A Comprehensive Analysis of Speech Disfluencies in Autistic Young Adults and Control Young Adults: Group Differences in Typical, Stuttering-Like, and Atypical Disfluencies

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Author Note

In this study, we use ‘identity-first’ terminology that is reportedly preferred by many autistic adults (e.g., Bury et al., 2020).

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Abstract

Purpose: To examine the nature of speech disfluencies in autistic young adults and controls by using a wide-range disfluency classification of typical disfluencies (TD; i.e., filled pauses, revisions, abandoned utterances, and multisyllable word and phrase repetitions), stuttering-like disfluencies (SLD; i.e., sound and syllable repetitions, monosyllable word repetitions, prolongations, blocks, and broken words), and atypical disfluencies (AD; i.e., word-final prolongations and repetitions, and atypical insertions).

Method: Thirty-two autistic young adults and 35 controls completed a narrative telling task based on socially complex events. Frequencies of total disfluencies, TD, SLD and AD as well as stuttering severity were compared between groups.

Results: The overall frequency of disfluencies was significantly higher in the autistic group and significant between-group differences were found for all disfluency categories. The autistic group produced significantly more revisions, filled pauses, and abandoned utterances, and each subtype of SLD and AD than the control group. In total, approximately every fourth autistic participants scored at least a very mild severity of stuttering, and every fifth produced more than three SLD per 100 syllables.

Conclusions: Disfluent speech can be challenging for effective communication. This study revealed that the speech of autistic young adults was highly more disfluent than that of the controls. The findings provide information on speech disfluency characteristics in autistic young adults and highlight the importance of evaluating speech disfluency with a wide-range disfluency classification in autistic persons in order to understand their role in overall communication. The results of this study offer tools for SLPs to evaluate and understand the nature of disfluencies in autistic persons.

Keywords: autism spectrum, autistic persons, speech disfluency, speech fluency disorder, stuttering, word-final disfluencies

A Comprehensive Analysis of Speech Disfluencies in Autistic Young Adults and Control Young Adults: Group Differences in Typical, Stuttering-Like and Atypical Disfluencies

Autism spectrum disorder (ASD) is characterized by deficits in social communication and interaction, and restricted, repetitive, and inflexible patterns of behavior (DSM; 5th ed.; American Psychiatric Association, 2013; ICD-11; 11th ed.; World Health Organization, 2019). Despite individual variation within the autism spectrum and some decrease in autistic behavior with age, the core features remain relatively persistent over time (Magiati et al., 2014). While previous research has mostly focused on pragmatics (e.g., Loukusa, 2021; Sng et al., 2018) and structural language (e.g., Boucher, 2012; Ellis Weismer & Kover, 2015) competencies of autistic persons, less is known about the features of spoken expressions, such as fluency. Fluent speech results from coordinated interaction of multiple serial and parallel speech production processes (Levelt, 1989; Lickley, 2017). Evaluation of speech fluency can provide information on how these different (i.e., cognitive, linguistic, and motor) processes function together (see also Lickley, 2015). Examining speech disfluencies in autistic persons could, therefore, provide information about their speech planning and execution processes, which might not be observed in formal testing. Wiklund and Laakso (2021) have discussed how difficulties in formulating fluent expressions in autistic persons may complicate communication between interlocutors. Given that many autistic adults often face challenges in the early stages of adulthood, due to increasing social and communicative demands (e.g., employment, education) (for a review, see Volkmar et al., 2017), it would be important to evaluate speech disfluency characteristics to gain more understanding of the spoken expressions of autistic adults.

The definitions of speech disfluencies vary, depending on the theoretical background and focus of the study at hand (for a review see Lickley, 2015; Logan, 2015). There is a consensus that some speech disfluencies are more typical than others. *Typical disfluencies* (TD, also called *linguistic mazes*, Loban, 1976) consist of filled pauses, revisions, abandoned utterances, and multisyllable word and phrase repetitions (Ambrose & Yairi, 1999; Yairi & Ambrose, 2005) and are observed in typically fluent speakers (Bortfeld et al., 2001; Penttilä & Korpijaakko-Huuhka, 2019; Roberts et al., 2009). *Stuttering-like disfluencies* (SLD) include sound and syllable repetitions, monosyllable word repetitions, prolongations, blocks, and broken words, and are dominant features in stuttered speech (Ambrose & Yairi, 1999; Yairi & Ambrose, 2005). Prolongations, blocks, and broken words are also described as disrhythmic phonation, since they differ from the typical phonation and disturb the flow of speech (Yairi & Ambrose, 2005, p. 97). A third disfluency category is *atypical disfluencies* (AD) such as word-final prolongations and repetitions, and mid-syllable insertions (e.g., Scaler Scott et al., 2014; Sisskin, 2006); these types of disfluencies are not common in stuttered or typical speech. Despite categorizing disfluencies based on their different nature, some disfluencies are neither exclusively stuttering nor exclusively typical (Yairi & Ambrose, 2005, p. 99). Both TD and SLD can occur in typical and stuttered speech, however, the frequency of SLD is much higher in people who stutter.

Many previous studies comparing disfluencies between autistic persons and controls have focused on TD without simultaneous evaluation of SLD (De Marchena & Eigsti, 2016; Engelhardt et al., 2017; Kuijper et al., 2017; Lake et al., 2011; MacFarlane et al., 2017; Suh et al., 2014). Moreover, AD have also been recognized in autistic persons (Healey et al., 2015; Miyamoto & Tsuge, 2021; Plexico et al., 2010; Scaler Scott et al., 2014; Sisskin, 2006; Sisskin & Scaler Scott, 2007b; Sisskin & Wasilus 2014). The preliminary study of Scaler Scott et al. (2014) is the only one to include all the aforementioned disfluency types in comparing the fluency of autistic children and their typically developing peers. The authors reported that 72% of their autistic participants were evaluated to have at least a very mild stuttering severity, and AD were considerably more prevalent in autistic children when compared to typically developing peers or children who stutter. Currently, there are no similar comparative group studies in autistic adults. As has been discussed in the literature, because of the many other socio-pragmatic challenges and communication issues in autistic persons, speech disfluency and its role in overall communication may not have received the needed attention (Scaler Scott et al., 2014; Smith et al., 2017). In order to increase our deeper understanding of the communicative phenotype and its developmental pathways in autistic spectrum, in addition to exploring autistic children, different kinds of communicative and speech features must also be studied in adulthood.

Disfluencies have been described as by-products of the cognitive processing demands associated with speech planning and execution in typical (Bortfeld et al., 2001; Levelt, 1989, Lickley, 2015) and stuttered (e.g., Smith & Weber, 2017) speech. Multiple challenges (i.e., linguistic, motor, and executive functioning), which have also been associated with autism spectrum, could impact the speech planning and execution processes and, consequently, increase the frequency of disfluencies. The level of language production varies considerably within this group; ranging from individuals with no language to individuals with language development within the typical range. Even for the latter, however, subtle deficits in structural language abilities can still occur (for a review, see Boucher, 2012). The core challenges associated with the autism spectrum are related to pragmatic language and communication (e.g., Loukusa, 2021), and these challenges could increase the cognitive load in social situations affecting speech fluency. In addition to abovementioned linguistic aspects, autistic persons have been found to differ from controls in the motor aspects of speech production (i.e., speech rate (see Patel et al., 2020), temporal aspects of speech motor planning (see Franich et al., 2021), and imprecise articulation (see Wynn et al., 2022)), as well as in executive functioning (Demetriou et al., 2018; Hill, 2004). Executive functions are an essential part of speech planning and execution (Levelt,1989; see also Engelhardt et al., 2010, 2013), and deficits in planning, flexibility, inhibition (Demetriou et al., 2018; Hill, 2004), and working memory (Demetriou et al., 2018; Wang et al., 2017) may result in an increase of disfluencies in autistic persons (see also Scaler Scott, 2015).

Typical Disfluencies in Autistic Speakers

Previous studies have identified both quantitative and qualitative differences in the use of TD between autistic participants and controls (De Marchena & Eigsti, 2016; Engelhardt et al., 2017; Kuijper et al., 2017; Lake et al., 2011; MacFarlane et al., 2017; Suh et al., 2014; Wiklund & Laakso, 2021). Most of these studies have observed autistic children and adolescents (De Marchena & Eigsti, 2016; Kuijper et al., 2017; MacFarlane et al., 2017; Suh et al., 2014; Wiklund & Laakso, 2021), and less is known about these disfluencies in autistic adults. The findings of these studies were mixed, presumably due to differences in the disfluency classification that was used and/or differences in methodological approaches. For example, some studies have found autistic participants to produce more revisions/self-repairs when compared to controls (De Marchena & Eigsti, 2016; Engelhardt et al., 2017; Suh et al., 2014; Wiklund & Laakso, 2021), whereas others have found the exact opposite (Lake et al., 2011) or no between-group differences at all (Kuijper et al., 2017). Similarly, some studies have found autistic participants to produce more repetitions (Kuijper et al., 2017; Lake et al., 2011; Shriberg et al. 2001; Suh et al., 2014), but other studies had conflicting findings (Engelhardt et al., 2017). Finally, some studies have found autistic participants to produce significantly fewer filled pauses than controls (Irvine et al., 2016; Lake et al., 2011), which has not been found in other studies (e.g., Suh et al., 2014).

Previous studies have also found differences in the composition of TD within the autistic group in comparison to the control group. Autistic participants have been found to produce more revisions and/or repetitions in relation to filled pauses, which differs from the controls (MacFarlane et al. 2017; Lake et al., 2011). Similarly, Wiklund and Laakso (2021) found that while the disfluent speaking turns of the controls were mostly unproblematic hesitations, autistic participants produced complex disfluent conversational turns consisting of word searches, repairs, and false starts. This qualitative difference may be related to pragmatic difficulties, because filled pauses have been suggested to serve intentional communicative functions that coordinate interaction between interlocutors and inform the listener about the delays in speech production (e.g., Bortfeld et al., 2001; Clark & Fox Tree, 2002; Lake et al., 2011; for a contrasting view, see Finlayson & Corley, 2012). Thus, filled pauses produced by typical speakers might serve conversational functions when the speaker is informing the listener of a delay in speech production (listener-oriented), whereas other TD produced by autistic persons could result from errors detected in the speech processing and not produced for the listener's benefit (speaker-oriented) (e.g., Lake et al., 2011).

Stuttering-like Disfluencies in Autistic Speakers

Previous studies have reported comorbidity between stuttering and the autism spectrum (e.g., Boulet et al., 2009; Briley & Ellis, 2018; Schieve et al., 2012). While the estimated prevalence of stuttering in general is 2.2%– 5.6% in childhood (for a review, see Yairi & Ambrose, 2013) and 0.37%–0.78% in adulthood (Craig et al., 2002), Schieve et al. (2012) have reported weighted prevalence of stuttering in approximately 16% of autistic persons aged 3–17 years (see also Boulet et al., 2009). However, the participants of this study were children and the analyses were based on parents' reports and not on a systematic evaluation of the speech characteristics. Shriberg et al. (2001) were one of the first to report more phrases including sound, syllable, or word repetitions, and misplaced stress such as blocks and prolongations in autistic adults than controls, yet their study did not include a systematic analysis of the total frequency of SLD. It is unclear to what extent the SLD and other stuttering behavior are prevalent in autistic adults.

Scaler Scott et al. (2014) analyzed speech disfluencies in autistic children (n = 11), children who stutter (n = 11), and typically developing peers (n = 11) in grades 4–7 and with typical cognitive performance. The speech samples were elicited by using an expository discourse, which represented a cognitively demanding situation. The authors reported autistic children to produce more SLD than controls but less than children who stutter. The same authors also reported that 72% of their autistic participants scored a very mild or higher stuttering severity on the *Stuttering Severity Instrument – Third Edition* (SSI-3, Riley, 1994) and 27% were diagnosed with stuttering. A few qualitative and descriptive case studies have also identified stuttering behaviors in both autistic children (Miyamoto & Tsuge, 2021; Sisskin, 2006; Sisskin & Scaler Scott, 2007a, 2007b; Sisskin & Wasilus, 2014) and autistic young adults (Brundage et al., 2013; Scott et al., 2007; Sisskin, 2006; Sisskin & Scaler Scott, 2007a). In these young adults, different severity ratings have been reported, ranging from very mild and mild (Scott et al., 2007) to moderate (Sisskin, 2006) and severe stuttering (Brundage et al., 2013). Many of these case studies also reported that autistic persons seem to lack awareness of their stuttering behaviors (Brundage et al., 2013; Miyamoto & Tsuge, 2021; Sisskin, 2006; Sisskin & Scaler Scott, 2007a; Sisskin & Wasilus, 2014), which seems to differ from the classically reported phenomenology of childhood onset fluency disorder (DSM; 5th ed.; American Psychiatric Association, 2013; Guitar, 2019). Sisskin and Scaler Scott (2007a) have speculated that also the quality of stuttering-like repetitions produced by an autistic person seemed to differ from those typically seen in stuttered speech. Therefore, it is unclear if the stuttering behavior in autistic persons differs from those typically seen in people who stutter.

Atypical Disfluencies in Autistic Speakers

Previous studies have identified atypical disfluencies in autistic persons (Healey et al., 2015; Miyamoto & Tsuge, 2021; Plexico et al., 2010; Scaler Scott et al., 2014; Sisskin, 2006; Sisskin & Scaler Scott, 2007b; Sisskin & Wasilus, 2014) which also indicates that the disfluency characteristics of autistic persons may differ from patterns that are typically associated with developmental stuttering. AD consist of repetitions and prolongations of the final parts of the word (word-final disfluencies), and mid/between-syllable insertions (e.g., Plexico et al., 2010; Sisskin, 2006). These patterns are not typically seen in developmental stuttering, where the disfluencies occur most often in the initial position of words, although some studies have also reported the occurrence of word-final disfluencies in children who stutter (Eichorn & Donnan, 2021; MacMillan et al., 2014; Scaler Scott et al., 2014).

Studies evaluating AD in autistic persons have mostly observed children or adolescents (Healey et al., 2015; Miyamoto & Tsuge, 2021; Plexico et al., 2010; Scaler Scott et al., 2014; Sisskin & Scaler Scott, 2007b; Sisskin & Wasilus, 2014). Sisskin (2006) is one of the few to report AD in an autistic person close to young adulthood. The 17-year-old autistic person had a moderate speech fluency disorder in which the most frequently occurring disfluencies were part-word repetitions in word-final positions and mid-syllable insertions. Many case studies have reported that autistic persons seemed to have no awareness their atypical speech disfluencies (Miyamoto & Tsuge, 2021; Sisskin, 2006; Sisskin & Scaler Scott, 2007b; Sisskin & Wasilus, 2014) or could not identify them in the moment of occurrence (Sisskin & Scott, 2007b).

The causal mechanism for atypical disfluency is unknown. In addition to autism spectrum, word-final disfluencies have been associated with other neurodevelopmental disorders (Evans & Owens, 2019; Scott et al., 2007; Tetnowski & Donaher, 2003), learning disabilities (Stansfield, 1995), and to a much lesser extent in typically developing children (McAllister & Kingston, 2005; Scaler Scott et al., 2014). Word-final disfluencies could share a similar underlying causal mechanism as palilalia, which is described as involuntary repetitions of one's own speech, usually at the end of word or phrase in a sentence (Jankovic, 2015; Lebrun, 1993; see also Van Borsel et al., 2005), and suggested to reflect dysfunctions in basal ganglia (e.g., Swanberg et al., 2007). Basal ganglia are an essential part of the subcortical brain network for coordinated and goal-directed movement execution (Mink, 2015), and dysfunctions in this area have also been associated with stuttering (Chang & Guenther, 2020). On this basis, Van Borsel et al. (2005) (see also MacMillan et al., 2014) have suggested fluency disorders to be a continuum that includes word- and phrase-initial disfluencies at one end (stuttering) and difficulties of termination of word and phrases at the other (palilalia). Word-final disfluencies could be located somewhere between the two extremes. Since word-final disfluencies might be related to difficulties in terminations of sounds, Scaler Scott (2015) suggested that those features could be related to seeking sensory feedback. It has also been speculated that word-final disfluencies produced by autistic persons could be a verbal form of perseveration (Sisskin & Wasilus, 2014).

Current Study

To summarize, previous findings indicate both qualitative and quantitative differences in speech fluency between autistic persons and controls. Although some studies have evaluated disfluencies in autistic adults (Engelhardt et al., 2017; Lake et al., 2011; Shriberg et al., 2001), a) information about the extent to which SLD and AD can be observed in autistic adults in comparison to controls is limited, and b) none have analyzed the presence of the different disfluency types (i.e., TD, SLD, and AD) a combined manner. Using an adapted version of the *Illinois Disfluency Classification System* (Ambrose & Yairi, 1999; Yairi & Ambrose, 2005), a widely used categorization system, allows us to a) gain more insight in both typical disfluencies and possible stuttering-like behaviors of autistic adults and b) compare the prevalence of stuttering characteristics in autistic adults with previously published findings in autistic children (Scaler Scott et al., 2014). An in-depth evaluation of the characteristics of speech disfluencies in autistic adults will enhance our understanding of the overlap between the autism spectrum and speech fluency disorders (see also Briley & Ellis, 2018).

The aim of the present study was to examine whether autistic young adults differ significantly from controls in their frequency of a) total disfluencies, b) typical disfluencies, c) stuttering-like disfluencies, and d) atypical disfluencies. We hypothesized that overall, the speech of autistic participants would be more disfluent and that the autistic group would produce more disfluencies in each category (i.e., TD, SLD, and AD). Given the earlier reported higher prevalence of stuttering characteristics in autistic children (e.g., Scaler Scott et al., 2014), we also hypothesized that autistic adults are more likely to meet the commonly used diagnostic criteria for stuttering.

Method

Participants

Originally, 34 autistic young adults and 37 controls took part in this study. All participants had Finnish as their native language. The participants were gathered from an epidemiological study (Mattila et al., 2011) and a clinical gene study (Weiss et al., 2009). Two controls were additionally recruited for this study to balance the sex ratio. All autistic participants were diagnosed in childhood at Oulu University Hospital by an interdisciplinary team consisting of a pediatrician, child psychiatrist and/or psychologist utilizing the results from the Autism Diagnostic Interview Revised (Lord et al. 1995) and Autism Diagnostic Observation Schedule (Lord et al. 2000), school day observations and patient records. The diagnoses were based on the ICD-10 criteria for autism spectrum disorder (WHO, 1993).

During the data collection of the adulthood measures, general cognitive performance was evaluated by the Wechsler Adult Intelligence Scale-IV (WAIS-IV; Wechsler, 2012). To avoid a possible confound of cognitive abilities on fluency of speech, a General Ability Index (GAI) < 70 was used as exclusion criterion for the current study (WAIS-IV; Wechsler, 2012). All participants had a general ability index of 70 or higher, often used as a cutoff for intellectual disability (DSM-5, 2013). Two autistic and one control participants were excluded based on this criterion. One control participant withdrew from the study after participation. The final sample consisted of 32 autistic young adults aged 19–33 and 35 controls aged 19–29 (Table 1). There were no between-group differences in age ($t = -1.41$, $p = .165$), and on the WAIS-IV indices of General Ability ($t = -1.11$, $p = .270$), Perceptual Reasoning ($t = -1.19$, $p = .238$) or Verbal Comprehension ($t = -0.60$, $p = .550$).

Table 1 about here

Speech Sample Collection

The speech samples were collected in a socio-pragmatic test situation in a large multidisciplinary follow-up study at the Unit of Child Psychiatry at the University of Oulu and Oulu University Hospital and the Research Unit of Logopedics at the University of Oulu. Participants were presented with seven video clips (duration range 1.2–3.6 min) from a Finnish TV series called *Ruusun aika* (Finnish commercial media operator, MTV). The interactions in the videos consisted of socially and pragmatically challenging situations which required comprehension of verbal and prosodic information, body language, and social rules. The content of the videos included conflicts, lying, teasing, joking, misunderstanding, and emotional aspects. After watching each video clip, the participants were asked to tell what they thought had happened in the video. At the same time, they were shown a still picture of the people from the video clips. The goal was to elicit independently formed narratives without any specifying questions or comments. If the participant answered only in one sentence, the researcher asked, “Could you tell a bit more?”. The entire assessment was video recorded.

The average length of the total speech samples was 1043 syllables (*Mdn* = 863, range = 222–4878) for the autistic group, and 976 syllables (*Mdn* = 876, range = 266–2105) for the control group. There was no between-group difference in the length of the speech sample ($U = 544.5$, $p = .85$). In total, 97% of all participants produced more than 300 syllables (only one participant in both groups produced less than 300 syllables) and 76% of the participants produced more than 600 syllables which indicates an adequate speech sample size for disfluency analysis (e.g., Guitar, 2019).

Speech Sample Analyses

Disfluency Coding

The disfluency coding system was adapted from the *Illinois Disfluency Classification System*, which divides disfluencies into groups of *typical disfluencies* and *stuttering-like disfluencies* (Table 2) (Ambrose & Yairi, 1999; see also Yairi & Ambrose, 2005). Even though the system was originally developed for children, it has also been used in adults (e.g., Chon et al. 2021) and, more specifically, in Finnish-speaking adults (Penttilä & Korpijaakko-Huuhka, 2019). We adhered to the guidelines provided by Ambrose and Yairi (1999; Yairi & Ambrose, 2005, p. 104), stating that when more than one type of disfluency occurs in a word, all disfluency types are counted separately (for different strategies, see Yaruss, 1998). In case off a repetition, repetition units are calculated based on the number of repeated segments (wo-wo-women = 1 part-word repetition with 2 repetition units). Two adaptations in the classification system were made for this study. First, we added filler words to the category of filled pauses (also labeled as interjections) since those have been labeled as disfluencies in previous studies (e.g., Eggers et al., 2020; Jansson-Verkasalo et al., 2021; Penttilä & Korpijaakko-Huuhka, 2019; Wiklund & Laakso, 2021). Filler words were defined as semantically meaningless, extraneous words, such as 'like' and 'well'. Thus, similar to Jansson-Verkasalo et al. (2021), the term 'filled pause' in this study referred to both hesitation sounds ('uh', 'um') and filler words, which were seen as a way to fill a pause while speaking and which have both been associated with message planning (Penttilä & Korpijaakko-Huuhka, 2019) (see also Table 2). Secondly, an additional category of *atypical disfluencies* was created for the disfluencies which did not fit into this classification system and were reported in previous studies of autistic persons (e.g., Plexico et al., 2010; Scaler Scott et al., 2014; Sissikin, 2006; Sisskin & Wasilus, 2014). In this study, these included word-final disfluencies which consisted of prolongations of the final sound of the word, and repetitions of the final sound or syllable of the word. Other AD were categorized as atypical insertions which included different types of meaningless sound and syllable insertions. These atypical insertions could occur in the middle, end, or between the words. Both stuttering-like prolongations and word-final prolongations were distinguished from voluntarily produced suprasegmental prolongations (Betz et al., 2017), and these prolongations were seen as intentional communicative acts and left out from disfluency analysis (see also Jansson-Verkasalo et al., 2021). Similar to the procedures by Ambrose and Yairi (1999), the speech samples were orthographically transcribed by the first author and disfluencies were identified and coded by repeated viewing of the video recordings and reading the transcriptions of the narrative task.

Table 2 about here

Frequency of Disfluencies

The frequency of disfluencies was calculated by dividing the total number of disfluencies by the total number of syllables to obtain the percentage of disfluencies per 100 syllables. For Finnish, this syllable-based metric, also used by Ambrose and Yairi (1999), is preferred (Jansson-Verkasalo et al., 2021) above a word-based metric (see e.g., Scaler Scott et al., 2014; Eggers et al., 2020). The counted syllables included only the ones that would have been produced if the speaker had been fluent (Guitar, 2019). The disfluency frequency per 100 syllables was calculated for a) total disfluencies, b) TD, c) SLD, and d) AD. Additionally, the frequency for each of the subtypes (e.g., monosyllable word repetition) was counted separately. In line with previous studies (Ambrose & Yairi, 1999; Curlee, 2007; Jansson-Verkasalo et al., 2021; Tumanova et al., 2014), we used a threshold of 3% SLD as an indicator for possible stuttering. Recently, Chon et al. (2013, 2021) have considered part-word repetitions in word-final positions as SLD when evaluating disfluency. In line with their work, we provided an additional figure in which the frequency of word-final disfluencies was considered together with SLD when evaluating possible stuttering.

Stuttering Severity

Stuttering severity was assessed by using the *Stuttering Severity Instrument – Fourth Edition* (SSI-4, Riley, 2009). The SSI-4 consists of three components, i.e., frequency (percentage of stuttered syllables during a speaking and reading task), duration (the average length of the three longest stuttering moments), and physical concomitants (distracting sounds, facial grimaces, head movements, and movements of the extremities). The three sub scores result in a total score, percentile, and five stuttering severity equivalents, ranging from *very mild* to *very severe*. Due to the lack of a reading sample in this study, the nonreaders' table was used for determining the frequency score. Todd et al.'s (2014) finding that using the readers' or nonreaders' procedure results in equivalent severity ratings, validates this approach.

Measurement Reliability

The disfluency analysis was done by the first author, who has extensive experience in analyzing speech disfluencies. To increase the reliability of the disfluency analysis, multiple joint analysis sessions and meetings were held together with the first, second and last author before and during the analysis. Uncertainties were discussed and solved together to obtain collective agreement on disfluencies. A second rater re-coded 10% of the speech samples. Inter-rater reliability was calculated with the intraclass correlation coefficient (ICC) (Shrout & Fleiss, 1979). The ICC analysis was conducted by using the two-way mixed model, "absolute agreement" definition, and a single measure intraclass correlation. The ICC was .99 (95% CI [.95, .99]) for total disfluencies, .99 (95% CI [.95, .99]) for TD, .95 (95% CI [.74, .99]) for SLD, and .72 (95% CI [.07, .94]) for AD.

Although the SSI-4 reliability measures provided by the test developers indicate a good reliability (Riley, 2009), a recent study criticized its reliability, especially for the domain of physical concomitants (Davidow & Scott, 2017). Therefore, a second rater independently coded the physical concomitants of those participants who were evaluated to have at least very mild stuttering based on the first rater's evaluation (n = 8). The Physical Concomitants Score ranges between 0 and 20. Utilizing procedures used by Davidow and Scott (2017), the reliability for The Physical Concomitants Score was examined by using the percentage of exact scores (identical score), percentage of scores within 1 score value (a maximum of 1 score difference) and percentage of scores within 2 score value (a maximum of 2 score difference) between the raters. The two raters had an identical score for The Physical Concomitants Score in 25% of the cases, while the agreement was higher for situations in which there was a maximum of 1 score difference (62.5%) and a maximum of 2 score difference (75%). The majority of the participants (75%) received low Physical Concomitants Score (0–2) from both raters. Thus, while the reliability for precise scoring between the raters was lower, the overall view observed by the raters was similar and the clear consensus between the raters was that the majority of the observed physical concomitants were mild. If the Physical Concomitants Scores observed by the second rater had been used when computing the final severity ratings of the SSI- 4, the severity ratings obtained by the first rater would have remained the same in six out of the eight participants. Thus, the difference in Physical Concomitants Scores between the raters did not have a major influence on the total severity ratings given by the first rater. This is in line with Davidow and Scott (2017), who also observed that despite a wide range in the reliability of the sub domains, the reliability is substantially better for the total severity score.

Procedure

Good scientific practice and the guidelines of the Finnish National Advisory Board on Research Ethics were followed. This study was part of a multidisciplinary research project named "*Autism spectrum disorders – A follow-up study from childhood to young adulthood"*, which has been approved by the Ethical Committee of the Northern Ostrobothnia Hospital District. The narrative task was part of a larger behavioral test battery, which took approximately 1.5–2 hours. The speech samples used in this study were collected at the beginning of the test session in a quiet room at the Oulu University Hospital. All participants were tested individually. Data was collected by two speech and language pathologists and a student in speech and language pathology.

Statistical Analysis

The statistical analysis was conducted by using The Statistical Package for Social Sciences (SPSS) version 27.0. Visual evaluation of histograms and Shapiro Wilk test were used to evaluate the normality of the data variables in order to choose a validated test for the group comparisons. Since the variables were not normally distributed, we used a Mann Whitney *U* test to examine whether the autistic group differed significantly from the controls in their frequencies of a) total disfluencies, b) TD, c) SLD, and d) AD. Similarly, we used a Mann Whitney *U* test to compare the mean number of repetitions units and stuttering severity between the groups. Effect sizes for group comparisons were calculated by using equation $r = Z/\text{sqr}(N)$. To avoid type I errors as a result of multiple comparisons, the Benjamini-Hochberg correction was applied which has been found to be a powerful procedure in multiple testing (Benjamini & Hochberg, 1995; see also Glickman et al., 2014). The reported *p* values are Benjamini-Hochberg adjusted values with a false discovery rate of .05.

Results

Frequency of Disfluencies

The frequencies for total disfluencies, TD, SLD, and AD for each group are presented in Figure 1. Although a high degree of variability was apparent in both groups, the frequency was significantly higher in the autistic group for each of these categories. In total, the autistic group (*Mdn* = 6.94; range = 3.02–20.80) produced significantly more disfluencies than the control group (*Mdn* = 3.57; range = 1.30–8.10) ($U = 197.0$, $p < .001$, $r = -.56$). The autistic group produced significantly more TD ($U = 246.0$, $p < .001$, $r = -.48$), SLD ($U = 307.0$, $p = .003$, $r = -.39$), and AD ($U = 363.0$, p = .001, $r = -.44$) than the control group (Figure 1, Table 3).

In the autistic group, five participants (16%) produced more than three SLD per 100 syllables. When repetitions and prolongations in word-final positions were included, six participants (19%) scored above the 3% stuttering threshold.

Figure 1 about here

Types of Disfluencies

On average, the autistic group had a higher frequency of each subtype of TD, SLD, and AD (Table 3). In the TD, between-group differences were found for filled pauses, revisions, and abandoned utterances. There was no statistically significant difference in multisyllable word and phrase repetitions. All subtypes of SLD and AD were significantly more prevalent in the autistic group. In the control group, only one participant exhibited one single word-final repetition, otherwise AD did not occur in this group.

Table 3 about here

There was no significant difference in the mean number of repetition units of TD between the autistic and the control group (U = 323.0, p = .264, r =−.18), nor in any of the TD subtypes (Table 4). When comparing the mean number of repetitions units of SLD between both groups, the autistic group produced significantly more repetition units than the control group (U = 295.0, p = .028, r =−.35). A significant difference was also found for part-word repetitions but not for monosyllable word repetition (Table 4). Due to only one event of word-final repetition in the control group, the statistical comparison between the groups in the mean number of word-final repetition units were not conducted, yet the descriptive statistics of word-final repetitions are presented in Table 4.

Table 4 about here

Stuttering Severity

The autistic group scored significantly higher (*Mdn* = 2.00, range = 0.00–29.00) on the SSI-4 than the control group (*Mdn* = 2.00, range = 0.00–6.00) (U = 344.0, p = .003, r = −.35) (Figure 2). In the autistic group, the variability of the stuttering severity ranged from *no stuttering* to *moderate*. In total, eight participants (25%) in the autistic group scored on or above the SSI-4-threshold for stuttering (i.e., a minimum score of 10), whereas none of the controls exceeded the threshold. Most of these autistic participants demonstrated physical concomitants which were mainly mild eye blinking/lifting eye brows, swallowing, coughing, clearing a throat, and/or avoidance of eye contact.

Figure 2 about here

Discussion

The present study is one of the first to systematically assess the occurrence of disfluencies, i.e., TD, SLD, and AD, in autistic adults. Only a few studies have previously compared speech disfluencies between autistic adults and controls (Engelhardt et al., 2017; Lake et al., 2011; Shriberg et al., 2001) but those have focused more on TD without examining SLD (Engelhardt et al., 2017; Lake et al., 2011), or have not systematically analyzed the frequency of disfluencies per words or syllables (Shriberg et al., 2001). Differences in theoretical background and methodological approaches enhance the understanding of the phenomenon, but they can also make it difficult to compare the results. Our aim was to provide an in-depth evaluation of speech disfluency characteristics to receive an overall understanding of fluency of speech in autistic young adults.

Total Disfluency Frequency

In line with our hypothesis, the speech of autistic adults was considerably more disfluent than that of controls; on average, they produced more than twice as many disfluencies. The variability of overall disfluencies was also much higher in the autistic group (3%–21%) than the control group (1%–8%). The findings for the control group are in line with a previous study documenting a total disfluency frequency between 0 and 8% in typical adult Finnish speakers (Penttilä & Korpijaakko-Huuhka, 2019). Considering that many of the autistic participants had an excessively disfluent speech and almost half of the autistic participants had higher total disfluency frequency than any of the controls, it would be important to acknowledge the possible influence of these features on social interaction. It may be possible that disfluencies affect also the listeners' ability to comprehend the message (for a review, see Scaler Scott, 2017; see also Wiklund & Laakso, 2021) or impact on how the speakers are perceived by the listeners (e.g., Panico et al., 2005), and this should be considered in future studies.

Typical Disfluencies

The overall frequency of TD in the autistic group was higher than in the control group. This is in line with our hypothesis and could arise from an increased cognitive load related to challenges in message planning (Bortfeld et al., 2001; Fraundorf & Watson, 2014) lexical selection (Hartsuiker & Notebaert, 2010) and executive functioning (Engelhardt et al., 2010, 2013; see also Scaler Scott, 2015). Scaler Scott et al. (2014) did not find a similar between-group difference in the frequency of TD when they compared autistic children to controls. In our study, a narrative sample based on socially and pragmatically challenging video clips was used, whereas Scaler Scott et al. used an expository discourse sample related to an educational video. Autistic persons have difficulties in socio-pragmatic comprehension (e.g., Loukusa, 2021), and therefore our narrative task based on a socio-pragmatic test situation might have elicited more difficulties in formulating their expressions resulting in a higher frequency of TD. In a way, this procedure could be more ecologically valid and represent the everyday life in which autistic participants may face difficulties and higher cognitive demands when acting and communicating in social situations. However, the current task may not be representative of their speech in all daily situations. Also, the participants were asked to tell what happened in the videos but the correctness of their responses was not controlled in this study, therefore, we cannot know for sure if they were experiencing the assumed socio-pragmatic challenges. However, in our recent study, in which we explored the same narratives of these participants, we found that the autistic persons differed from the control participants in their pragmatic understanding (Dindar et al., accepted), suggesting pragmatic challenges. Additional studies evaluating the speech by using different methods (i.e., retelling versus spontaneous speech) and controlling the content of the speech samples (i.e., socio-pragmatic topics versus other topics) are needed in order to receive a better understanding of speech disfluency and the underlying mechanisms in autistic persons.

Although TD are typical phenomena in speech, an excessive number of these disfluencies can be also associated with stuttering (Curlee, 2007; Tumanova et al., 2014). It has been suggested that linguistic skills and TD are related (e.g., Tumanova et al., 2014), and subtle difficulties in language abilities observed in people who stutter in comparison to controls (Ntourou et al., 2011) could explain this association. Additionally, people who stutter might produce TD while trying to avoid stuttering events. For example, speakers might use a particular filler or reformulate their sentence to avoid certain words in which they might stutter (e.g., Guitar, 2019).

A closer examination of TD revealed that, on average, also each subtype occurred more frequently in the autistic group. Comparing our findings with many of the previous studies is difficult due to methodological (De Marchena & Eigsti, 2016; Engelhardt et al., 2017; Kuijper et al., 2017; MacFarlane et al., 2017; Suh et al., 2014; Wiklund & Laakso, 2021) and age differences (De Marchena & Eigsti, 2016; Kuijper et al., 2017; MacFarlane et al., 2017; Suh et al., 2014; Wiklund & Laakso, 2021). Previous studies found qualitative differences in the production of TD suggesting that autistic persons produce less filled pauses (listener-oriented disfluencies) (Lake et al., 2011; MacFarlane et al., 2017; Wiklund & Laakso, 2021) in relation to other TD (i.e., repetitions as speaker-oriented disfluencies) (Lake et al., 2011) than controls. On the contrary, our study found that the autistic group produced significantly more filled pauses than the controls, and that the filled pauses were the most common disfluency type in both groups. This might be explained by differences in methodologies and disfluency classification. The aforementioned studies have examined disfluencies in situations including conversational activity, which differs from our narrative task. It is not clear to what extent filled pauses are a volitional choice and intentionally produced (see also Lake et al., 2011), and it has been suggested that they may serve multiple functions in speech production (Bortfeld et al., 2001; Eklund & Wirén, 2010). It might be that the control participants use more filled pauses in conversational situations as a volitional choice to structure the conversation, whereas autistic persons have more filled pauses in the narrative tasks as a by-product of speech planning difficulties. Geelhand et al. (2020) have studied narrative production in autistic adults, and they found that autistic adults produced more discourse and hesitation markers in their narratives than controls. The discourse markers were defined as words with a structuring or meta-discursive function and hesitation markers were non-linguistic sounds, which both are akin to filled pauses (filler words and hesitation sounds) in fluency research. Thus, together with our study, findings of Geelhand et al. (2020) support the idea that filled pauses produced by autistic persons may occur differently in narrative versus conversational situations. In some studies, filled pauses have been associated with difficulties in message planning (e.g., Bortfeld et al., 2001; Fraundorf & Watson 2014). In our study, autistic participants could have had difficulties in conceptualizing the message related to socially challenging events. Additionally, deficits in working memory, word-finding difficulties, a pedantic style of finding the exact and specific words to convey the message, and a perseverative behavior as an inability to move on with the speech planning could also explain the higher frequency of filled pauses found in the autistic group in comparison to the controls (see also Scaler Scott, 2015).

In addition to filled pauses, the autistic group revised their speech more often than the control group, which is in line with most previous findings (De Marchena & Eigsti, 2016; Engelhardt et al., 2017; Suh et al., 2014; Wiklund & Laakso; 2021), but not with those of Lake et al. (2011). These revisions could be related to all levels of speech production (Levelt, 1983, 1989) and indicate difficulties in both organizing the story structure and formulating the message into proper linguistic form. However, our results also revealed that the autistic participants tended to abandon an utterance and move on to a totally different topic without any further specification, which has also been reported previously (Geelhand et al., 2020). The tendency to abandon utterances supports Lake et al.'s (2011) hypothesis of autistic persons not always being aware of taking account of the listeners' perspective. Additionally, since executive functions have been associated with speech disfluency (Engelhardt et al., 2010, 2013), a tendency to revise and abandon utterances could be explained by deficits in inhibition control and self-monitoring, which can weaken the ability to keep attention on the current topic and inhibit new ideas (see also Scaler Scott, 2015).

Stuttering-like Disfluencies

SLD were more frequent in the autistic group than in the controls which is in line with the previous preliminary findings (Scaler Scott et al., 2014; Shriberg et al., 2001). In total, 16% (or 19% if word-final disfluencies were included) of the autistic participants had an SLD frequency higher than 3%, which has been used as an indication for possible stuttering (Ambrose & Yairi, 1999; Curlee, 2007; Jansson-Verkasalo et al., 2021; Tumanova et al., 2014). A closer examination of SLD revealed between-group differences in all subtypes. Stuttering-like repetitions were the most common type in both groups. More prolongations, blocks and broken words (also labeled as disrhythmic phonation) were observed in the autistic group, whereas they were rare in the control group. Most of the disrhythmic phonations were observed in autistic participants who had a high frequency of SLD.

Based on the SSI-4 (a combination of SLD frequency, duration, and physical concomitants), 25% of the autistic participants were found to have at least very mild severity of stuttering. Similar to Scaler Scott et al. (2014), the stuttering severity in the autistic group ranged from no stuttering to moderate, whereas all the control participants received a 'no stuttering' -score. The majority of the observed physical concomitants in the autistic participants were mild. This is in line with the previous case studies which have reported no physical concomitants (Sisskin & Scaler Scott, 2007a) or mild physical concomitants (Scott et al., 2007; Sisskin, 2006) in autistic young adults who stutter, yet the number of studies documenting physical concomitants in autistic adults is limited. While the agreement for the identical score between the raters for the physical concomitants in this study appeared low, and there is need to address the interpretations with caution, the majority of the participants received low scores (0–2) from both raters. Accordingly, despite some differences in the exact scoring, the overall view observed by the raters was similar. Even though the physical concomitants observed in the current study were only scored when they were related to speech disfluencies, we acknowledge there can be ambiguity when evaluating physical concomitants in autistic persons. Some of the features, such as avoidance of eye contact or coughing, may also be related to the autism spectrum or comorbidity features (e.g., as a tic) rather than a secondary reaction to speech disfluencies in stuttering. This ambiguity might set challenges to the evaluation.

Overall, both the 3% criterion and the SSI-4 evaluation indicate that stuttering seems to be more prevalent in autistic adults when compared to the general adult population (0.4%–0.8%) (Craig et al., 2002), which is in line with previous findings obtained on autistic children (Scaler Scott et al., 2014). Our findings were obtained in a situation that required socio-pragmatic comprehension, and, therefore, the autistic participants may have experienced high cognitive demands. This is an important finding to acknowledge, especially when considering that, in early stages of adulthood, autistic persons may face situation including more social and communicative requirements (Volkmar et al., 2017). When evaluating the speech fluency in autistics participants (but undoubtedly also in others), it might be wise to include collecting a speech sample under increased cognitive demands (see also Scaler Scott et al., 2014). However, as there can be significant variability in stuttering characteristics (e.g., Tichenor & Yaruss, 2021), these results may not reflect the disfluency patterns in each situation.

While overt speech characteristics related to stuttering (e.g., increased SLD frequency, duration of disfluencies) occurred frequently in our autistic participants, these in itself are not definitive measures of stuttering (e.g., Guitar, 2019). Psychosocial factors and social anxiety are associated with stuttering (e.g., Smith & Weber, 2017), and therefore, alongside the overt features, the assessment should include methods which evaluate the covert features, such as feelings and attitudes (e.g., Guitar, 2019). There is evidence that autistic people with disfluent speech often seem to lack awareness of these disfluencies (Brundage et al., 2013; Miyamoto & Tsuge, 2021; Sisskin, 2006; Sisskin & Scaler Scott, 2007a, 2007b; Sisskin & Wasilus, 2014), yet more studies are needed to evaluate the covert features of stuttering in autistic persons. Additionally, since SLD can occur also in the speech of typical speakers, not all SLD are reflecting the causal mechanisms associated with stuttering (Yairi & Ambrose, 2005). Thus, while this elevated frequency of SLD in many of our autistic participants might reflect the higher prevalence rates of stuttering, not all SLD observed in the autistic persons automatically indicate stuttering. For example, Miyamoto and Tsuge (2021) were able to reduce the frequency of stuttering-like repetitions in an autistic child with a language-based therapy. This suggests that at least some of the SLD could be related to linguistic deficits.

Atypical Disfluencies

The AD reported in this study are similar to those observed in autistic persons in the previous studies (Healey et al., 2015; Miyamoto & Tsuge, 2021; Plexico et al., 2010; Scaler Scott et al., 2014; Sisskin, 2006; Sisskin & Scaler Scott, 2007b; Sisskin & Wasilus, 2014) and document that (some of) the disfluency characteristics associated with the autism spectrum differ from those that are typical for developmental stuttering. The autistic group produced significantly more word-final prolongations and repetitions, and atypical insertions than the controls. To the best of our knowledge, there is no previous information about the extent to which these atypical disfluency patterns related to autism spectrum are present in adulthood in comparison to controls, and our study provides new information of the prevalence of such disfluencies in autistic adults. Word-final disfluencies occurred in 25% (n = 8) of the autistic participants, but only in two of these participants they occurred frequently (approximately half of the produced prolongations and part-word repetitions); in the other six participants they were more seldom produced. Five of the eight participants with word-final disfluencies scored above the SSI-4 threshold for at least very mild stuttering severity. These findings are in line with previous reports in autistic children (Scaler Scott et al., 2014) and give support to the hypothesis that stuttering-like and word-final disfluencies could share, at least to some extent, a similar etiology (MacMillan et al., 2014; Van Borsel et al. 2005).

In addition to word-final disfluencies also atypical insertions were identified in 22% (n = 7) of the autistic group. These insertions consisted of meaningless sounds and syllables that could be distinguished from typical hesitation sounds such as uh and um (in Finnish: öö, mm, ää). Plexico et al. (2010) and Sisskin (2006) have described meaningless mid/between-syllable insertions in the middle of the word as atypical disfluency characteristics in autistic persons. Sisskin (2006) has observed the mid-syllable insertions to precede the repetition of the final part of the word. This is somewhat similar to our finding, since we observed similar atypical sound insertions in a participant who had excessive frequency of word-final prolongations. These insertions of extra sounds could be an attempt to overcome or prevent a disfluent event. In addition to those insertions occurring with word-final prolongations, the other atypical insertions observed in this study consisted of many varying features similar to mannerism, stereotypes, compulsions, or vocal tics (Hatcher-Martin et al., 2015; Jankovic, 2015), which are all defined as repetitive movement behaviors but differ in the level of voluntary versus involuntary nature.

Limitations and Future Directions

Our results strengthen the notion of heterogeneity among the autistic persons, and the wide variation in both groups illustrates that the interpretations made in this article are not generalizable to all autistic persons. Also, participants with an intellectual disability were excluded from this study. Therefore, the sample and results do not represent the entire heterogeneous autism spectrum, yet it did allow us to rule out the effect of some cognitive factors on the results. The features analyzed in this study were based on one speech sample, which limits the generalization of the results. Future studies could compare disfluencies of autistic persons in different situations by using multiple speech samples. Despite the findings of Todd et al. (2014), which suggest that the severity ratings are equivalent when using the readers' or nonreaders' procedure, the lack of reading samples in the SSI-4 analysis can be stated as a limitation. There are different strategies for analyzing the situations in which more than one type of disfluency occurs in a word and counting each instance of different disfluency on a single word might have inflated the frequency of SLD (Yaruss, 1998). Yet, according to Yairi and Ambrose (2005), "counting only one disfluency type or event per word or syllable where two or three actually occurred is a misrepresentation of the speech phenomena under study" (p. 104). Despite our findings of higher frequencies of each disfluency type in autistic young adults, the causal mechanism for these disfluencies remains somewhat unclear. In the future, more studies with a wide-range and comprehensive disfluency analysis, as well as an investigative focus on the connections between disfluencies, cognitive, and linguistic abilities is needed. In the future, it would also be important to explore the development of speech disfluencies in autistic persons from childhood to adulthood in order to understand the developmental pathways of speech disfluency.

Conclusions

The current study shows the importance of using wide-range disfluency analysis when assessing speech disfluencies of autistic persons and provides a foundation for further studies. Our overall conclusion was that the speech of autistic participants, compared to controls, was more disfluent as a result of increased TD, SLD, as well as AD. It is likely that the speech disfluency of autistic young adults reported in this study can arise from more cognitive/linguistic-based (typical disfluencies) to more speech-motor based (stuttering-like disfluencies) etiologies. Speech disfluency can affect the intelligibility of expressions, and this can have disabling effects on everyday communication, especially in adulthood due to the associated increasing social demands. However, given the multiple challenges in social communication and interaction, an evaluation of the impact of speech disfluencies in overall communication is needed when evaluating and diagnosing autistic persons.

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Data Availability Statement

The data analyzed in this study is not publicly available due to ethical restrictions.

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Table 1

The Ratio of Males and Females, Age, and the Test Scores as Means (SD) by Group

	Autistic group (*n* = 32)	Control group (*n* = 35)
Males/females	25/7	25/10
Age (years)	23.7 (3.2)	22.8 (1.8)
GAI	108.2 (17.3)	104.0 (12.9)
VCI	108.3 (18.2)	105.9 (14.4)
PRI	106.1 (18.1)	101.4 (14.1)

Note. GAI = General Ability Index; VCI = Verbal Comprehension Index; PRI = Perceptual Reasoning Index.

Table 2

Summary of the Disfluency Classification

Type of disfluency	Description	Example
Typical disfluencies		
Multisyllable word repetition	Repetition of a multisyllable word	vanhempana vanhempana henkilönä *as an older older person*
Phrase repetition	Repetition of a phrase (= two or more words)	ja se näkee nuo näkee nuo nuoret *and she sees the sees the young people*
Filled pause	Filler word or a non-linguistic extraneous sound	ja sitten tota noin tuo mies *and then well that man* tää tummatukkainen öö selitti *this darkhaired person uhm explained*
Revision	Correction of a detected grammatical or phonological error and adding, deleting, or substituting information	neito oli tuntu olevan vähän itsekeskeinen *the young lady was seemed to be a bit self-centered*
Abandoned utterances	Abandoned word or utterance	ja sitten tää Heidi tossa on eräänlainen ironia *and then this Heidi there is some kind of irony there*
Stuttering-like disfluencies		
Monosyllable word repetition	Repetition of a monosyllable word	tää tää isoäiti sitten *this this grandma then*
Part-word repetition	Repetition of a sound or a syllable in the beginning of a word	oli i-ilmeisen järkyttynyt *was d-decidedly shocked* ja tämä tum-tummempi *and this dar-darker*
Prolongation	Unusual prolongation of a sound within a word	anto sille Mmmmerille *gave it to that Mmmmary*
Block	Stopping airflow or sound during or before the sound production	…kattoo *…looks*
Broken Word	Stopping airflow or sound in the middle of a word	kohta…us *atta…ck*
Atypical disfluencies		
Word-final prolongation	Prolongation of the final sound of a word	vähän värikkäämpiii villapaita *a little more colorfulll jumper*
Word-final repetition	Repetition of the final sound or syllable of a word	kaks nuorta naista-a kävelee-ee *two young girls-s are walking-ing*
Atypical insertion	Atypical insertion of a meaningless sound (e.g., əh) or a syllable, or an unusual vocalization	vaalea nainenəh *fair woman*əh mutta kee tietenki jos siellä oli *but kee of course if there was*

Table 3

Descriptive Statistics of Disfluency Frequencies per 100 Syllables by Group

	Autistic group (n = 32)		Control group (n = 35)		U	p	Effect
Type	Mean (SD)	Median (range)	Mean (SD)	Median (range)	value[a]	value[b]	size r[c]
Typical disfluencies							
Multisyllable WR	0.73 (1.12)	0.28 (0.00–5.68)	0.41 (0.58)	0.22 (0.00–2.52)	461.0	.230	−.15
Phrase R	0.17 (0.41)	0.00 (0.00–1.51)	0.05 (0.13)	0.00 (0.00–0.72)	545.0	.826	−.03
Filled pause	3.68 (2.50)	2.68 (0.80–9.97)	2.20 (1.34)	1.98 (0.31–6.08)	352.0	.015	−.32
Revision	1.38 (0.91)	1.20 (0.00–4.57)	0.94 (0.34)	0.94 (0.37–1.49)	388.0	.035	−.26
Aband. Utt.	0.32 (0.28)	0.28 (0.00–1.11)	0.07 (0.12)	0.00 (0.00–0.62)	179.5	<.001	−.60
Total	6.28 (3.09)	5.74 (1.86–14.67)	3.66 (1.68)	3.25 (1.11–7.80)	246.0	<.001	−.48
Stuttering-like Disfluencies							
Monosyllable WR	0.23 (0.36)	0.14 (0.00–1.93)	0.08 (0.10)	0.00 (0.00–0.30)	378.0	.026	−.29
Part-word R	1.14 (1.83)	0.35 (0.00–8.93)	0.23 (0.24)	0.21 (0.00–0.93)	376.5	.027	−.28
Prolongation	0.40 (1.69)	0.00 (0.00–9.51)	0.00 (0.00)	0.00 (0.00–0.00)	367.5	<.001	−.46
Block	0.40 (1.51)	0.00 (0.00–7.85)	0.00 (0.00)	0.00 (0.00–0.00)	455.0	.015	−.33
Broken W	0.08 (0.15)	0.00 (0.00–0.59)	0.01 (0.03)	0.00 (0.00–0.18)	410.0	.008	−.34
Total	2.26 (3.70)	0.51 (0.00–14.83)	0.32 (0.30)	0.29 (0.00–1.17)	307.0	.003	−.39
Atypical disfluencies							
Word-final P	0.17 (0.76)	0.00 (0.00–4.30)	0.00 (0.00)	0.00 (0.00–0.00)	472.5	.027	−.29
Word-final R	0.10 (0.34)	0.00 (0.00–1.75)	0.00 (0.03)	0.00 (0.00–0.15)	470.0	.033	−.26
Atypical insertion	0.42 (1.26)	0.00 (0.00–6.22)	0.00 (0.00)	0.00 (0.00–0.00)	437.5	.008	−.35
Total	0.69 (1.78)	0.00 (0.00–7.88)	0.00 (0.03)	0.00 (0.00–0.15)	363.0	.001	−.44

Note. Multisyllable WR = Multisyllable Word Repetition; Phrase R = Phrase Repetition; Aband. Utt. = Abandoned Utterance; Monosyllable WR = Monosyllable Word Repetition; Part-word R = Part-word Repetition; Broken W = Broken Word; Word-final P = Word-final Prolongation; Word-final R = Word-final Repetition

[a]Statistical group comparison was calculated with Mann–Whitney U -test.

[b]Due to multiple comparisons, the false discovery rate was corrected with the Benjamini-Hochberg procedure.

[c]Effect sizes were calculated by using equation $r = Z/\mathrm{sqr}(N)$.

Table 4

Mean Number of Repetition Units by Group

	Autistic group[a]		Control group[a]		*U*	*p*	Effect
Type	Mean (SD)	Median (range)	Mean (SD)	Median (range)	value[b]	value[c]	size *r*[d]
Typical disfluencies							
Multisyllable WR	1.03 (0.07)	1.00 (1.00–1.33)	1.03 (0.11)	1.00 (1.00–1.50)	325.0	.330	−.14
Phrase R	1.02 (0.04)	1.00 (1.00–1.10)	1.00 (0.00)	1.00 (1.00–1.00)	33.0	.147	−.45
Total	1.03 (0.07)	1.00 (1.00–1.33)	1.03 (0.10)	1.00 (1.00–1.50)	323.0	.264	−.18
Stuttering-like Disfluencies							
Monosyllable WR	1.06 (0.17)	1.00 (1.00–1.75)	1.02 (0.06)	1.00 (1.00–1.25)	155.0	.330	−.17
Part-word R	1.07 (0.12)	1.00 (1.00–1.44)	1.00 (0.00)	1.00 (1.00–1.00)	208.0	.004	−.46
Total	1.06 (0.11)	1.00 (1.00–1.36)	1.01 (0.05)	1.00 (1.00–1.25)	295.0	.028	−.35
Atypical disfluencies							
Word-final R[e]	1.04 (0.10)	1.00 (1.00–1.25)	1.00 (−)	1.00 (1.00–1.00)	−	−	−

Note. Multisyllable WR = Multisyllable Word Repetition; Phrase R = Phrase Repetition; Monosyllable WR = Monosyllable Word Repetition; Part-word R = Part-word Repetition; Word-final R = Word-final Repetition

[a]Because all participants did not produce every disfluency type, the number of participants differs in each comparison.

[b]Statistical group comparison was calculated with Mann–Whitney *U* -test.

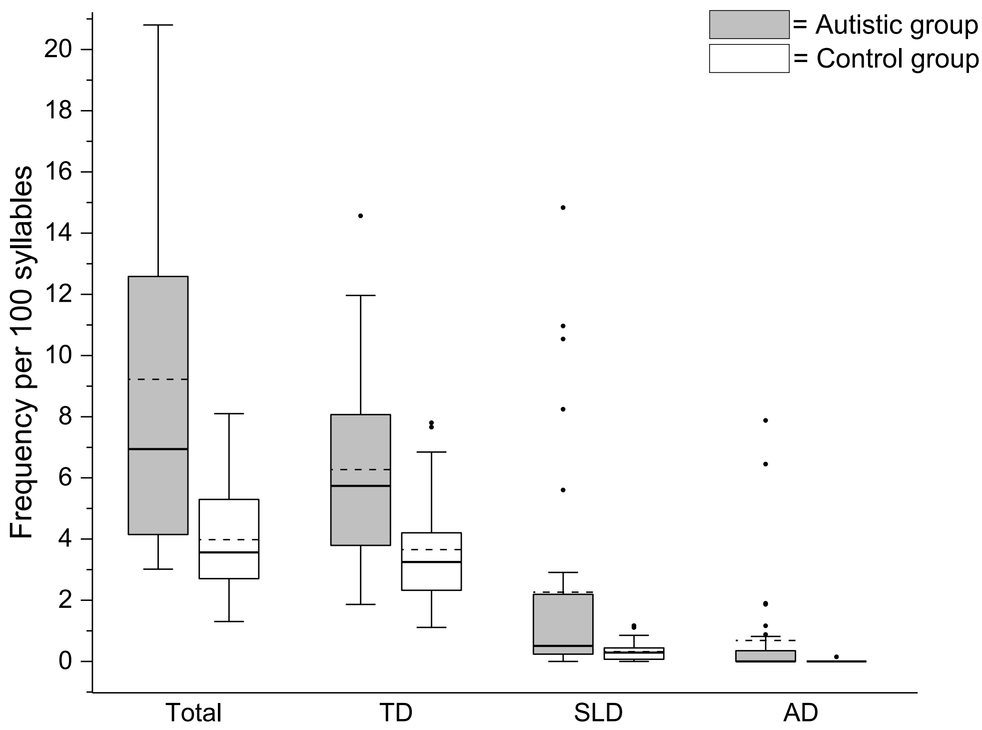
[c]Due to multiple comparisons, the false discovery rate was corrected with the Benjamini-Hochberg procedure.

[d]Effect sizes were calculated by using equation $r = Z/\text{sqr}(N)$.

[e]Since only one control participant produced one event of word-final repetition, statistical group comparison was not conducted.

Figure 1

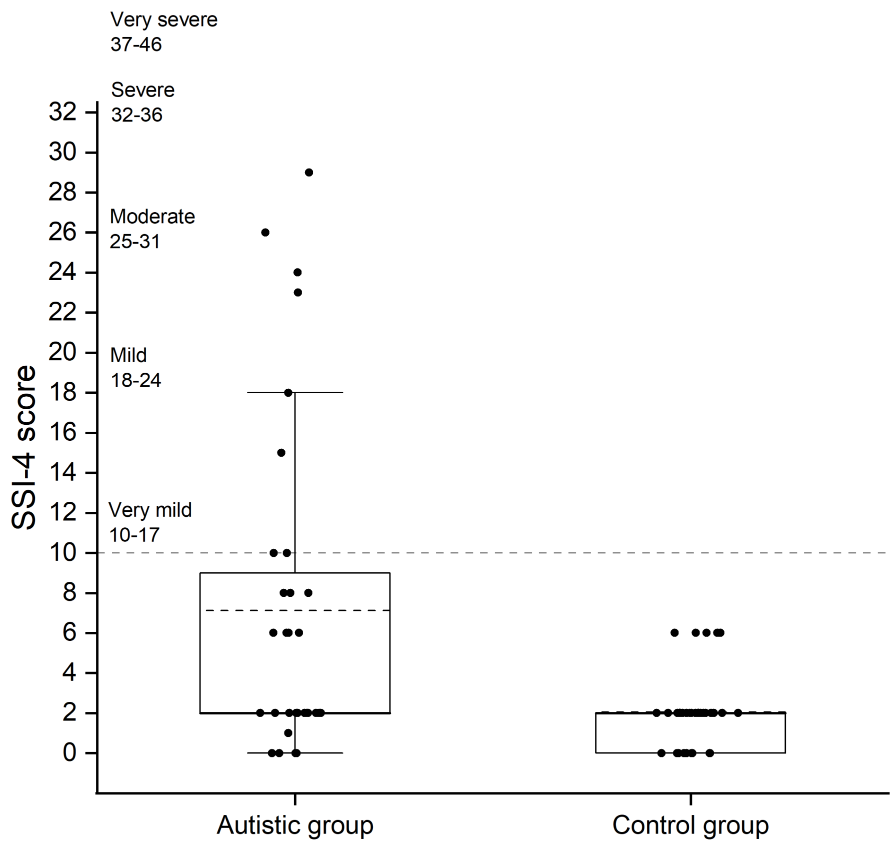
Frequencies for Total Disfluencies, Typical Disfluencies (TD), Stuttering-Like Disfluencies (SLD), and Atypical Disfluencies (AD) per 100 Syllables by Group



Note. Dots represent the group outliers, solid black lines represent the group median, and dashed black lines represent the group mean.

Figure 2

Scores of Stuttering Severity by Group



Note. Each dots represent an individual participant, solid black lines represent the group median, and dashed black lines represent the group mean. The dashed gray line at score 10 represents the SSI-4 threshold for stuttering.