Phonetic and phonological errors in children with high functioning autism and Asperger syndrome

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Abstract

This study involved a qualitative analysis of speech errors in children with autism spectrum disorders (ASDs). Participants were 69 children aged 5-13 years; 30 had high functioning autism and 39 had Asperger syndrome. On a standardised test of articulation, the minority (12%) of participants presented with standard scores below the normal range, indicating a speech delay/ disorder. Although all the other children had standard scores within the normal range, a sizeable proportion (33% of those with normal standard scores) presented with a small number of errors. Overall 41% of the group produced at least some speech errors.

The speech of children with ASD was characterised by mainly developmental phonological processes (gliding, cluster reduction and final consonant deletion most frequently), but non-developmental error types (such as phoneme specific nasal emission and initial consonant deletion) were found both in children identified as performing below the normal range in the standardised speech test and in those who performed within the normal range. Non-developmental distortions occurred relatively frequently in the children with ASD and previous studies of adolescents and adults with ASDs shows similar errors, suggesting that they do not resolve over time. Whether or not speech disorders are related specifically to ASD, their presence adds an additional communication and social barrier and should be diagnosed and treated as early as possible in individual children.

Articulation and phonology skills are often a relative strength in children with autism spectrum disorders (ASDs), with most studies reporting either age-appropriate or superior speech compared to other expressive language abilities (Rapin & Dunn, 2003). Kjelgaard and Tager-Flusberg (2001, p. 287) studied 89 children with ASD and concluded that "among the children with autism there was significant heterogeneity in their language skills, but across all the children, articulation skills were spared". An earlier study by Boucher (1976) reached a similar conclusion. She used the Edinburgh Articulation Test (Anthony, Bogle, Ingram, & McIsaac, 1971) to compare articulation in children with autism, delayed language development and receptive dysphasia. The results showed that the children with autism had superior articulation compared to the children in the other two groups.

However, a recent study by Rapin et al. (2009) has shown that a significant proportion of children with ASD do present with impaired speech. They used standard scores from an articulation test to drive cluster analysis of language abilities in 62 school-aged children with ASD (mean age 8;6) and proposed two main types of language disorders in this age group: severe impairment in expressive phonology (24%) and borderline/normal phonology with impaired comprehension (76%). Since there was no analysis of the actual errors made by the children it is not possible to know whether they were presenting with a delayed or disordered profile.

Some earlier studies suggest that Kjelgaard and Tager-Flusberg (2001) may have been premature in concluding that speech is spared in children with autism. Indeed a small number of studies have shown that children with ASD can have speech difficulties of varying severity (Bartak, Rutter, & Cox, 1975). Bartolucci, Pierce, Streiner and Eppel (1976) investigated articulation in 10 children with autism and found that their speech development was delayed, although it was commensurate with their overall developmental rate. A follow up study by Bartolucci and Pierce (1977) compared speech in children with autism with those with cognitive delay. Their results showed that the speech delays were similar in both groups. The authors concluded that children with autism in general have delayed, but not deviant, speech development. Both of these studies suggest that speech delays are likely to be in line with development of other skills, but McCann et al. (2007) found no relationship between scores on language measures or cognitive measures and standard scores from an articulation test.

Therefore, although people with ASD present with delayed language it is unclear whether this co-occurs with delayed speech.

Moreover, adolescents and adults with ASDs and well developed language skills often produce residual articulation errors. Shriberg, Paul, McSweeny et al. (2001) found that these residual errors were most frequently distortions of specific sounds, such as sibilant dentalization and lateralization, in other words deviant articulations. Shriberg et al. found that, compared to typically developing speakers, significantly more individuals with high functioning autism and Asperger syndrome had residual articulation distortion errors. The presence of residual errors may make listeners judge speech as immature, unusual or at least different from the norm, although these errors may not have a detrimental effect on speech intelligibility.

Some research has suggested that a small number of children with high functioning autism have "extraordinary difficulty producing intelligible speech" (Lord & Paul, 1997, p. 205). An example is a case reported by Wolk and Edwards (1993), who reported an 8-year-old boy with autism whose speech was unintelligible. This child showed both developmental and atypical patterns of phonological development. Koegel, Camarata, Koegel et al. (1998) also reported severe speech disorders in a group of 5 children with autism aged 3;8 to 7;6. Wolk and Giesen (2000) described 4 siblings with autism and found that "autistic children, at least the more severely disordered ones, do not only exhibit delayed phonological behaviour, but also show some atypical patterns that rarely occur in normal development" (p. 371).

In relation to children with severe articulation disorders, Tager-Flusberg, Paul, and Lord (2004), stated that their unintelligible speech often excluded them from research studies and that "little is known about either the existence or the phenomenology of this pattern of development" (p. 205). These authors suggested that further research into the speech abilities of this group is needed. Of particular relevance is whether children with ASD in general have delayed or disordered speech. This is an important distinction because it will affect diagnosis, choice of intervention and prognosis in children who have speech disorders in addition to ASD.

The goal of the present study was to investigate the types of speech errors, both phonetic and phonological, in a group of children with high-functioning autism or Asperger syndrome. Although the findings of other studies conflict, they suggest that either a minority or no children with ASD present with speech disorders, we therefore expected most children with ASD to perform within normal limits on a standardised test of speech. The use of standardised tests enabled us to compare children with ASD disorders to norms for typical children without the addition of a control group. In terms of the phonetic and phonological analysis, the types of processes found in typical development are well documented in the literature, so again a control group was not required.

Method

Participants

The participants were 69 children with ASDs: 30 children with high functioning autism (HFA) and 39 children with Asperger syndrome (AS). HFA and AS are closely related disorders, distinguished here by the presence of preschool language delay in HFA. All of the children were in receipt of special services and were registered on a special needs services database (see Harrison et al. 2006). Diagnosis of both HFA and AS was based on DSM-IV (American Psychiatric Society, 1994) and ICD-10 (WHO, 1993) and made using observational assessment by a consultant (senior) paediatrician and a specialist speech-language pathologist in a multidisciplinary team. A range of assessment tools including the Childhood Autism Rating Scale (CARS, Schopler et al. 1980), Gilliam Autism Rating Scale (Gilliam, 1995) and the Autism Diagnostic Observation schedule (ADOS, Lord et al., 2004) were used (as in Harrison et al. 2006).

Each child's case notes were reviewed in order to exclude children for whom any of the following criteria applied: (1) English was not the child's first language and the main language of the home; (2) there was evidence of current hearing loss; (3) receptive language skills were less than 5 years; (4) there was a major physical disability or structural abnormality of the vocal tract; or (5) the family had lived in Scotland for less than 3 years (as part of a larger research project the children were required to be familiar with the Scottish accent).

Standardised Assessments

The children completed a battery of standardised assessments as part of a larger research project. The current study focused on data from a standardised test of speech – the sounds in words subtest of the Goldman Fristoe Test of Articulation (GFTA-2, Goldman & Fristoe, 2000). This tests accuracy of 39 different English consonants and clusters in single words. All consonants are sampled in word initial, medial and final positions, where appropriate. Errors are transcribed and counted, therefore higher raw scores reflect more errors, the ceiling score (no errors) is zero and the floor score (no correct consonants) is 77.

The children's receptive vocabulary was measured using the British Picture Vocabulary Scale (BPVS-II, Dunn, Dunn, Whetton, & Burley, 1998) and receptive language was measured using the Test for Reception of Grammar (TROG-2; Bishop 2003). Expressive language was measured using the three expressive subtests of the Clinical Evaluation of Language Fundamentals-3^{UK} (CELF-3^{UK}; Semel, Wiig, & Secord, 2000). Children's normal non-verbal ability was confirmed using the Raven's Progressive Matrices (RPM; Raven, Court, & Raven, 1986). A qualified speech-language pathologist, who was experienced in testing children with ASD and in transcribing disordered speech, carried out and scored the assessments. The tests were carried out in one-to-one settings in accordance with the relevant manual instructions and in a suitable location such as a quiet room in a paediatric speech and language therapy clinic, a school or the child's home.

Children were considered to have articulation and phonology in the normal range if their GFTA-2 standard scores were +/- one standard deviation from the mean. The GFTA-2 has a mean of 100 and a standard deviation of 15, therefore scores of 85 or more were considered to be within the normal range and scores of less than 85 were considered impaired. It is relevant to note that, unlike many other language tests, GFTA-2 standard scores are not normally distributed. Whereas for most tests, 16% of the normal population would be expected to gain a standard score less than 85, in the GFTA-2 the percentage is much smaller. The percentage varies with chronological age, but for illustrative purposes, at age 9.6 years (the mean age of participants in this study), a standard score of 85 is equivalent to a percentile rank of 2-3. In other words, 2-3% of the normal population, as opposed to 16%, have a standard score of less than 85. In younger children the percentage expected to achieve a standard score of 85 is obviously greater, therefore at age 5;0 (the minimum receptive language age equivalent of the children) 18% score less than 85.

<u>Phonological and Phonetic Analyses</u>

All errors produced in the GFTA-2 were subjected to a phonetic and phonological analysis which allowed them to be classified as either delayed/ developmental (normally occurring in the speech of at least 10% of children aged 2;0 to 5;11) or disordered/ non-developmental (not occurring in at least 10% of typical children of any age, in other words, unusual errors) using data from Dodd et al. (2002).

Local dialect was taken into account when judging whether an error had occurred. For example, in the central belt of Scotland a glottal stop replaces word medial and final /t/ most of the time (Scobbie, Gordeeva & Matthews, 2007), so when this occurred, it was not counted as an error. Although all of the children's errors were described in terms of processes, this does not necessarily suggest that the errors were the result of a phonological impairment. While it is possible that some errors might be phonological in nature, for example fronting of /k/ to [t], other processes were more likely to be phonetic in nature, for example, lateralisation and other distortions. For the purposes of the analysis all errors were counted together. In addition to calculating the number of times an error type occurred, the number of children displaying an error type three or more times (Dodd et al. 2002) was also calculated. Although each phoneme was only sampled three times in the data, most processes apply to classes of sounds rather than individual phonemes. In the case of phoneme specific nasal emission, this usually affected /s/ which was sampled more than three times due to the inclusion of s-clusters in the test. This enabled us to identify whether errors occurred only occasionally in a child's speech or whether they were more prevalent. It also allowed us to determine how many children in the group presented with each error type.

Results

Standardised Assessments

The scores from the test battery are in Table 1. The table shows that the AS group performed within normal limits on all the language and cognition tests. The HFA group were delayed in all aspects of receptive and expressive language, but within normal limits for cognition, as expected. Using standard scores and Pearson's correlations, the r value for correlations on GFTA-2 with the other tests were non-significant. For the HFA group, r value on GFTA-2 with CELF-3UK was -.062, (p=.748); BPVS-II was .084 (p=.654); TROG-2 was -.241 (p=.191). For the AS group, r value on GFTA-2 with CELF-3UK was .083, (p=.610); BPVS-II was .037 (p=.823); TROG-2 was -.092 (p=.571). The results do not indicate a relationship between speech and other language skills or between speech and cognition in the children with ASD.

Table 1 about here

GFTA-2 Scores

Based on GFTA-2 raw scores, 28 children with ASD (41%, N=69) produced errors. Out of this group of 28, based on the GFTA-2 standard scores, 20 children had speech within the normal range and 8 children had speech that was outwith the normal range. Of these 6 had a diagnosis of HFA and 2 had a diagnosis of AS. There was no significant correlation between GFTA standard scores and chronological age (r=.011, p=.926), or between GFTA raw scores and chronological age (r=-.221, p=.064).

Phonetic and Phonological Analyses.

A total of 228 errors were produced by participants (M=3.30, SD=12.26). In the group as a whole, 24 different error types were identified. Of these 24 different error types, only 12 were evident at least three times in the speech of one or more children. Figure 1 shows the frequency of the 12 different error types; Figure 2 shows the number of children producing each error type at least three times. In both figures developmental processes are marked with white bars and disordered processes/errors are marked with black bars.

Insert Figures 1 and 2 here

The most common process was gliding (25% of the errors, 7 children), followed by cluster reduction (15% of the errors, 3 children) and final consonant deletion (10% of the errors, 2 children). These three processes are found frequently in typically developing children, with gliding usually resolving by 5;11, cluster reduction by 4;11 and final consonant deletion by aged 2;0 (Dodd et al., 2002). The majority of processes (82%, paired samples t-test, t(70)=2.268, *p*=.026) exhibited by the children with ASD in our study were those found in younger typically developing children, as defined by Dodd et al. (2002), suggesting a mainly delayed pattern of development. Some errors occurred in just one child out of the whole group; of these, three errors were developmental (stopping, velar fronting and context sensitive voicing) and three were non-developmental (backing of alveolar stops to a velar place of articulation, phoneme specific nasal emission and dentalisation of sibilants). The Appendix shows examples of developmental and non-developmental errors.

GFTA-2 Scores and Error Types.

Children with standard scores on the GFTA-2 in the normal range inevitably and predictably produced fewer errors (M=1.06, SD=2.44) than children with standard scores below the normal range (M=20.13, SD=17.72), this difference was significant ($t(7.034)=-3.040$; $p=.019$). Looking only at the 28 children who produced errors, there were 20 children with standard scores within the normal range, and 8 children with standard scores out with the normal range. Of the 20 with standard scores in the normal range, 11 children produced developmental errors only; five children produced non-developmental errors only and four children produced both types. In this group, 70% of errors were developmental in nature but because the number of errors was small (M=3.35, SD=3.36), there was no significant difference between the number of developmental and non-developmental errors ($t(19)=1.406$; $p=.176$). Again, gliding was the most frequent error type, but 1 child also presented with non-developmental errors of lateral sibilants and another with phoneme specific nasal emission, despite having standard scores in the normal range.

In the group of 8 children with standard scores outwith the normal range, 3 children produced developmental errors only; 1 child produced non-developmental errors only and 4 children produced both types. Table 2 shows the types of errors produced 3 or more times by this group of 8 children. Again, most (74.68%) errors were developmental in nature, but this time the higher frequency of developmental errors compared to non-developmental errors was significant ($t(7)=2.817$; $p=.025$).

Insert Table 2 Here.

Discussion

Previous literature has suggested that articulation and phonological skills are a relative strength in children with ASD (Kjelgaard & Tager-Flusberg, 2001; Rapin & Dunn, 2003). However, this conclusion could be an underestimate of the extent to which these children experience difficulties with this aspect of speech and language. One possible explanation for studies underestimating the number of children may relate to methodology used to identify difficulties. In large N studies, such as those conducted by Kjelgaard and Tager-Flusberg (2001) and Rapin et al. (2009), single word articulation tests were scored only on a right/wrong basis, giving no information about the nature of the errors. Moreover, typically developing children of school age, or at least over the age of 7-years, are expected to score at ceiling level. However, the two studies of Rapin et al. and Kjelgaard and Tager-Flusberg, reported that many children made a small number of errors. The finding that many children with autism make a small number of errors is consistent with the results of our study, where a sizeable proportion (41%) had a small number of errors in their speech. In children of school age, with and without ASD, even a small number of errors can constitute a significant speech disorder, or at least make their speech stand out as different from their peers.

We found that a minority of children (12%) with ASDs performed below the normal range on this standardised test of articulation, although the percentage of children producing a small number of errors was much higher than this (41%). Unlike previous studies of larger groups of children with ASDs, we analysed the types of errors made by the children. Most errors were developmental in nature, suggesting a pattern of delayed speech, although the fact that GFTA-2 scores were not correlated with scores on other language tests suggests that the delayed speech may not be part of an overall language delay.

Non-developmental errors occurred in the speech of children with ASD regardless of whether their GFTA-2 standard scores were within or outwith the normal range. Despite some children having standard scores in the normal range, it was possible for them to produce errors consistently. The GFTA-2 samples each consonant a maximum of three times, (initial, medial and final word positions) unless it appears in a consonant cluster. However, should a child make an error on one phoneme in each word position (resulting in a raw score of three) he or she will still achieve a standard score in the normal range. Several children therefore produced errors consistently but achieved normal scores. For example, one child aged 7;5 used the developmental process of post-alveolar fronting consistently (/ʃ/ produced as [s]) but achieved a normal standard score even though [ʃ] is usually acquired by 5;0 to 5;5 (Dodd, 2005). Where errors occur on phonemes that are frequent in the ambient language, such as /s/, the impact on speech is more pervasive and noticeable to listeners than for errors affecting less frequently occurring phonemes, such as affricates. For example one child with a standard score in the normal range consistently produced /s/ as a voiceless lateral fricative (a lateral lisp), because /s/ is a frequently occurring phoneme (Shriberg and Kwiatkowski, 1982) this results in speech that is noticeably different from the norm.

The finding that some children produce atypical, non-developmental, errors supports evidence from previous research of deviant speech development in some children with ASD (Wolk & Edwards, 1993; Wolk & Giesen, 2000). Two children in our sample showed the deviant pattern of phoneme specific nasal emission (Peterson-Falzone & Graham, 1990). This deviant speech pattern was due to abnormal learning and involves nasal emission during specific speech sounds, (e.g., /s/ and /z/), with air emitting from the nose instead of the mouth during production. This unusual speech pattern has not been reported in typically developing children and only rarely reported in children with phonological or articulation disorders (Peterson-Falzone & Graham, 1990). To our knowledge, this is the first time phoneme specific nasal emission has been reported in children with ASD. Interestingly, one of the children who produced this error achieved a standard score in the normal range. This highlights the need to analyse the errors made by the children, as a normal score does not necessarily indicate normal speech.

Distortions such as phoneme specific nasal emission and lateralisation may affect the social acceptability of speech even if the overall intelligibility of speech is not reduced. The children who produced these distortions made no other types of errors. Shriberg et al. (2001) reported similar “residual articulation errors”: dentalised sibilants, derhoticisation (for American speakers), lateralised sibilants and labialised /l/, in their sample of 30 adolescents and adults with ASDs. The participants in the Shriberg et al. study (2001) were on average older than our participants, suggesting that non-developmental distortions such as these may persist in people with ASDs. Moreover, we found no correlation between chronological age and number of speech errors, suggesting that non-developmental distortions occur relatively frequently in the speech of children and adults with ASDs and do not appear to resolve over time. Articulation distortions, like abnormal prosody, may not necessarily affect intelligibility, but they nevertheless represent a significant additional social and communication barrier for people with ASD.

In our study we found both errors that are usually described as phonological (for example, velar fronting) and errors that are usually described as phonetic (for example distortions such as lateral sibilants). It is important to note that although many errors could be described in terms of known phonological processes this does not necessarily mean that the errors are caused by a phonological or cognitive impairment, although it is possible that for at least some children a phonological impairment exists alongside an ASD diagnosis. Since no correlation was found between language skills and the number of errors, delayed language is not an obvious cause of delayed articulation. However, it is still possible that a history of early language delay, or a difference in language learning environment, specifically less reciprocal interaction (a core feature of ASDs) may play some part in the speech difficulties we described. For example, children with ASD may be less likely to respond to modelling of correct speech since they have difficulty with social interaction.

Another possible explanation for the difficulties in speech experienced by the children with ASD in this study is that they are due to an underlying neuromotor difficulty. This could help to explain the distortions seen in both our study and the Shriberg et al. study (2001) of adolescents and adults with ASD. Some support for this explanation comes from a study by Amato and Slavin (1998) who assessed oromotor development in children with autism and found a variety of oromotor difficulties to be present. In addition, Noterdaeme, Mildenberger, Minow and Amorosa (2002) found that children with high functioning autism had more motor problems than control children on most of the neurological subsystems they investigated.

Page and Boucher (1998) also found a high incidence of oromotor impairments in a group of children with autism. These authors found that children with autism had manual and gross motor impairments, but these were less affected than oromotor skills. Rapin (1996) found that, despite the exclusion of children with identifiable neurological findings, 30% of children with autism had mild-to-moderate sensorimotor deficits (mostly apraxia). Rapin found that, overall, the children had a higher rate of oromotor impairments compared to a group of children with specific language impairments. Rapin reported that, although intelligibility and oromotor functioning were highly correlated, some children with poor intelligibility did not have associated oromotor impairments. Rapin suggested that this could be explained by the fact articulation programming and oromotor functioning are independent skills, although both could potentially contribute to children having speech difficulties. Children’s oromotor skills were not assessed in the present study, so it may be that the children in the current study who had speech disorders also had poor oromotor skills, suggesting this should be an important line of investigation in future research.

Conclusion

While only 12% of children with ASD in this study presented with standard scores indicating a speech delay/ disorder many more (41%) children presented with a small number of errors. In some cases, such as the child with phoneme specific nasal emission, this leads to highly unusual sounding speech.

The speech of children with ASD is generally characterised by developmental phonological processes, but non-developmental or unusual error types are found both in children identified as performing below that normal range in a standardised articulation test and in children who present with scores outwith the normal range. Whether or not speech disorders are related specifically to autism, their presence adds an additional communication and social barrier and should be diagnosed and treated as early as possible in individual children.

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Appendix. Examples of developmental and non-developmental errors from children with ASD

Child	Target	Transcription	Error type	Process
1	house	[haʊfŋ̊]	Non-developmental	Phoneme Specific Nasal Emission
	swimming	[fŋ̊ɪmɪn]	Non-developmental	Phoneme Specific Nasal Emission
	spoon	[fŋ̊pʉn]	Non-developmental	Phoneme Specific Nasal Emission
2	fishing	[fɪsɪn]	Developmental	Post-alveolar fronting
	jumping	[ʒʌmpɪn]	Developmental	Deaffrication
	flowers	[faʉʌɹz]	Developmental	Cluster Reduction
3	glasses	[gwasɪz]	Developmental	Gliding
	telephone	[tɛwɪfon]	Developmental	Gliding
	flowers	[faʉʌɹz]	Developmental	Cluster Reduction
4	rabbit	[wabɪt]	Developmental	Gliding
	blue	[bʉ]	Developmental	Cluster Reduction
5	knife	[mːaɪf]	Non-developmental	Labialised and prolonged
	brush	[gw̤ʌs]	Non-developmental	Backed
6	shovel	[çʌdl̩]	Non-developmental	Palatalised
	tree	[çi]	Non-developmental	Palatalised

Table 1. Mean chronological age (CA) and standard scores (standard deviations in brackets) for test battery completed by children with autism spectrum disorders.

Participants	CA yrs/mnths	BPVS-II	TROG-2	CELF-3^{UK}	GFTA-2	RPM
High functioning autism (n=30)	9.6 (2.4)	81.3 (15.8)	80.1 (17.4)	70.5 (8.9)	93.4 (19.3)	97.7 (15.0)
Asperger's syndrome (n=39)	9.5 (2.1)	101.8 (17.0)	104.5 (17.0)	94.6 (20.2)	103.4 (7.0)	107 (13.9)

Key. Tests measured receptive vocabulary (British Picture Vocabulary Scale, BPVS-II), receptive language (Test for Reception of Grammar, TROG-2), expressive language (Clinical Evaluation of Language Fundamentals, CELF-3^{UK}), articulation (Goldman Fristoe Test of Articulation, GFTA-2), and cognition (Raven's Progressive Matrices, RPM).

Table 2. Errors produced three or more times by children with standard scores outwith the normal range.

Key. GFTA SS= standard score on the Goldman Fristoe Test of Articulation 2.

		Number of Developmental Errors							Number of Non-Developmental Errors					
Child	GFTA SS	Gliding	Velar Fronting	Post Alveolar Fronting	Stopping	Context Sensitive Voicing	Cluster Reduction	Final Consonant Deletion	Sibilant Dentalisation	Backing	Palatalisation	Phoneme Specific Nasal Emission	% Developmental	% Non-Developmental
1	40	6				3	4						100	0
2	40	4	6		10		13	13		3	3		88.46	11.54
3	59	7		3			3	3					100	0
4	61	12											100	0
5	74											6	0	10
6	74	4		8									100	0
7	82								9				0	100
8	83			7									100	0

Captions for Figures

Figure 1. Frequency of error types produced by participants. White bars show developmental processes, black bars show non-developmental processes.

Figure 2. Number of children producing each error type at least three times. White bars show developmental processes, black bars show non-developmental processes.

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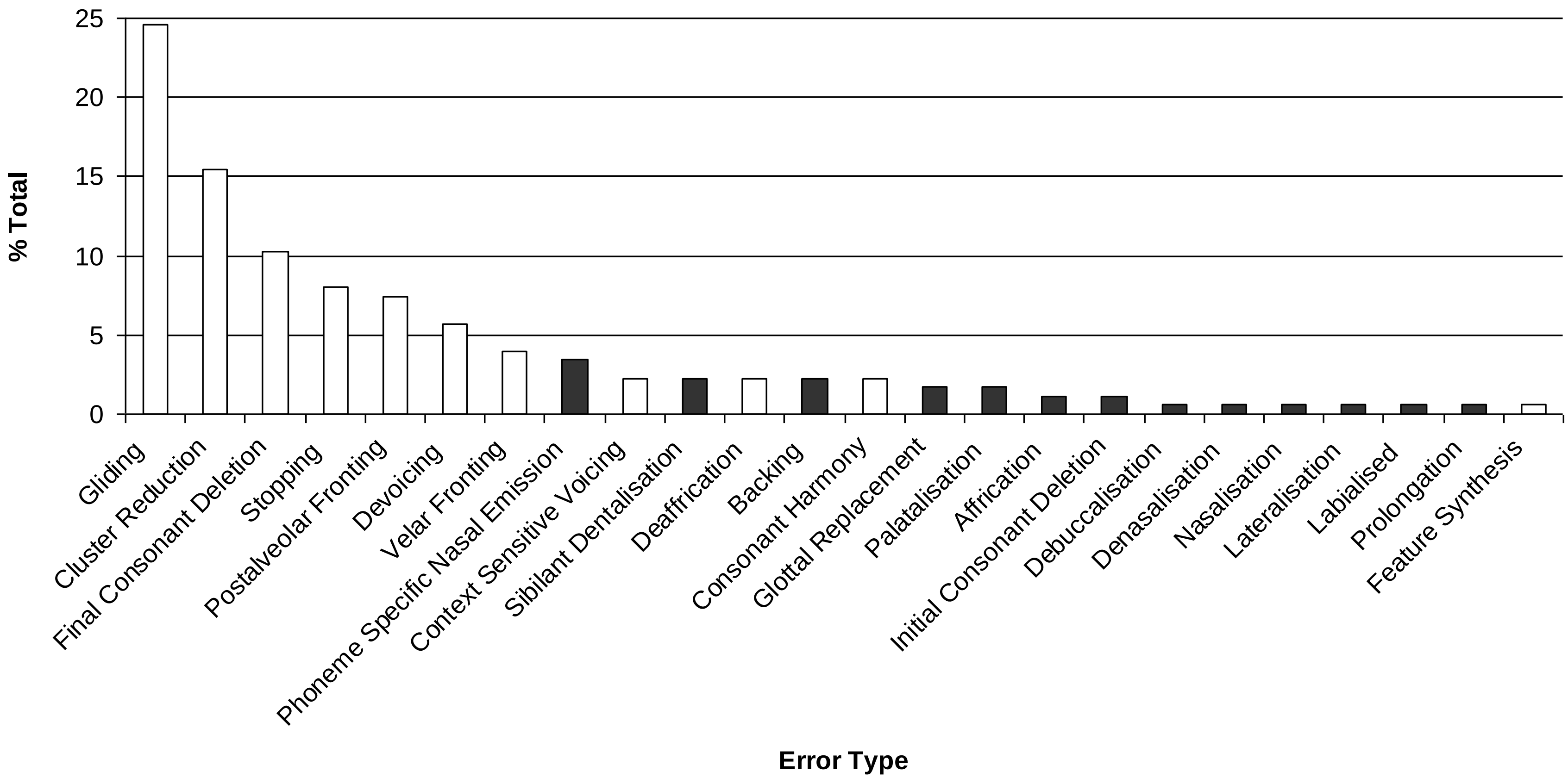

Figure 2. Number of children producing each error type at least three times. White bars show developmental processes, black bars show non-developmental processes.