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ORIGINAL PAPER

Uh, *Um*, and Autism: Filler Disfluencies as Pragmatic Markers in Adolescents with Optimal Outcomes from Autism Spectrum Disorder

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Abstract Filler disfluencies—*uh* and *um*—are thought to serve distinct discourse functions. We examined fillers in spontaneous speech by youth with autism spectrum disorder (ASD), who struggle with pragmatic language, and by youth with ASD who have achieved an 'optimal outcome' (OO), as well as in peers with typical development (TD). While *uh* rates did not differ, participants with ASD produced *um* less frequently than OO or TD groups. *Um* rate was associated with autism symptom severity, but not executive function or language abilities, suggesting that *um* serves a pragmatic, listener-oriented function. Moreover, in contrast to minimal production in ASD, the typical OO *um* production substantiates the normalization of subtle social communication in this population.

Keywords Autism · Optimal outcomes · Pragmatics · Discourse · Disfluency · Fillers

Introduction

Disfluencies, such as repetitions, self-corrections, silent pauses, and filled pauses, are frequent in spontaneous speech, particularly when a speaker has difficulty planning an utterance (Clark and Fox Tree 2002). In general, disfluency reflects difficulty in organizing, timing, and monitoring language output; see Griffin and Spieler (2006) for a detailed review. Disfluencies, including repetitions and self-corrections, have been linked to executive functions such as inhibitory control (Engelhardt et al. 2011, 2013). Not *all* disfluencies, however, are associated with executive dysfunction: filled pauses, or filler disfluencies, are *not* correlated with cognitive load or executive dysfunction (Engelhardt et al. 2011, 2013). In fact, fillers—*um* and *uh*—are thought to serve distinct pragmatic functions (Clark and Fox Tree 2002). Given that pragmatic language impairment is central to autism spectrum disorder (or ASD; Shriberg et al. 2011), the current study aimed to explore filler production among individuals with autism spectrum disorder (ASD), and those who have achieved 'optimal outcomes' (OO) from ASD. In the current study, we examined filler production by youth with ASD and OO, as compared to youth with typical development (TD). We also investigated the association between filler rates, autism symptom severity, and general cognitive and language abilities, to illuminate the processes implicated in filler production.

Fillers

Fillers appear to be a nearly universal feature of language. *Uh* and *um* are the most common fillers in American English; *eh* is a produced frequently in Swedish, Norwegian, Spanish, French, and Hebrew. Indeed, the most frequent vowel sounds in the lexicon for a given language's generally correspond with the vowel sounds in that language's fillers (Shriberg 1994).

Saying *uh* or *um* affords a momentary halt in speech, offering time for speech planning and production. This momentary delay could otherwise be achieved with a silent

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pause. Why, then, do speakers fill their pauses? It has been shown that *uh*s and *um*s are more than vocal artifacts: they communicate information about discourse itself. Speakers use fillers to signal intent to hold the conversational floor (Maclay and Osgood 1959), convey uncertainty and equivocation (Brennan and Williams 1995), or announce momentary delays in speech for utterance planning (Clark and Fox Tree 2002) and word-finding (Goodwin and Goodwin 1986).

Multiple findings support the hypothesis that fillers serve a pragmatic function. When conversing on the telephone, people produce more fillers than in face-to-face discourse (Oviatt 1995), suggesting that, when nonverbal cues such as gesture and eye contact are unavailable, speakers rely more heavily on the use of *uhs* and *ums* to coordinate discourse. Oviatt (1995) also found that speakers produce more fillers when speaking to a human audience than to a machine audience (i.e., voice recognition software). This increased filler rate in the presence of 'mindful' or conscious interlocutors suggests that fillers are produced at least in part for the benefit of the listener. This account is consistent with the finding that people giving instructions produce more fillers than those following instructions (Bortfeld et al. 2001).

Although most studies to date have collapsed *uh* and *um* into a single category of disfluency, these fillers tend to appear in complementary distribution and to be produced in different grammatical contexts, suggesting that they may serve distinct functions. Many languages, in fact, contain two types of fillers: one filler consisting only of a vowel, and one including a nasal (i.e., *m* and *n*), which allows the speaker to extend the length of the filled pause indefinitely (Shriberg 1994). While both fillers signal a speech delay, *uh* typically precedes shorter delays, while *um* generally precedes longer ones (Clark and Fox Tree 2002; Smith and Clark 1993). Furthermore, *uh* is produced more often within utterances, whereas *um* is produced more often at utterance boundaries (Clark and Fox Tree 2002). This study measured *uh* and *um* separately to test whether they differ in terms of self-regulatory versus communicative functions.

Studies also suggest that fillers affect speech comprehension. When listeners hear *uh* or *um*, they are more likely to look at referents that are new to the discourse (Arnold et al. 2003) or that are difficult to describe (Arnold et al. 2004, 2007). Such anticipation effects have been reported for children as young as 2 years (Kidd et al. 2011). While it is possible that these anticipation effects are due to the pragmatic function of fillers, it is also possible that these effects may merely reflect statistical learning and do not necessitate perspective taking. To address these two hypotheses, Arnold et al. (2007) tracked eye movements while participants heard fluent versus disfluent speech. In some cases, they were told that the speaker had impaired object recognition. On those trials, participants did not make anticipatory eye movements towards novel referents after hearing fillers, presumably because they inferred that the speaker's impairments would make fillers less indicative of referent novelty and more indicative of difficulty labeling objects. Similarly, changing the identity of the speaker decreases the presence of anticipatory eye movements for discourse-new referents (Barr and Seyfeddinipur 2010), suggesting that listeners assess discourse novelty from the *speaker's* perspective, providing further evidence that fillers have a pragmatic function. Taken together, these studies suggest that interlocutors (e.g. conversational partners) use fillers to comprehend and manage discourse, and to communicate and parse mental-state information. The effective use of *uh* and *um* therefore requires a speaker to consider the listener's perspective while constructing an utterance. Perspective-taking is an area of particular difficulty for people with ASD.

Disfluency in Autism Spectrum Disorder

ASD is a neurodevelopmental disorder marked by deficits in reciprocal social interaction and communication (American Psychiatric Association 2000). Pragmatic language is broadly impaired in ASD, and atypical prosody, including disfluencies affecting the rhythm of speech, is a core feature, with increased rates of repetition and self-correction (Shriberg et al. 2001; Suh et al. 2014), and silent pauses (Lake et al. 2011). Speech in ASD can also be marked by 'atypical' disfluencies that are uncommon outside of the disorder, including sound repetitions and within-word breaks (Plexico et al. 2010).

Filler Production in ASD

Although individuals with ASD are generally more disfluent, the pragmatic account of filler disfluencies would lead one to expect fewer fillers in ASD. To our knowledge, only two studies to date have probed this inconsistency. One study found results consistent with the reduced-filler prediction: analysis of a large speech corpus found that adults with ASD produced significantly fewer fillers relative to adults with TD (Lake et al. 2011).

Optimal Outcomes

Although ASD was previously considered a lifelong condition, a growing body of literature indicates that some 8–25 % of children diagnosed with ASD in early childhood make such significant gains over the course of development that they lose their ASD diagnosis, achieving an 'optimal outcome' (OO) from ASD (Fein et al. 2013; for a review of optimal outcomes, see Helt et al. (2008). Studies of OO suggest that most pragmatic language deficits are completely resolved, although some persist at least through early development. A study of young OO children ages 5–9 reported pragmatic language deficits during narrative production, such as providing fewer causal explanations and character motivations, and misinterpreting story events (Kelley et al. 2006). In contrast, an older group of OO children (ages 8–13, including many who also participated in the 2006 sample) showed no pragmatic deficits on standardized language measures (Kelley et al. 2010). Moreover, during spontaneous narrative production, OO and TD groups did not differ in ambiguous pronoun production, and produced fewer ambiguous pronouns than their ASD peers (Suh et al. 2014). However, participants with ASD and OO used more idiosyncratic language. Therefore, some pragmatic deficits, particularly those relating to spontaneous narrative production, appear to persist in OO.

Suh et al. (2014) also examined disfluency in OO during the narrative task. There was significant participant overlap between Suh et al.'s sample and that of the current study. Like their peers with ASD, OO individuals produced more self-corrections than TD individuals; however, unlike their peers with ASD, OO individuals did not produce more repetitions. There were no group differences in filler production, among any of the three groups. As described below, the narrative task in Suh et al.'s study may have minimized filler production. Furthermore, in the two studies that have measured filled pause production in ASD (Lake et al. 2011; Suh et al. 2014), neither contrasted *uh* and *um* production.

Current Study

In the current study, we examined filler production by youth with ASD, OO, and TD, during a spontaneous speech sample produced under cognitive load. Speakers produce more fillers when discourse is more difficult (Arnold et al. 2004, 2007) and when their task is less constrained, with a larger range of expressive options (Schachter et al. 1991). Suh et al.'s narrative elicitation task was untimed; participants were asked to generate a narrative from a picture book. In contrast, our open-ended picture description task was used to elicit speech under constrained conditions (the requirement to describe a particular image), in a timed fashion, and under an additional cognitive load.

This study had two primary goals. First, we sought to evaluate the unique frequencies of both *uh* and *um* for ASD, OO, and TD participants. Given the evidence that fillers, and particularly um, are pragmatic in nature, we hypothesized that ASD participants would produce *uh* and *um,* particularly *um,* less frequently than their TD peers. Further, we were particularly interested in filler production in OO, as the degree of 'normalization' of subtle pragmatic language abilities in OO remains an open question. A second goal was to explore the mechanisms associated with filler production by probing correlations among filler production and ASD symptomatology and executive functions (including verbal fluency), as well as general language ability. Given the pragmatic account of fillers, we hypothesized that *uh* and *um* production would correlate with core ASD symptomatology *per se* rather than executive functions or language ability.

Methods

Participants

Participants included individuals between 8 and 21 years with a history of ASD who achieved optimal outcomes (OO; $n = 24$); high-functioning individuals with a current ASD diagnosis (ASD; $n = 24$); and individuals with a history of typical development (TD; $n = 16$). The groups did not differ on age, gender, and nonverbal IQ (NVIQ). Mean verbal IQ (VIQ) of the OO and TD groups was marginally higher than the ASD group. All participants had verbal, nonverbal, and full-scale IQ scores at or above the average range (Standard Scores >77). Participant data are shown in Table 1. All participants were part of a larger study of OO (Fein et al. 2013).

OO Group

Participants in the OO group had to have received a diagnosis prior to age 5 years from a specialist in the field of autism, focusing directly on the ASD diagnosis and verified in a written report. OO participants could not exhibit current ASD symptomatology on the basis of the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2002) or by clinical judgment. In addition to IQ scores in or above the average range, OO participants were required to demonstrate the presence of age-appropriate social and communication skills, operationalized as scores on the Communication and Socialization domains of the Vineland Adaptive Behavior Scales, Second Edition (Vineland-II; Sparrow et al. 2005) that were within the normal range (Standard Scores >77), and participation in general education classes.

ASD Group

Participants in the ASD group met DSM-IV-TR criteria for pervasive developmental disorders (Autistic Disorder, $n = 12$; Pervasive Developmental Disorder—Not Otherwise Specified, $n = 12$) based on expert clinical judgment

Table 1 Descriptive characteristics for autism spectrum disorder (ASD), optimal outcome (OO), and typically developing (TD) groups

	ASD	OO	TD	F/χ^2	*p*	Post-hoc	Cohen's *d*
N	24	24	16				
Sex gender (M:F)	21:3	19:5	14:2	0.79	0.67		
Age	12;10	13;6	13;4	0.30	0.74		
	(2.4)	(4.3)	(1.8)				
	9;0–16;4	8;6–21;2	9;10–15;7				
VIQ[a]	103.5	111.6	113.2	2.96	0.06	ASD < OO, TD	ASD/OO: 0.56
	(13.8)	(15.0)	(12.9)				
	81–133	80–137	99–136				ASD/TD: 0.73
NVIQ[b]	111.1	110.6	115.1	0.59	0.56		
	(14.7)	(13.8)	(12.2)				
	78–147	87–134	89–139				
ADOS[c]	10.4	1.4	0.9	123.49	0.001	ASD < OO, TD	ASD/OO: 3.56
	(3.2)	(1.6)	(1.1)				
	7–19	0–4	0–4				ASD/TD: 3.97
SCQ lifetime[d]	23.1	17.1	1.27	78.92	0.001	TD < OO < ASD	TD/OO: 3.59
	(6.0)	(6.1)	(1.3)				ASD/TD: 5.03
	10–31	7–28	0–4				OO/ASD: 0.99
BRIEF global EF[e]	66.5	51.1	40.9	43.90	0.001	TD < OO < ASD	TD/OO: 1.38
	(9.3)	(8.4)	(6.2)				ASD/TD: 3.24
	49–82	38–68	32–54				OO/ASD: 0.99
D–KEFS Cat. Flu.[f]	10.58	12.9	11.6	2.14	0.13		
	(4.2)	(3.7)	(3.7)				
	3–19	7–19	7–19				
CELF Core Lang.[g]	99.9	109.9	119.3	12.0	0.001	ASD < OO < TD	ASD/OO: 0.78
	(14.1)	(11.9)	(7.8)				ASD/TD: 1.70
	70–124	79–126	109–132				OO/TD: 0.93

Data are shown as mean, SD, and range

[a] VIQ: Stanford-Binet Verbal IQ, Standard Score

[b] NVIQ: Stanford-Binet Nonverbal IQ, Standard Score

[c] Summed social and communicative domain scores from the ADOS; higher scores indicate greater severity. On the ADOS, 7 is the cutoff for an ASD

[d] SCQ = Social Communication Questionnaire, Lifetime severity score; higher scores indicate greater severity. A score of 15 is recommended as the threshold for ASD (Rutter et al. 2003)

[e] BRIEF: The BRIEF (Gioia et al. 2000) parent questionnaire for executive functions generates a Global Executive Composite score; higher scores indicate greater impairment

[f] D–KEFS: Delis–Kaplan Executive Function System (Delis et al. 2001), Category Fluency subtest

[g] CELF: Comprehensive Evaluation of Language Fundamentals, 4th Edition, Core Language Score

using DSM-IV-TR criteria (American Psychiatric Association 2000). Diagnosis was confirmed using the ADOS (Lord et al. 2002). Early language delay (no words by 18 months or no phrases by 24 months) was required for inclusion, and no participants met formal diagnostic criteria for Asperger's disorder.

TD Group

Participants in the TD group could not meet criteria for any ASD based on the ADOS, parent report on the Social Communication Questionnaire (SCQ; Rutter et al. 2003), or clinical judgment. Participants had no first-degree relatives with an ASD diagnosis. In order to avoid a hyper-normative group, TD children were not excluded for learning disorders.

Exclusion Criteria

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

Measures

Participants completed a comprehensive assessment of ASD symptom severity, IQ, executive functions, and language ability, as well as an experimental task, as part of a larger study of OO (Fein et al. 2013). The following measures were of relevance to the current study:

- The *Autism Diagnostic Observation Schedule* (ADOS; Lord et al. 2002) is a semi-structured play-based assessment, and is the gold-standard tool for diagnosing ASD. Participants completed either Module 3 or Module 4, and it was administered and scored by trained and research-reliable graduate student clinicians. Assessments were digitally recorded for later review by expert clinicians.
- The *Social Communication Questionnaire*, *Lifetime Version* (SCQ; Rutter et al. 2003) is a parent questionnaire that screens for ASD symptoms across the lifespan. Higher scores indicate more severe ASD symptomatology.
- The *Wechsler Abbreviated Scale of Intelligence* (WASI; Wechsler 1999) is a brief measure of verbal and nonverbal intelligence; it was used to assess cognitive abilities.
- The *Clinical Evaluation of Language Fundamentals* (CELF; Semel et al. 2003) Core Language Score provides a clinical measure of general language abilities.
- The *Delis–Kaplan Executive Function System* (D–KEFS; Delis et al. 2001) is a neuropsychological battery for assessing executive functions. The Category Fluency subtest, in which participants list as many words as possible that fit in a semantic category, was used as a measure of verbal fluency.
- The *Behavior Rating Inventory of Executive Function* (BRIEF; Gioia et al. 2000) is a parent questionnaire; the Global Executive Composite score was used as a measure of executive functioning.

Experimental Task

Participants completed a computerized dual-task paradigm in which they were instructed to tap a key with their index finger (reanalysis of data presented in Fitch et al. 2015). Unlike some tasks involving tapping, participants were not asked to synch their tapping with any external stimulus; rather, they were simply asked to tap as quickly as possible. Tapping hand (right, left) was randomized and counterbalanced; each participant tapped an equal number of trials with each hand.

Participants completed ten baseline tapping-only and six dual task trials. Only the dual task trials are relevant for the current study. Each trial lasted 10 s; the words 'Go' and 'Stop' served as start and stop signals. During dual task trials, participants were instructed to describe each of six paintings (presented on the computer display) to the experimenter while simultaneously tapping their right index finger. There were two practice trials to insure comprehension of the procedure. Graduate student experimenters administered the task and served as the audience for the participants' painting descriptions. Trials were videotaped for transcription and later analysis. Sample transcripts of painting descriptions, and the painting, are provided in Fig. 1.

Procedures

The University of Connecticut Institutional Review Board approved study procedures, and written consent and assent were obtained from parents and participants. Testing took place either at the participant's home or at the University of Connecticut.

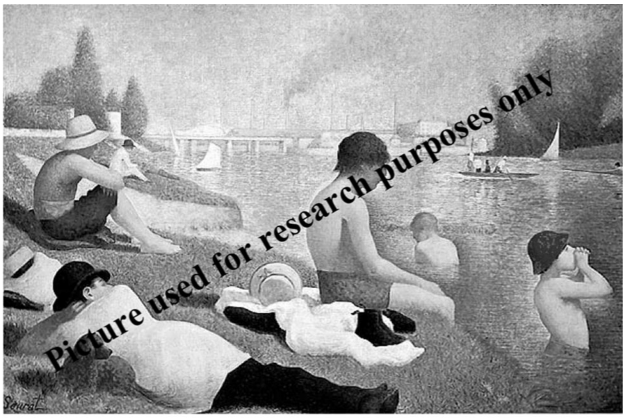
Transcription and Reliability

Three trained transcribers (the first author and two trained research assistants, all naïve to diagnosis) transcribed participants' painting descriptions. All words and fillers were transcribed. Transcribers specifically differentiated between the fillers *uh* and *um*. *Uh* and *um* count, as well as total word count (including fillers), were tallied across the six transcribed trials for each participant. Partial words were not included. Filler totals were divided by total word count and multiplied by 100, yielding *uh* and *um* ratio scores for each participant.

Two additional trained research assistants re-transcribed 16 of the 64 descriptions (25 %). Because filler ratio scores were continuous variables, intraclass correlations (ICC) were used to calculate interrater reliability for *uh* and *um* rates, using average-measures ICC, with an "absolute agreement" definition (Shrout and Fleiss 1979). As transcribers varied across participants, we used a "one-way random," ICC (1) model. Reliability was excellent: ICC (1,2) = .94 for *uh*; ICC (1,2) = .98 for *um*.

Results

All data were evaluated for standard assumptions of normality. Filler rates were not normally distributed and violated assumptions of normality, per Shapiro–Wilk tests, so



ASD: *There's people sitting at a beach or next to a lake and there pe* some people are swimming some people are sitting and sunbathing*

OO: *Um there's these swimmers swimming in um the ocean with all these ships and the people*

TD: *Um it's a bunch of people at the beach there's some boats on the water and um some people are in the water as well they're sitting*

Fig. 1 One of the six paintings *(Bathers atAsnieres*; Georges Seurat) that participants were asked to describe for 10 s, along with sample descriptions from an individual with autism spectrum disorder (ASD), optimal outcome (OO), and typical development (TD). *Asterisks* indicates a self-interruption

nonparametric tests were used. Kruskal–Wallis tests compared the variables of interest (*uh* rate and *um* rate) with group (TD, OO, and ASD) as an independent variable. Post hoc analyses used Mann–Whitney *U* tests; effect sizes were calculated with rank-biserial correlation (*r*; conventions for effects: small = .10–.29, medium = .30–.49, large = .50–1). The presence or absence of *um* as a function of group was tested via χ^2 analyses, with effect sizes calculated using Odds Ratios (*OR*). Although groups differed marginally in VIQ, because VIQ is inherently related to diagnostic category, it was not included as a covariate (see Dennis et al. 2009). To ensure that age, NVIQ, and VIQ did not independently correlate with *um* rate, correlations were tested across groups. Within-group Pearson correlations were calculated to test mechanisms underlying variations in filler use.

Kruskal–Wallis analyses indicated no group differences in *uh* rate, H (2) = 2.92, $p = .23$. However, the groups differed in *um* rate, H (2) = 10.59, $p < .01$. Mann–Whitney *U* analyses indicated that the OO group (*Mdn* = 0.7) produced *um* significantly more frequently than the ASD group (*Mdn* = 0.0), $U = 182.5$, $p < .05$, with a medium effect size ($r = .34$); the TD versus ASD group comparison was also significant (*Mdn* = 2.3), $U = 88.5$, $p < .01$, with a medium effect size ($r = .48$). The TD and OO groups did not differ, $U = 146.0$, $p = .20$, with a small effect size ($r = .20$). Data are shown in Table 2 and Fig. 2.

To further explore group differences, *um* production was dichotomized: *um* rate >0 (for participants who produced at least one *um*) or *um* rate = 0. *Uh* production was dichotomized as well (uh rate >0, uh rate = 0). Chi square tests indicated no difference in *uh* production among ASD, OO and TD groups, χ^2 (2, $N = 64$) = 3.10, $p = .21$. There was, however, a difference between ASD and OO groups, χ^2 (1, $N = 48$) = 5.34, $p < .05$, $OR = 4.86$, and ASD and TD groups, χ^2 (1, $N = 40$) = 8.44, $p < .01$, $OR = 10.52$. Both TD and OO participants were significantly more likely to say *um* than ASD participants. The TD and OO groups did not differ, χ^2 (1, $N = 40$) = .42, $p = .52$. Data are shown in Table 2.

There were no significant correlations between *um* rate and age, VIQ, or NVIQ across groups, all *ps* > .17. Analyzing groups separately, *um* rate was not correlated with CELF Core Language, D–KEFS Category Fluency, or BRIEF Global Executive Composite scores, all *ps* > .39. For both TD and OO groups, *um* rate and SCQ score were uncorrelated, *ps* > .34. For the ASD group, *um* rate and SCQ scores were correlated, $r = -.45$, $n = 24$, $p < .05$, such that lower *um* rate was associated with greater ASD symptomatology, as shown in Fig. 3. These results suggest that reduced *um* production in ASD relates to core pragmatic defects, rather than factors that may impact fluency, such as executive function or general language abilities.

Discussion

This study examined the production of fillers in spontaneous speech among individuals with high-functioning ASD, optimal outcomes, and typical development. There were two primary goals: to test for group differences in the frequency of *uh* and *um* production and to probe possible factors underlying filler production, including social, executive, and general language abilities. Given the pragmatic role that fillers play, ASD participants were expected to produce *uh* and *um* (particularly *um*) less frequently than their TD peers, and *uh* and *um* production were expected to correlate with ASD symptomatology *per se* rather than executive functions or language ability. Results supported these hypotheses.

Although there were no group differences for *uh* production, the ASD participants produced significantly fewer *um*s than their TD and OO peers, and were also less likely to produce *um* at all (11 times less likely then TD peers, and 5 times less likely than OO peers). This finding is consistent with a report by Lake et al. (2011), and substantiates prior research suggesting that fillers are unique among disfluencies, serving a pragmatic, listener-oriented function. Given that people with ASD are generally less able to account for their listener's perspective and constrain their discourse to meet social goals (Colle et al. 2008; Paul et al. 2009), it is consistent that they utilize this filler as a pragmatic conversational cue less frequently than their TD peers.

Table 2 Median and mean *uh* and *um* rates (per 100 words), and odds ratios for participants who produced at least 1 uh or at least 1 um, as a function of group

	ASD	OO	TD		H/χ^2	p	Post-hoc	r/OR
Uh rate					2.92	0.23		
Median	0.00	0.72	0.00					
Mean	0.48	0.92	0.91					
SD	(1.0)	(1.5)	(1.5)					
Range	0–3.6	0–7.1	0–5.1					
Uh > 0 (%)[a]	29.2	54.2	43.8	ASD/OO/TD:	3.10	0.21		
Um rate					10.59	<0.01	ASD < OO, TD	ASD/OO[b]: 0.34
Median	0.00	0.71	2.34					ASD/TD[b]: 0.48
Mean	0.78	1.90	2.39					
SD	(1.5)	(2.5)	(1.7)					
Range	0–4.8	0–9.0	0–5.1					
Um > 0 (%)[a]	29.2	66.7	81.3	ASD/OO:	5.34	<0.05		ASD/OO[c]: 4.86
				ASD/TD:	8.44	<0.01		ASD/TD[c]: 10.52
				OO/TD:	0.42	0.52		

[a] The percentage of participants per group who produced at least 1 *uh* or at least 1 *um*

[b] Point-biserial correlation (r) effect sizes

[c] Odds ratios (OR)

It was particularly interesting that this pattern applied specifically to *um*. Because *uh* and *um* appear in complementary distribution, speakers may use them to convey distinct information. *Um* has a more marked phonological construction than *uh*, which is produced with a 'reduced' schwa (see Clark and Fox Tree 2002). In essence, *um* may be more deliberately produced and reflect more explicit discourse meanings than *uh*. Consistent with this suggestion, the current findings indicate that *uh* serves a self-directive, inward-oriented function, whereas *um* serves a communicative, listener-oriented function. In other words, these results could be taken as evidence that filled *uh* pauses are produced to serve a speaker's needs, whereas filled *um* pauses are produced specifically for the benefit of a listener.

Despite substantial participant overlap, the current study findings contrast with a prior report from Suh et al. (2014), which used a narrative task. Although filler rates in Suh et al. (2014) trended in the expected direction, with OO and TD participants producing more fillers than those with ASD, this difference did not reach statistical significance. One possible explanation for the discrepancy is differing task demands. In the previous study, participants generated a narrative from a picture book without additional cognitive load or time constraint. In the current study, by contrast, participants freely produced descriptions of six discrete unrelated images under mild cognitive load (tapping the index finger as rapidly as possible) and time constraint. At least one study has found that speakers produce more fillers when choosing from a larger range of expressive options due to less constrained task parameters (Schachter et al. 1991). It is therefore possible that the task in the current study more robustly elicited fillers, and that floor effects contributed to the lack of group differences found previously. Buttressing this explanation, filler rates even in the TD group were quite low in Suh et al. (2014), with 1.03 fillers per 100 words; there was a threefold increase in fillers (3.30 fillers per 100 words) in the current study, possibly reflecting the greater cognitive demand.

The current study elucidates not only the use of *um* in spontaneous speech among individuals with ASD, but also those who have achieved an optimal outcome. The greater frequency of *um* production in OO, at rates comparable to TD, suggests that *optimal outcomes are marked by the normalization of subtle listener-oriented pragmatic cues during spontaneous speech*. This finding contributes to the current literature suggesting a broader normalization of language abilities in OO, particularly in the pragmatic domain.

An evaluation of a possible mechanism underlying filler production indicated that domain-general cognitive processes did not drive individual differences in filler production. Executive functions broadly, including verbal fluency specifically, as well as general language ability, were not associated with *um* rate in any group, despite significant within-group variability. This finding is consistent with Engelhardt et al. (2011, 2013), who found no association between executive dysfunction and filler production, despite an association with other disfluencies. In contrast, greater ASD severity was associated with reduced

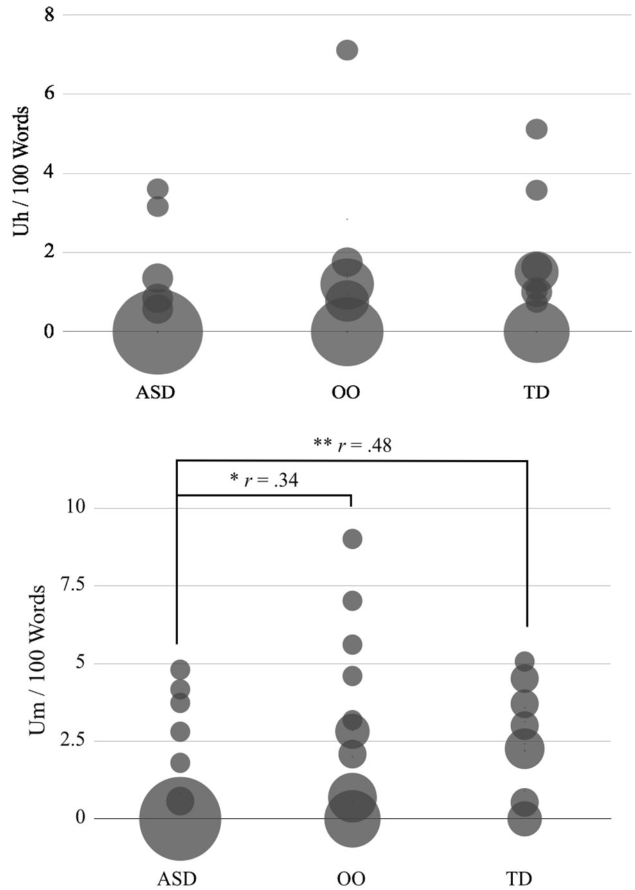


Fig. 2 Mean Uh (*above*) and Um (*below*) rates by autism spectrum disorder (ASD), optimal outcome (OO), and typically developing (TD) groups. Circle size corresponds to number of participants at a given rate; the smallest circles represent a single participant

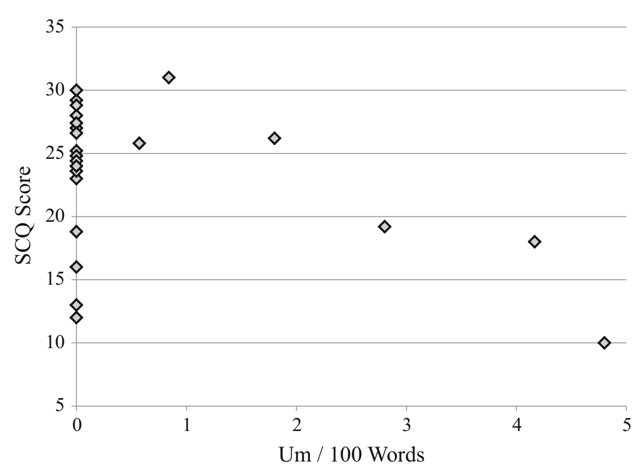


Fig. 3 Association between autism severity (SCQ score) and *um* rate within the ASD group. A cutoff score of 15 is recommended as an indication of a possible ASD (Rutter et al. 2003); higher scores indicate greater severity. All ASD participants, except three, were above this cutoff; these three participants had ADOS scores that were well within the clinical range, and were judged to carry an ASD diagnosis by expert clinicians

um production. These findings suggest that, in ASD, *underproduction of um relates specifically to core social deficits rather than executive dysfunction or general language deficits.* One might therefore predict that these findings are specific to ASD, and that individual with other neurodevelopmental disorders involving language disorder but not pragmatic impairments, such as specific language impairment or intellectual disability, would produce fillers, especially *um*, at a normative rate. This is a question for future research.

There are at least two explanations for the association of symptom severity and *um* rates. First, because people with ASD show decreased attention to social cues, they may fail to develop an implicit understanding of the social meaning of fillers. Reduced *um* production, then, would reflect a reduced understanding of pragmatic cues in general. A second possibility is that people with ASD *do* comprehend the social meaning of fillers in conversation, but have difficulty employing these cues to meet social goals. Future studies employing visual world paradigms (e.g. Huettig et al. 2011) could help investigate whether fillers influence the anticipation of novel referents in ASD, thereby addressing this competence versus performance question.

The present findings also may have interesting implications for our understanding of one of the most noticeable characteristics of ASD, atypical speech qualities (Mesibov 1992). Speech is often described as 'mechanical' or 'stilted.' Given the apparent social nature of *um* in conversation, the decreased production of *um* in ASD may factor into this stilted or 'pedantic' speech quality. Indeed, while clinical impression finds ubiquitous abnormal prosodic in ASD, studies report quantifiable prosodic deficits in only 50 % of participants (Paul et al. 2005; Shriberg et al. 2001). Interestingly, studies suggest that fillers possess signature prosodic characteristics, even across tonal and non-tonal languages (i.e., monolingual English-speaking listeners are able to recognize fillers in German and Mandarin; Lai et al. 2007). It is possible that it is the *absence* of this prosodic particle (*um*)—an absence not typically measured in studies of prosody—that contributes to the perception of atypical speech quality.

There were several limitations to this study. First, the speech samples consisted of monologues rather than dialogues. While studies have reported that fillers are produced in both contexts (Clark and Fox Tree 2002), this method may be less representative of everyday communication. Note that, because the social demands of monologues are lower, this method should theoretically *advantage* the ASD group, reducing the likelihood of group differences. A second limitation is the brevity of the speech samples (60 s total, produced in a single discourse context). Although findings were robust, it would be informative to examine filler production across variety of rhetorical and conversational contexts. Further, the current study focused on American English; findings may not generalize across languages. Finally, and perhaps most importantly, individuals in the OO group were not evaluated longitudinally, making it impossible to determine OO was characterized by normative *um* production early in development or whether it 'emerged' as other symptoms remitted.

In summary, the current findings contribute both to our understanding of filler disfluencies as pragmatic cues, and to our understanding of optimal outcomes from ASD. First, these results suggest that the filler *um* serves a uniquely pragmatic, listener-oriented function, as its prevalence in spontaneous speech is linked to core social competence. Additionally, the normative production of this pragmatic marker among OO individuals suggests a fundamental improvement of social communication, substantiating the possibility of true normalization of function in some individuals with well-documented ASD.

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References

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders IV-TR* (IV-TR Ed.). Washington, DC: American Psychiatric Association.

Arnold, J. E., Fagnano, M., & Tanenhaus, M. K. (2003). Disfluencies signal theee, um, new information. *Journal Psycholinguistic Research, 32*(1), 25–36.

Arnold, J. E., Hudson Kam, C. L., & Tanenhaus, M. K. (2007). If you say thee uh you are describing something hard: The on-line attribution of disfluency during reference comprehension. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 33*(5), 914–930. doi:10.1037/0278-7393.33.5.914.

Arnold, J. E., Tanenhaus, M. K., Altmann, R. J., & Fagnano, M. (2004). The old and thee, uh, new: Disfluency and reference resolution. *Psychological Science, 15*(9), 578–582.

Barr, D. J., & Seyfeddinipur, M. (2010). The role of fillers in listener attributions for speaker disfluency. *Language and Cognitive Processes, 25*(4), 441–455. doi:10.1080/01690960903047122.

Bortfeld, H., Leon, S. D., Bloom, J. E., Schober, M. F., & Brennan, S. E. (2001). Disfluency rates in conversation: Effects of age, relationship, topic, role, and gender. *Language and Speech, 44*(2), 123–147.

Brennan, S. E., & Williams, M. (1995). The feeling of another's knowing: Prosody and filled pauses as cues to listeners about the metacognitive states of speakers. *Journal of Memory and Language, 34*, 383–398.

Clark, H. H., & Fox Tree, J. (2002). Using uh and um in spontaneous speaking. *Cognition, 84*(1), 73–111.

Colle, L., Baron-Cohen, S., Wheelwright, S., & van der Lely, H. K. (2008). Narrative discourse in adults with high-functioning autism or Asperger syndrome. *Journal of Autism and Developmental Disorders, 38*(1), 28–40. doi:10.1007/s10803-007-0357-5.

Delis, D. C., Kaplan, E., & Kramer, J. H. (2001). *Delis–Kaplan executive function system (D–KEFS) examiner's manual*. San Antonio, TX: The Psychological Corporation.

Dennis, M., Francis, D. J., Cirino, P. T., Schachar, R., Barnes, M. A., & Fletcher, J. M. (2009). Why IQ is not a covariate in cognitive studies of neurodevelopmental disorders. *Journal of the International Neuropsychological Society, 15*, 1–13.

Engelhardt, P. E., Ferreira, F., & Nigg, J. T. (2011). Language production strategies and disfluencies in multi-clause network descriptions: A study of adult attention-deficit/hyperactivity disorder. *Neuropsychology, 25*(4), 442–453. doi:10.1037/a0022436.

Engelhardt, P. E., Nigg, J. T., & Ferreira, F. (2013). Is the fluency of language outputs related to individual differences in intelligence and executive function? *Acta Psychologica, 144*(2), 424–432. doi:10.1016/j.actpsy.2013.08.002.

Fein, D., Barton, M., Eigsti, I. M., Kelley, E., Naigles, L., Schultz, R. T., & Tyson, K. (2013). Optimal outcome in individuals with a history of autism. *Journal of Child Psychology and Psychiatry, 54*(2), 195–205.

Fitch, A., Fein, D. A., & Eigsti, I. M. (2015). Detail and gestalt focus in individuals with optimal outcomes from autism spectrum disorders. *Journal of Autism and Developmental Disorders, 45*(6), 1887–1896. doi:10.1007/s10803-014-2347-8.

Gioia, G. A., Isquith, P. K., Guy, S. C., & Kenworthy, L. (2000). Behavior rating inventory of executive function. *Child Neuropsychology, 6*(3), 235–238.

Goodwin, M. H., & Goodwin, C. (1986). Gesture and coparticipation in the activity of searching for a word. *Semiotica: Journal of the International Association for Semiotic Studies/Revue de l' Association Internationale de Sémiotique, 62*(1–2), 51–75.

Griffin, Z., & Spieler, D. (2006). Observing the what and when of language production for different age groups by monitoring speakers' eye movements. *Brain and Language, 99*(3), 272–288.

Helt, M., Kelley, E., Kinsbourne, M., Pandey, J., Boorstein, H., Herbert, M., & Fein, D. (2008). Can children with autism recover? If so, how? *Neuropsychology Reviews*, *18*(4), 339–366. doi:10.1007/s11065-008-9075-9.

Huettig, F., Rommers, J., & Meyer, A. S. (2011). Using the visual world paradigm to study language processing: A review and critical evaluation. *Acta Psychologica, 137*(2), 151–171. doi:10.1016/j.actpsy.2010.11.003.

Kelley, E., Naigles, L., & Fein, D. (2010). An in-depth examination of optimal outcome children with a history of autism spectrum disorders. *Research in Autism Spectrum Disorders, 4*, 526–538.

Kelley, E., Paul, J. J., Fein, D., & Naigles, L. R. (2006). Residual language deficits in optimal outcome children with a history of autism. *Journal of Autism and Developmental Disorders, 36*(6), 807–828.

Kidd, C., White, K. S., & Aslin, R. N. (2011). Toddlers use speech disfluencies to predict speakers' referential intentions. *Developmental Science, 14*(4), 925–934.

Lai, C., Gorman, K., Yuan, J., & Liberman, M. (2007). *Perception of disfluency: Language differences and listener bias. Paper presented at the annual conference of the international speech communication association*, Antwerp, Belgium.

Lake, J. K., Humphreys, K. R., & Cardy, S. (2011). Listener vs. speaker-oriented aspects of speech: Studying the disfluencies of individuals with autism spectrum disorders. *Psychonomic Bulletin and Review, 18*(1), 135–140.

Lord, C., Rutter, M., DiLavore, P. C., & Risi, S. (2002). *Autism diagnostic observation schedule (ADOS)*. Los Angeles: Western Psychological Services.

Maclay, H., & Osgood, C. E. (1959). Hesitation phenomena in spontaneous English speech. *Word-Journal of the International Linguistic Association, 15*(1), 19–44.

Mesibov, G. (1992). Treatment issues with high-functioning adolescents and adults with autism. In E. Schopler & G. Mesibov (Eds.), *High-functioning individuals with autism* (pp. 143–156). New York: Plenum Press.

Oviatt, S. L. (1995). Predicting spoken disfluencies during human–computer interaction. *Computer Speech and Language, 9*(1), 19–35.

Paul, R., Orlovski, S. M., Marcinko, H. C., & Volkmar, F. (2009). Conversational behaviors in youth with high-functioning ASD and Asperger syndrome. *Journal of Autism and Developmental Disorders, 39*(1), 115–125.

Paul, R., Shriberg, L., McSweeney, J., Cicchetti, D., Klin, A., & Volkmar, F. (2005). Relations between prosodic performance and communication and socialization ratings in high functioning speakers with autism spectrum disorders. *Journal of Autism and Developmental Disorders, 35*(6), 861–869.

Plexico, L. W., Cleary, J. E., McAlpine, A., & Plumb, A. M. (2010). Disfluency characteristics observed in young children with autism spectrum disorders: A preliminary report. *SIG 4 Perspectives on Fluency and Fluency Disorders, 20*(2), 42–50.

Rutter, M., Bailey, A., & Lord, C. (2003). *The Social Communication Questionnaire (SCQ)*. Los Angeles: Western Psychological Services.

Schachter, S., Christenfeld, N., & Ravina, B. (1991). Speech disfluency and the structure of knowledge. *Journal of Personality and Social Psychology, 60*(3), 362–367.

Semel, E., Wiig, E. H., & Secord, W. A. (2003). *Clinical evaluation of language fundamentals* (4th ed.). San Antonio, TX: Harcourt Assessment Inc.

Shriberg, E. E. (1994). *Preliminaries to a theory of speech disfluencies*. Oakland: University of California.

Shriberg, L. D., Paul, R., Black, L. M., & van Santen, J. P. (2011). The hypothesis of apraxia of speech in children with autism spectrum disorder. *Journal of Autism and Developmental Disorders, 41*(4), 405–426.

Shriberg, L. D., Paul, R., McSweeny, J. L., Klin, A. M., Cohen, D. J., & Volkmar, F. R. (2001). Speech and prosody characteristics of adolescents and adults with high-functioning autism and Asperger syndrome. *Journal of Speech, Language, and Hearing Research, 44*(5), 1097–1115.

Shrout, P. E., & Fleiss, J. L. (1979). Intraclass correlations: Uses in assessing rater reliability. *Psychological Bulletin, 86*(2), 420.

Smith, V. L., & Clark, H. H. (1993). On the course of answering questions. *Journal of Memory and Language, 32*, 25–38.

Sparrow, S. S., Cicchetti, D. V., & Balla, D. A. (2005). *Vineland adaptive behavior scales, Second Edition (Vineland-II)*. Circle Pines, MN: AGS Publishing.

Suh, J., Eigsti, I. M., Naigles, L., Barton, M., Kelley, E., & Fein, D. (2014). Narrative performance of optimal outcome children and adolescents with a history of an autism spectrum disorder (ASD). *Journal of Autism and Developmental Disorders, 6*, 6.

Wechsler, D. (1999). *Manual for the wechsler abbreviated scale of intelligence* (1st ed.). New York: Pearson Psychological Corporation.