* and *uh*) was tallied across the six transcribed trials. Partial words were not included in the present analysis. For each participant, *uh* and *um* totals were divided by total word count and multiplied by 100, yielding a filler-per-100 word ratio (i.e. filler rate).

Results

All data were examined to determine whether they met standard assumptions of normality. Filler rates were not normally distributed and violated assumptions of normality, according to Shapiro-Wilk tests; nonparametric tests were therefore used. Kruskal-Wallis tests were conducted for the dependent variables of interest (*uh* rate, and *um* rate) with group (TD, OO, and ASD) as an independent variable. Post hoc analyses were conducted using Mann-Whitney U tests with effect sizes calculated using Pearson's *r* (conventions for effects: small = .10, medium = .30, large = .50). The presence or absence of *um* use as a function of group was then tested via χ^2 analyses, with effect sizes calculated using Cramer's *phi* (conventions for effects: small = .10, medium = .30, and large = .50) as well as Odds Ratios (see Table 2).

Although the groups differed marginally in VIQ, because VIQ is inherently related to the independent variable (diagnostic category), VIQ was not included as a covariate (see Dennis et al., 2009). However, to ensure that age, NVIQ, and VIQ did not independently correlate with *um* rate, Pearson product-moment correlations of these variables were conducted collapsing across groups. Within-group Pearson correlations were calculated to test constructs underlying variations in filler use.

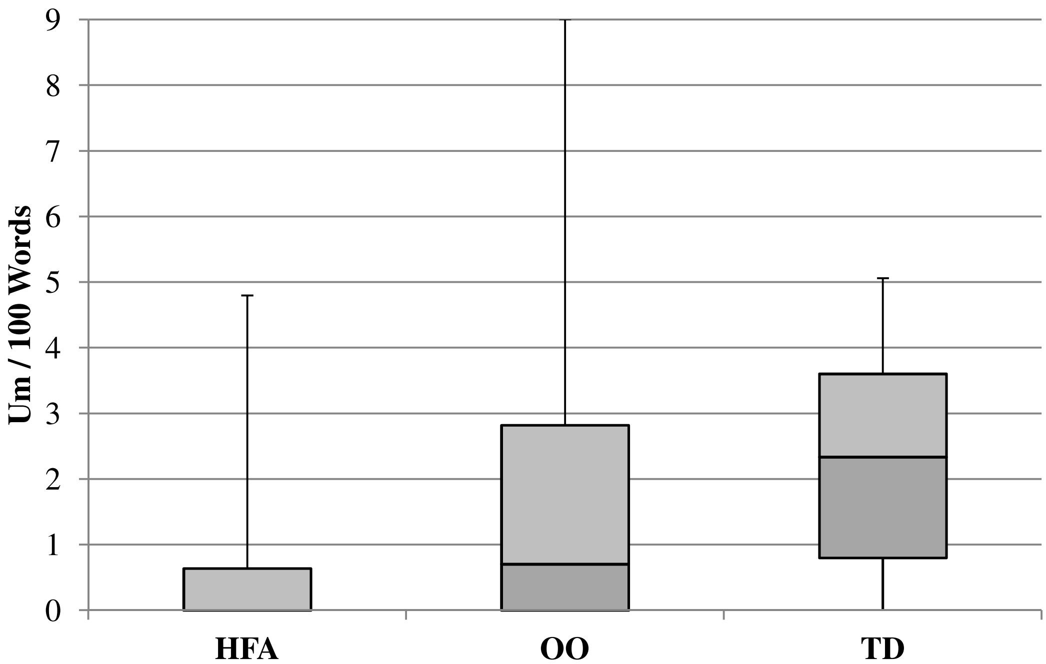
Table 2. *Uh and um group median differences for HFA, OO, and TD groups; group differences for ratios of participants who produced at least 1 um.*

	HFA	OO	TD		H/χ^2	*p*	Post-Hoc	Pearson's *r* / Odds Ratios
***Uh* Rate**					2.92	0.23		
Median	0.00	0.72	0.00					
Mean (SD)	0.48 (1.0)	0.92 (1.5)	0.91 (1.5)					
Range	0-3.6	0-7.1	0-5.1					
***Um* Rate**					10.59	0.005	HFA < OO, TD	HFA/OO: 0.34
Median	0.00	0.71	2.34					HFA/TD: 0.48
Mean (SD)	0.78 (1.5)	1.90 (2.5)	2.39 (1.7)					
Range	0-4.8	0-9.0	0-5.1					
***Um* > 0 (%)**[1]	29.2	66.7	81.3	HFA/OO:	5.34	0.021		HFA/OO OR = 4.86
				HFA/TD:	8.44	0.004		HFA/TD OR = 10.52
				OO/TD:	0.42	0.52		

[1]Um > 0 shows the proportion of participants per group who produced at least 1 *um*.

To examine *uh* and *um* rates across the three groups, Kruskal-Wallis tests were conducted with both fillers. There was no difference in *uh* rate across groups, *H* (2) = 2.92, *p* = .23. There was, however, a group difference in *um* rate, *H* (2) = 10.59, *p* = .005. Post hoc Mann-Whitney U analyses revealed that the TD group had significantly higher *um* rates (*Med* = 2.34) than the HFA group (*Med* = 0.00), *z* = -3.05, *p* = .002, *r* = .48, as did the OO group (*Med* = 0.71), *z* = -2.35, *p* = .019, *r* = .34. There was no difference between the TD and OO groups, *z* = -1.28, *p* = .20, *r* = .20 (see Figure 1).

Figure 1. *Boxplots of um rates by group.*

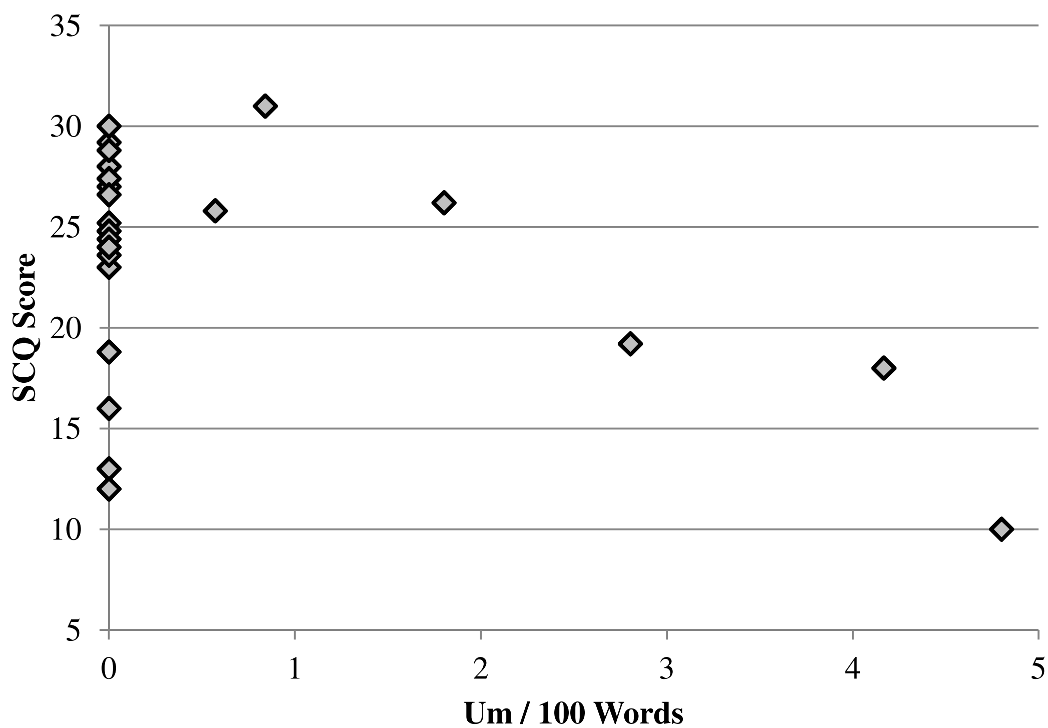


To further explore the impact of diagnosis on *um* production, *um* productions were dichotomized: *um* rate > 0 (for participants who produced *um* at least once) or *um* rate = 0. Chi-square tests for independence (with Yates Continuity Corrections) indicated a difference between HFA and TD groups, χ^2 (1, *n* = 40) = 8.44, *p* = .004, *phi* = .51, odds ratio = 10.52, and between HFA and OO groups, χ^2 (1, *n* = 48) = 5.34, *p* = .021, *phi* = .38, odds ratio = 4.86, indicating that

TD and OO participants were significantly more likely to use *um* than HFA participants. The TD and OO groups did not differ, χ^2 (1, n = 40) = .42, p = .515, *phi* = .16.

There was no significant correlation between *um* rate and age, VIQ, and NVIQ across groups, all *p*'s > .17. Analyzing groups separately, there were no correlations between *um* rate and: CELF Core Language, D-KEFS Category Fluency, or BRIEF Global Executive Composite, all *p*'s > .39. For both TD and OO groups, *um* rate and SCQ score were uncorrelated, *p*'s > .34. For the HFA group, there was, a negative correlation between *um* rate and SCQ score, r = -.45, n = 24, p = .03, such that lower *um* rate was associated with higher ASD symptomatology. These data are shown as a scatterplot in Figure 2. These results suggest that lower *um* production in HFA relates directly to core social-pragmatic defects rather than factors that may impact fluency, such as general language or executive function abilities.

Figure 2. *SCQ Score by Filler Rate in HFA participants. Scores > 15 indicate clinically significant ASD symptomology.*



Discussion

This study evaluated filler production during spontaneous speech in individuals with HFA, OO, and typical development. There were two primary goals: to examine rates of *uh* and *um* production as a function of group and to test whether filler production is driven by social-communicative factors or by general cognitive factors (executive functions, verbal fluency, and general language ability). Together, these inquiries help to address the question of whether a primary determinant of filler production is a bottom-up, distributional process (in which case, individuals with ASD would be unlikely to show reduced filler production), or top-down, social-pragmatic processes (in which case, individuals with ASD would be likely to show reduced filler production).

With regard to the first question, HFA, OO, and TD participants did not differ in their production of *uh*. HFA participants did, however, produce *um* less frequently than both their TD and OO peers: HFA participants were approximately 10 times less likely to use *um* than their TD peers, and 5 times less likely to use *um* than their OO peers. These results expand prior findings that HFA individuals produce more fillers in general (Lake et al., 2010). Because individuals with HFA are less able to constrain their discourse to meet social goals, these findings provide further support for the hypothesis that *um* serves a particularly social-communicative, listener-oriented function — filling a pause with *um* is specifically for the benefit of the listener.

The greater frequency of *um* production in OO versus HFA individuals, at rates comparable to TD, suggests that *optimal outcomes are marked by normalization of listener-oriented cues during spontaneous speech*. Because filler production during discourse appears to be a byproduct of accounting for the interlocutor's perspective, the normalization of filler production in OO reflects a fundamental improvement in social attunement. In other words, this finding likely reflects the broader normalization of social-pragmatic abilities in OO.

Interestingly, however, Suh et al. (2014) found no differences in filler production among HFA, TD, and OO groups during a narrative production task, although the differences between the groups trended in the expected direction. This inconsistency is particularly puzzling given the significant participant overlap between Suh et al. (2014) and the present study. One possible explanation for these discrepant findings relates to task demands. In Suh et al. (2014), participants were not under time constraint nor cognitive load when generating their narratives; in the present study, however, participants were under time constraint and cognitive load – they had only ten seconds to complete each description and were required to tap rapidly while speaking. Moreover, in Suh et al. (2014), participants constructed narratives from a sequence of related images; in the present study, by contrast, participants produced descriptions of discrete paintings that were unrelated to each other, thereby necessitating that participants process the unique content of each painting before generating a description. At least one study has found that speakers do in fact use more fillers when choosing from a larger range of expressive options (Schachter et al., 1991). Whereas TD individuals in Suh et al. (2014) produced few fillers (1.03 fillers per 100 words on average), raising the possibility of floor effects, task demands in the present study presumably heightened speech planning and production difficulties, thereby increasing the production of fillers.

In addition, we found that executive functions, verbal fluency, and general language ability were not associated with filler rate, despite significant variability across these variables within groups. For the HFA group, however, greater ASD symptomatology was associated with reduced *um* production. These findings are consistent with Engelhardt et al. (2010; 2011; 2013), who found no differences in filler production for adults with ADHD or higher levels of impulsivity as compared to controls, though they did find that these executive functions were associated with repetitions and repair disfluencies. These findings suggest that reduced *um* production in HFA is unrelated to executive abilities; rather, the spontaneous use of *um* during discourse reflects core social skills rather than language or executive skills. The use of *um* in spontaneous speech may therefore serve as a specific marker of pragmatic skills.

There are at least two potential explanations for the association between ASD symptomatology and reduced *um* production. First, because people with ASD do not normatively attend to social cues early in development, it is possible that they fail to develop an implicit understanding of the social "meaning" of fillers. Reduced filler production, then, would be due to generally poor awareness of interpersonal cues, including fillers. A second possibility is that people with ASD *do* understand the social meaning of fillers in conversation but, due to problems with interpersonal coordination, have difficulty employing these cues to meet social goals. Future research could explore these questions by investigating whether fillers influence language comprehension in ASD. Paradigms similar to those previously described, which used anticipatory looking to demonstrate that typically developing individuals utilize fillers to predict speakers' referential intentions (Arnold et al., 2003; Arnold et al., 2007; Kidd et al., 2011), could be used to investigate this phenomenon in ASD. If people with ASD anticipate novel referents when hearing filler, this would suggest that people with ASD implicitly grasp the social meaning of fillers, but are unable to use them effectively to help manage discourse; if people with ASD do not anticipate novel referents when hearing a filler, however, this would suggest that they do not implicitly grasp the social meaning of fillers.

Limitations

There are several limitations of the current study. First, the spontaneous speech samples in this study were monologues. Although they were in the presence of an interlocutor (the experimenter), participants generated monologic descriptions while being video-recorded rather than engaging in face-to-face dialogue. Studies have, however, reported the presence of *uh* and *um* in both dialogues and monologues (Clark et al, 2002; Fox Tree, 1999). In addition, because the social demands of this task were decreased relative to a two-way conversation, the task should have *advantaged* the HFA group. As such, the current study may provide a particularly sensitive index of filler production.

Moreover, speech samples in the present study were brief (60 seconds). Although findings were robust, with medium to large effect sizes, additional studies examining filler production in longer samples of spontaneous speech would help clarify whether results are representative of everyday language production. In addition, the HFA sample included only people with high functioning ASD. As such, findings may not generalize to the full spectrum of ASD. Finally, the OO individuals were not evaluated longitudinally; early ASD diagnosis was confirmed based upon prior records. Therefore, we cannot distinguish between alternative explanations that the OO participants' normalization of *um* production either occurred concurrently with symptom remediation, or that normal *um* use was present from the outset. A longitudinal study design is needed to address this question.

Conclusion

In summary, these findings shed new light on the role of fillers – specifically, *um* – in speech production. The finding that people with HFA do not produce *um* at a normative rate, and that in this population, reduced *um* production is associated with greater ASD symptomatology, provide unequivocal evidence that the use of *um* in spontaneous speech has social-communicative roots. These findings contribute to our understanding of the speech idiosyncrasies that characterize ASD – *underproduction* of fillers likely plays a significant role in making the speech of individuals with ASD less comprehensible and fluid. This helps to clarify a hitherto puzzling fact that, while clinicians report a consistent and nearly universal sense of prosodic impairments in ASD, careful quantification of the acoustic qualities of speech in ASD indicates that only 50% show measurably impaired prosody (L. D. Shriberg et al., 2001). Clearly, the lack of *um* in speech would not be measured in such analysis. Moreover, the normative frequency of production of these subtle, listener-oriented *ums* in OO, along with prior findings of normative pragmatic language, suggests a fundamental normalization of social-communication in this population, providing further evidence of true recovery from ASD.

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