Differentiating Speech Delay From Disorder
Does it Matter?

Barbara Dodd

Aim: The cognitive-linguistic abilities of 2 subgroups of children with speech impairment were compared to better understand underlying deficits that might influence effective intervention. Methods: Two groups of 23 children, aged 3;3 to 5;6, performed executive function tasks assessing cognitive flexibility and nonverbal rule abstraction. Following the system of differential diagnosis of speech disorders first described by Dodd, Leahy, and Hambly (1989), one group was identified as having delayed speech development, as their non–age-appropriate speech error patterns were typical of younger children. The other group was diagnosed as disordered because children consistently used at least one speech error pattern atypical of any age group in an assessments’ normative sample (Dodd, Zhu, Crosbie, Holm, & Ozanne, 2002). Results and Conclusions: The disordered group performed less well than the delayed group: They had poorer cognitive flexibility and difficulty abstracting nonlinguistic rules. They made more consonant errors and different types of errors. The 2 groups did not differ on measures of language, vowel accuracy, or consistency of multiple productions of the same words. The findings suggest that different interventions, reflecting knowledge of underlying deficits, might benefit specific subgroups of children with speech impairment. Key words: cognitive flexibility, error patterns, executive functions, speech delay, speech disorder

All young children make errors when pronouncing words (e.g., [pun] spoon; [tæt] cat). Most children of a particular age share the same error patterns, with different error patterns characterizing specific age bands. In English, for example, stop may initially be pronounced as [tn], followed by [tnp], then correctly as [stnp]. English-speaking children’s speech comes to resemble the adult-target production by around 5 years. Researchers have argued that error pattern change indicates linguistic reorganization of the phonological system that occurs in a systematic order, within specific time frames and without explicit instruction (Grunwell, 1977; Macken, 1979; Williams, 1993). Reorganization reflects cognitive-linguistic development that allows children to identify the phones, contrasts, and phonotactic constraints of the language being learned.

Although most children exposed to the same language use error patterns that resolve at somewhat similar ages (Grunwell, 1997; Preisser, Hodson, & Paden, 1988), this is not the case for all children. The most common diagnosis made by clinicians working with pediatric caseloads is speech impairment.1 Children’s errors make their speech difficult
differentiating speech delay from disorder to understand resulting in communication breakdowns that place them at risk for social and academic, particularly literacy, failure (Gillon, 2004). The National Institute on Deafness and Other Communication Disorders (1994) estimated that 10% of children receive intervention for impaired speech intelligibility in the United States. An incidence survey of a speech-language pathology service in England (Broomfield & Dodd, 2004a), reported that 6.4% of all children are treated for speech impairment.

Successful intervention for speech impairment relies on clinicians’ knowledge of the nature of the deficit underlying children’s impairment (Stackhouse & Wells, 1997). Although some children with speech impairment have been shown to have deficits in input (e.g., Boets, Ghesquiere, van Wieringen, & Wouters, 2007) or output (e.g., motor processing, Gibbon, 1999), many researchers have argued that most children’s speech impairment reflects a linguistic (i.e., phonological) impairment (Bowen, 2010; Gierut, 1998; Stackhouse & Wells, 1997; Vihman, 1996). This hypothesis was examined by a study comparing the auditory-visual speech perception, oral-motor ability, and cognitive-linguistic processing skills of 78 children with speech impairment (mixed delay and disorder) and 87 age-matched controls aged 3 to 6 years (Dodd & McIntosh, 2008). No child in the group with speech impairment was identified as having an input difficulty, and only two children performed below the normal range on an oral sequenced-movements task. In contrast, the group with speech impairment performed significantly less well than controls on both cognitive-linguistic tasks of rule abstraction and cognitive flexibility.

This article examines the processes of cognitive flexibility and rule abstraction in children with speech impairment. The literature review first highlights the importance of the role of cognitive-linguistic abilities for typical phonological development followed by a summary of findings from research comparing children with delayed as opposed to disordered speech impairment. Delayed speech development is defined by the presence of speech error patterns, each observed in at least five different lexical items in a 50-word picture-naming task, that are typical of at least 10% of children of a younger chronological age in the normative data for that standardized assessment. To be classified as having disordered speech, children must evidence at least one speech error pattern, identified as occurring at least five times in different lexical items in the 50-word task, that is atypical of any age group in the normative sample for the assessment.

Typical speech development

Three primary factors are posited as alternative explanations for developmental errors in speech during the acquisition of phonology: output, input, and cognitive linguistic processing.

1. Output approaches: Motor theory holds that children gradually master the intricacies of sequencing complex articulatory movement that reflects more general motor maturity (e.g., Green, Moore, & Reilly, 2002). For example, McCune and Vihman (2001) argued that children establish “vocal motor schemes” for consonant production that influence the error types made in early phonological development.

2. Input approaches: Immature input processing has been claimed to explain developmental errors. Some researchers argue that, as children’s ability to discriminate differences between the speech sounds of their native language gradually improves, it allows more accurate production (e.g., Edwards, Fox, & Rogers, 2002). Discrimination tasks might, however, evaluate phonological learning rather than auditory-visual speech perception. For example, Burnham,
Earnshaw, and Clark (1991) showed that the development of the ability to discriminate speech sounds is “tuned” post infancy. The infant ability to discriminate contrasts not relevant to their native language (Jusczyk, 1992) is lost so that children older than 2 years are unable to discriminate between similar sounds that are not native language phonemes.

3. Cognitive-linguistic processing approaches: Cognitive-linguistic approaches propose that children’s ability to process speech changes over time, reflecting the development of other general mental abilities such as phonological working memory (Adams & Gathercole, 2000), processes for forming and revising lexical representations (Elbro, 1993), and/or cognitive capacities for rule abstraction (Dodd & Gillon, 1997).

We studied the contribution of input, output, and cognitive-linguistic abilities to phonological development in one group of 2-year-old children (Dodd & McIntosh, 2010). We measured the perception of conflicting heard and lip-read speech, production of isolated and sequenced oral-motor movements, and verbal and nonverbal rule abstraction abilities of 62 children aged between 25 and 35 months. All three domains were shown to contribute to phonological accuracy, although regression analyses showed that the contribution of rule abstraction ability to phonological accuracy exceeded that of both input and output factors. The findings were interpreted as evidence for cognitive-linguistic ability being the primary determinant of 2-year-olds’ phonological development. It seems likely, then, that children who are classified as speech disordered because they abstract nondevelopmental phonological constraints would perform more poorly on measures of rule derivation than children whose phonology is merely delayed. Consequently, the current article focuses on the difference between the cognitive-linguistic abilities of children with delay as opposed to disorder.

**Speech impairment**

Children with speech difficulties are heterogeneous, differing in severity, underlying cause, speech error characteristics, profile of associated abilities and response to treatment. In Broomfield and Dodd’s (2004b) incidence study, 320 children with speech difficulties were assessed. Of this group, 12.5% had an *articulation disorder*, which was defined as an inability to produce a perceptually acceptable version of phones due either to a physiological condition such as dysarthria or mislearning of the sounds’ motor program (e.g., lisp). Most of the children assessed (57.5%) had a phonological delay characterized by all errors being accounted for by phonological error patterns (e.g., cluster reduction and fronting) that occur during typical speech development at a younger chronological age level. Children who used one or more error patterns that were atypical of normal development in English (e.g., backing, favored sound, and initial consonant deletion) were classified as having consistent atypical phonological disorder. This group, constituting 20.6% of the 320 children referred, made a significantly greater number of errors than the children with articulation difficulties and delayed phonology. An additional 9.4% of children pronounced the same lexical item using different error forms on at least 10 of the 25 words that were assessed three times within one assessment session (see Dodd, Holm, Crosbie, & McIntosh, 2010).

The focus of this article is on two of the subgroups of children with speech impairment described by Broomfield and Dodd (2004b): delay and disorder. The reasons for choosing these two groups are that they are the two largest subgroups (57% and 21%), and they are similar in that they have no oral-motor difficulties, but their speech is characterized by the consistent use of non-age-appropriate phonological error patterns. Previous research on these two groups can be compared on four parameters: associated abilities, literacy, natural history, and response to intervention.
**Associated abilities**

Auditory-visual speech perception is demonstrated by an illusion (McGurk & MacDonald, 1976) that occurs when listeners perceive /ta/ although hearing /pa/ in synchrony with the lip movements for /ka/. Dodd, McIntosh, Erdener, and Burnham (2008) compared 22 children with delayed speech development with 12 children whose speech was disordered, on a same–different judgment task assessing perception of the illusion. Neither group perceived many illusions. Children with disorder, however, usually reported the auditory component of the illusion, whereas the responses of those with delay were more evenly split between the auditory and visual components of the illusion. These findings indicated that children with disordered speech differed in their phonological processing of the auditory-visual speech illusion from children with phonological delay. One plausible hypothesis is that the children with disordered phonology had difficulty learning the consistent relationships between heard and seen speech.

Phonological awareness refers to the ability of children to implicitly acquire knowledge of the phonological constraints (i.e., how speech sounds can be combined to make words) of the language they are learning (Stackhouse & Wells, 1997). Sound sequences that do not conform to those constraints are termed “illegal.” Phonological legality tasks are often used to assess children’s knowledge of the phonological system (Stackhouse & Wells, 1997). Children might be asked, for example, to choose between two nonsense names that differ by one phoneme, making one word phonologically legal and the other illegal (e.g., [frim] and [srim] as a name for a monster). Research has indicated that children with phonological delay perform like typically developing peers, showing a significant preference for phonologically legal words, whereas children with disorder (who make consistent errors) perform at chance level on this task (Dodd, Leahy, & Hambly 1989; Harris, Botting, Myers, & Dodd, in press).

**Literacy**

It is well established that children with speech impairment are, as a group, at risk for literacy difficulties, as has been shown by studies comparing children with impaired speech and typically developing controls (e.g., Snowling, Adams, Bishop, & Stothard, 2001). Other studies have examined the literacy abilities of children with impaired speech in greater depth in an attempt to understand why a significant number of children with impaired speech learn to read and spell without difficulty (Leitao & Fletcher, 2004). Surface speech errors may allow identification of deficits underlying differences in literacy development. One recent study (Harris et al., in press) investigated the relationship between type of speech impairment, phonological awareness and literacy in children aged 5:2 to 7:9. The children had either delayed phonology ($n = 8$), disordered phonology ($n = 5$), or were typically developing controls ($n = 6$). They were compared on tasks measuring syllable and onset-rime awareness, letter knowledge, phonological rule knowledge, and real-word and nonword reading. Children with delayed speech development performed like typically developing controls on all phonological awareness and reading measures. Children with speech disorder, who consistently made errors atypical of normal development, had difficulties on all phonological awareness tasks with the exception of syllable awareness. None of the children with disorder could read and they showed no measurable emergent reading ability such as letter recognition.

Findings from this small-scale study reflect previous research. For example, Leitao and Fletcher (2004) reported that children with speech impairment who made errors atypical of normal speech development have the most difficulty acquiring literacy. Leitao, Hogben, and Fletcher (1997) had previously found that a mixed group of children with speech disorder and delay differed...
significantly from a control group on all measured aspects of phonological awareness, supporting the notion that speech difficulty is associated with impaired development of phonological awareness skills. Further analysis, however, showed a bimodal distribution. A proportion of children with speech impairment achieved scores similar to those of the controls, whereas the remainder showed significant difficulty with all tasks. No correlation was found between severity of speech impairment and phonological awareness. Nine of the eleven subjects who had consistent phonological disorder were found to have severe phonological awareness difficulties compared with one in seven of the phonologically delayed group who performed like controls. These findings might explain conflicting reports in the literature about the relationship between speech impairment, phonological awareness, and literacy.

**Natural history**

Risk factors for speech impairment have received increased attention in the search for genetic markers (Shriberg et al., 2005). One study of 100 German-speaking children with speech impairment (Fox, Dodd, & Howard, 2003) indicated that children with delay were more likely to have a reported history of more than four episodes of middle-ear infection with effusion than controls or other children with speech impairment. The only risk factor for children with consistent disorder was reported history of speech disorder in the family.

Measurement of spontaneous progress without treatment is rarely possible because of ethical concerns. One small study assessed Putonghua-speaking children in a Beijing nursery, where no speech-language pathologist services were available. The first assessment identified two children who made consistent atypical errors and three children with phonological delay according to developmental norms (Zhu, 2002). At a second assessment, 9 months later, the disordered children remained disordered, whereas one of the children with delay now made age appropriate errors and a child who had previously made age appropriate errors was diagnosed with delay. Another study of children on a 6-month waiting list for speech therapy in the United Kingdom showed that children with speech disorder did not make progress without intervention, whereas children with delay did (Broomfield & Dodd, 2005).

**Response to intervention**

Stackhouse and Wells (1997) argued that only treatment targeting the speech-processing deficit underlying a child’s speech disorder will result in efficient systemwide change. One clinical trial (Alcorn, Jarrett, Martin, & Dodd, 1995) reported the outcome of a 2-week intensive whole language therapy for 12 children who had delayed or disordered error patterns. There was a significant improvement in receptive vocabulary, number of words pronounced accurately in spontaneous speech, and phone repertoire between pre- and postprogram and maintenance measures. There was no change, however, in the number of atypical error patterns used, or the number of atypical errors made, suggesting that although whole language intervention led to positive change for delay, disordered speech showed limited change. Both delayed and disordered phonology, however, can be successfully addressed by phonological contrast intervention (Dodd et al., 2008).

**Research hypotheses**

The research reviewed indicates that different deficits may underlie delayed and disordered subgroups of speech impairment. Differences are reported for the two groups’ profiles of associated abilities, literacy, natural history of acquisition, and response to therapy (although this factor provides the weakest evidence). Two symptoms mark the difference between the two groups: the type of speech error patterns used and the number of speech errors made. Children with disorder use some error patterns that do not occur during typical phonological development. This may reflect an impaired ability to abstract the rule-based system of constraints that
governs each language’s phonological system. It is hypothesized that children with consistent speech disorder will perform less well than children with delayed phonological development on measures of rule abstraction and cognitive flexibility.

METHODS

Participants

The data presented in this article come from 46 children drawn from a large-scale study that examined preschool children’s speech development. In the larger study, the input processing, executive function and oral-motor abilities of 275 children were assessed (see Dodd & McIntosh, 2008). All children were referred to the large study by their parents following advertisements in preschools, childcare centers, and parish newsletters in Brisbane, offering free assessment of speech and language abilities by qualified speech-language pathologists. In this article, data are reported for a subset of children from that large study. The children included were all children identified as having delayed speech development \((n = 23)\) and children with disordered speech development \((n = 23)\) who were selected from the data base to be closely matched for age and gender.

The 23 children who were diagnosed with delayed speech development met the following criteria:

1. Performance more than 1 SD below the mean on a standardized speech assessment (The Diagnostic Evaluation of Articulation and Phonology—DEAP; Dodd, Zhu, Crosbie, Holm, & Ozanne, 2002) on measures of percent consonants correct (PCC);

2. All speech error patterns identified as occurring at least five times in different lexical items were typical of a child of a younger chronological age;

3. When naming the 50 words of the DEAP’s phonology subtest, no child made more than four atypical errors, on the basis of normative data where an atypical error pattern was one identified in fewer than 10% of the population (e.g., backing of alveolar stops, initial consonant deletion).

The children with delay were matched pairwise, as far as possible, for age and gender with children diagnosed as having phonological disorder. The diagnostic criteria for disordered rather than delayed speech development were as follows:

1. Performance more than 1 SD below the mean on the DEAP (Dodd et al., 2002) on measures of PCC;

2. Children consistently used at least one speech error pattern, identified as occurring at least five times in different lexical items, that was atypical of any age group in the normative sample for the DEAP (Dodd et al., 2002). In addition, many of these children evidenced error patterns typical of children of a younger chronological age.

All children had language abilities within normal limits as determined by standardized assessment (The Quick Test of Language, McIntosh & Liddy, 2006; see materials section). Apart from language disorder, other exclusion criteria were bilingualism, current hearing impairment, and neurological or cognitive impairment. There were more boys than girls in the sample: 11 girls and 35 boys. The mean age of the children with speech delay was 4;7 \((SD: 8\) months; range 41–66 months). For the disordered group the mean age was 4;4 \((SD: 7\) months; range 39–65). A one-way analysis of variance (ANOVA) showed that there was no significant difference in chronological age between the delayed and disordered groups; \(F(1, 44) = 2.556, p = .117\).

Case history information was gained by asking parents to complete a questionnaire when they signed consent forms. Socioeconomic status was determined by completed years of mothers’ education (Hoff & Tian, 2005). For the mothers of children with speech delay, 29% had completed 11 years and 62% had completed tertiary education (16 years), in comparison to 17% and 52% for mothers of the children with disordered speech. The number
of children who had a history of treatment for ear infections was 30% for the delayed group and 52% for disordered group. The proportion of children with a reported family history of speech or language difficulties was 40% for the delayed group and 48% for the disordered group. Of the children with delay, 39% were first born in the sibling order compared with 35% of children with disorder. Statistical analyses are not reported for these data because of small numbers, which may account for the slightly lower than expected reports of family history of communication difficulty for the disordered subgroup. However, apart from unexpectedly low levels of reported otitis media with effusion for the delayed children, the groups seem reasonably well matched.

Procedure

The children were assessed in their home, at their preschool, or in their child-care center in a relatively quiet space, in two 30-min sessions, usually on the same day. In one session, their speech ability was assessed using all subtests of the DEAP (Dodd, Zhu, Crosbie, Holm, & Ozanne, 2002), as well as assessment on the Flexible Item Selection Test (FIST; Jacques & Zelazo, 2001) and a language screening measure (Quick Test of Language; McIntosh & Liddy, 2006). In the other session, they were asked to perform the input processing task and a rule abstraction executive function task. The order of presentation of the tasks was randomized within sessions. Data on the groups’ performance on the input tasks are reported elsewhere (see Dodd et al., 2008) and discussed in the introduction to this article. Few children performed below the normal range on oral-motor tasks and those data were presented in Dodd and McIntosh (2008). This article presents data from the speech assessment and executive function tasks.

Materials

The Quick Test of Language

The children’s language skills were assessed using the Quick Test of Language (McIntosh & Liddy, 2006), a screening test standardized on population of Queensland children. This test is based on Blank, Rose, and Berlin’s (1978) concept of four language levels. Level 1 includes reporting and responding to salient information, for example, “What is this called?” (pointing to a picture of a toothbrush). Level 2 involves reporting and responding to delineated and less salient clues, for example, “What do we do with it?” (pointing to a picture of a toothbrush). Level 3 assesses the use of language to restructure perceptual input and inhibit predisposing responses, for example, “At the farm, a boy saw something that was not an animal. What could he have seen?” The most difficult level involves the use of language to predict, reflect on, and integrate ideas and relationships, for example, “Why can’t the girl reach the cat?” (pointing to a picture of a cat on a roof and a girl crying). The test has a total of 30 randomized stimulus questions, where 21 questions have a pictorial stimulus. Children start and finish with a Level 1 question to give a feeling of success. The test takes 10 min to administer and has been shown to have good reliability and validity (McIntosh & Liddy, 2006).

Diagnostic Evaluation of Articulation and Phonology

The standardized speech assessment used consists of five subtests that enable the tester to differentiate between disorders of articulation (organic and functional), delayed phonological development, consistent and inconsistent phonological disorder, and childhood apraxia of speech. All children first completed the Diagnostic Screen and the Oro-Motor Test (diadochokinetic test, isolated and sequenced oromotor movement). In the original large scale study, those children performing within normal limits on the Diagnostic Screen were allocated to a typically developing control group (see Dodd & McIntosh, 2008); their data are not reported in this study. Those who failed the Diagnostic Screen were given the Phonology Assessment, allowing calculation of PCC, single words versus connected speech agreement, and description of error patterns. Children identified as
producing speech characterized by multiple error forms for the same lexical items on the Diagnostic Screen, were also administered the Inconsistency Assessment. Children who scored above the criterion of 40% inconsistency were excluded from the analyses presented in this article.

**Flexible Item Selection Test (FIST)**

Flexible Item Selection Test (FIST; Jacques & Zelazo, 2005) was designed as a measure of executive function. Children are shown three pictures (e.g., a large red boat, a large yellow boat, and a large yellow shoe) on 21 × 29.7 cm white cards (printed version of the computerized FIST; Jacques & Zelazo, 2005). Children were asked to “Show me two pictures that go together” (Selection 1). In this trial, children needed to match two pictures by pointing to ones that were the same shape (e.g., both boats), or by color (e.g., both yellow); size was not a relevant cue in this trial. Children were then given an acknowledgement irrespective of response accuracy and the next instruction “Well done. Now show me two other pictures that go together” (Selection 2). Children had to reselect one of the pictures indicated in Selection 1 and match it with another picture on a different conceptual dimension. For example when shown a card with a large red teapot, a small red teapot, and a large red shoe, children might first select the two pictures with the same shape (teapots) and when asked for another two pictures that went together, select the two large items (matching size). Color is an irrelevant cue in this trial because all pictures are red.

On each trial, then, participants were shown three items devised from a combination of three dimensions: color, shape, and size. There were three cues within each dimension: color—red, blue, and yellow; shape—boat, shoe, and teapot; size—small, medium, and large. In each trial, two dimensions were relevant for matching (e.g., shape and size) and one was irrelevant (color). Each cue (color, shape, and size) occurs four times as a relevant nonmatching cue (e.g., “small” in the large red teapot, a small red teapot, and a large red shoe trial) and twice as an irrelevant cue (the cue that remains constant across all three items). All children initially completed ten orientation trials (three Item Identification trials, four Favorite Items trials, and three practice trials) followed by the 15 experimental trials of the FIST. The Item Identification Task was administered to ensure children could identify all of the dimensions and cues in the FIST. The Favorite Items Task oriented children to the task (i.e., the need to point to pictures). Jacques and Zelazo’s (2005) presentation order 1 was used in this experiment, where the placement of items that matched on a dimension was counterbalanced.

**The nonlinguistic rule abstraction task**

The nonlinguistic rule abstraction task (Dodd & McIntosh, 2008) required children to sit facing a 34 × 26.5 cm computer touch screen that presented the stimuli. There were four practice trials to teach the task. Children first saw a 15 × 15 cm yellow square that they were told to touch. When touched, the square disappeared to reveal a 3-s animation (cockatoo flapping its wings, a puppy sitting up in a box, or a seal spinning a ball on its nose). The next stimulus was a red 15-cm equilateral triangle. When they touched it, children saw one of the three animations. The third trial presented an 11-cm equilateral red triangle and a yellow circle with a diameter of 11 cm. When one of these shapes was touched, there was a “boing” electronic noise, but no animation appeared. The experimenter said “You must have touched the wrong one. Try this next one.” A red triangle and a purple square appeared on the screen and children were told to touch the one they thought the animal was hiding behind. When touched either shape resulted in the appearance of an animation.

The test trials were then presented. Two 12-cm diameter circles were shown side-by-side, one red and one blue. If children touched the blue circle, they heard the noise and saw
no animation. If they touched the red circle, they saw one of the three animations (which appeared randomly). Then the next identical trial was presented. If children did not learn to touch the red circle, making random selections on 20 trials, the game finished. When children demonstrated that they had learned the rule (“touch the red circle to see an animal”) five times consecutively, the rule changed. No instruction was given; children just had to learn to touch the blue circle to see the animations. If they did not derive the new rule within 20 trials, the game finished. If they learned the rule, making five correct choices consecutively, they were presented with three shapes all of the same color (either all red or all blue): a circle, a square, and a triangle, all of 8-cm dimension. They had to learn to touch the square. If they did not learn the new rule, which was based on shape rather than color, the game finished. If they selected the square five times consecutively, they saw four shapes (two triangles, a square, and a circle) of different colors (red, blue, green, or yellow). The last rule children were asked to learn was to touch the blue triangle, combining both shape and color. Throughout the experiment, the assessors encouraged children by saying “I wonder which one the animals are hiding behind” or “Where are those animals hiding?” The computer was programmed to code and store children’s performance, including how many of the four rules were learned.

Project design

Each task was analyzed using one or two factor analysis of variance (speech delay group and speech disorder group × tasks) with planned Bonferroni-corrected post hoc tests where appropriate between and within groups. Parametric statistics were chosen because participant numbers gave sufficient statistical power and comparison of tasks (repeated measures) was desirable to explore interactions (profiles of groups across tasks). Chi-square tests were used to examine categorical data.

### Table 1. Performance Means, Standard Deviations, and Range for Delayed and Disordered Groups for Measures of Language and Speech

<table>
<thead>
<tr>
<th>Measure</th>
<th>Delayed</th>
<th>Disordered</th>
<th>Range</th>
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<tbody>
<tr>
<td>Quick Test of Language</td>
<td>20.7 (4.6)</td>
<td>20.6 (3.6)</td>
<td>14–30</td>
</tr>
<tr>
<td>Percent consonants correct</td>
<td>74.8 (9.6)</td>
<td>56.9 (12.4)</td>
<td>55–88</td>
</tr>
<tr>
<td>Percent vowels correct</td>
<td>95.1 (5.4)</td>
<td>91.8 (6.3)</td>
<td>75–100</td>
</tr>
<tr>
<td>Ratio of single words versus continuous speech</td>
<td>75.9 (19.1)</td>
<td>75.2 (14.5)</td>
<td>25–100</td>
</tr>
<tr>
<td>Inconsistency</td>
<td>13.9 (11.1)</td>
<td>16.1 (10.3)</td>
<td>0–30</td>
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</table>

### RESULTS

Table 1 shows the means, SDs, and range for the delayed and disordered groups’ performance on language and speech measures. Each of these measures was used to compare the two groups using ANOVAs. There was no significant difference in the two groups’ language scores on the Quick Test of Language; $F(1, 44) = .021, p = .886$. As all children had to perform within the normal range on the language measure to participate in the study, this result was expected. Data in Table 1 suggest that the speech accuracy measures differentiated the groups. A two-factor ANOVA (two groups × consonants and vowels) showed a significant groups term; $F(1, 44) = 22.483, p < .001$. Although both groups needed to perform below the normal range on a standardized assessment to be included in the study, the result indicates that the delayed group made fewer errors than the disordered group. More consonant errors were made than vowel errors, $F(1, 44) = 411.72, p < .001$, by the combined groups but the interaction between groups and sound type (consonant or vowels) was also significant; $F(1, 44) = 28.602, p < .001$. Post hoc one-way ANOVAs indicated that although the children in the disordered group were less accurate on consonants than
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those in the delayed group, $F(1, 44) = 29.979$, $p < .001$, the difference between the groups in vowel accuracy was not statistically significant; $F(1, 44) = 3.607, p = .064$.

The groups also did not differ on the measure comparing single word versus continuous speech. This measure, based on a ratio that is converted to a percentage for establishing standard scores, compared whether the same 14 words were pronounced in the same way in picture naming and picture description tasks. The findings, based on broad transcription of children’s speech, indicated that both groups pronounced around three-quarters of the words in the same way in both contexts. This finding shows less consistency of production between single words and continuous speech for children with speech impairment than is indicated by normative data where the mean ratios for the same age range are between 84% and 87%. Similarly, there was no difference in the two groups’ consistency of single word pronunciation when the same words were named on three separate occasions; $F(1, 44) = .469, p = .497$. Normative data (Holm, Crosbie, & Dodd, 2007) indicate that once children are older than 3 years, their inconsistency of production of the same lexical items is below 10%. Table 1 indicates that both groups of children with speech impairment had higher inconsistency scores, although below the criterion level of 40% (Dodd et al., 2002).

Table 2 presents the means, standard deviations and range for delayed and disordered groups for measures of cognitive flexibility and rule abstraction. A two-factor ANOVA (groups $\times$ FIST selections 1 and 2) indicated no significant difference between the groups when scores correct for FIST 1 and FIST 2 are combined; $F(1, 44) = 1.653, p = .205$. There was a difference on the two FIST measures with the combined group performing better on FIST 1 than FIST 2; $F(1, 44) = 77.937, p < .001$. Most importantly, there was a significant interaction, $F(1, 44) = 5.916, p = 0.019$, indicating that the two groups performed differently across tasks. Table 2 indicates that the difference between the delayed group’s performance on the FIST 1 and 2 differed less than that of the disordered group on the two measures.

Also shown in Table 2 are data from the rule abstraction task. The table displays the number of children in each group who learned no rules, and rules one, two, three, and four. More children in the delayed group learned the first rule than did children in the disordered group. These categorical data were analyzed using a $2 \times 2$ Chi-Square comparing the number of children in each group learning either no rules, or at least one rule ($\chi^2_1 = 11.29, p < .001$). The result indicates that children with delayed phonological acquisition are more likely to derive nonlinguistic rules than children with disordered phonological development.

**DISCUSSION**

Identifying appropriate treatment for children with speech impairment depends on knowledge of the impaired mental mechanisms underlying the surface speech errors (Stackhouse & Wells, 1997). The data described here provided evidence concerning the cognitive-linguistic abilities of children with speech impairment who performed below the normal range on a standardized speech assessment, in the absence of language, neurological, sensory, or other explanatory impairment. Two matched groups of 23 children each were compared on executive function tasks of cognitive flexibility and nonverbal rule abstraction. One group had delayed speech development, as their speech error patterns were typical of younger children; whereas the other had disordered speech development, as they used at least one speech error pattern that was atypical of any age group. Although the disordered group made more consonant errors and different types of errors in comparison to the delayed group, the two groups did not differ on measures of language, vowel accuracy, difference ratio between single words versus continuous speech, or...
Table 2. Performance Means, Standard Deviations, and Range for Delayed and Disordered Groups for Measures of Cognitive Flexibility and Rule Abstraction

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<td><strong>Cognitive flexibility task</strong></td>
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<tr>
<td>Flexible Item Selection Test 1</td>
<td>13.83 (1.5)</td>
<td>14.17 (1.2)</td>
</tr>
<tr>
<td></td>
<td>(11–15)</td>
<td>(11–15)</td>
</tr>
<tr>
<td>Flexible Item Selection Test 2</td>
<td>10.74 (2.6)</td>
<td>8.74 (4.4)</td>
</tr>
<tr>
<td></td>
<td>(4–15)</td>
<td>(1–15)</td>
</tr>
<tr>
<td><strong>Difference scores: Flexible Item Selection Test 1</strong> minus Flexible Item Selection Test 2</td>
<td>3.09 (2.2)</td>
<td>5.44 (4.1)</td>
</tr>
<tr>
<td></td>
<td>(0–9)</td>
<td>(0–13)</td>
</tr>
<tr>
<td><strong>Nonlinguistic rule learning task</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of children learning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No rules</td>
<td>9</td>
<td>20</td>
</tr>
<tr>
<td>First rule</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Second rule</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Third rule</td>
<td>3</td>
<td>0</td>
</tr>
<tr>
<td>Fourth rule</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

consistency of word production. The results indicated that the disordered group performed less well than the delayed group on two executive function tasks: they had poorer cognitive flexibility and difficulty abstracting nonlinguistic rules. The findings are now considered in more depth.

**Similarities between the groups**

The speech of the groups of delayed and disordered children assessed were similar in important ways. Both groups made more consonant than vowel errors and there was no group difference between the number of vowel errors made (although there was a non-significant trend for the disordered group to make more vowel errors). The groups did not differ in their degree of inconsistency for single word production when asked to name the same pictures three times, both groups exhibiting around 15% inconsistency, which is about 10% more than typically developing children (Holm et al., 2007). Nor did the groups differ in the extent to which their word production differed between single words and continuous speech. It should also be noted that both groups were selected to have age appropriate receptive language.

Few previous research studies have compared delayed as opposed to disordered subgroups of functional speech disorder. Two important factors have contributed to this lack of research. There is no agreed terminology. Some researchers use the terms as synonyms, or only ever use the term delay (e.g., Shriberg et al., 2005), whereas others make a clear distinction. It is only fairly recently, however, that country-specific normative data on speech error pattern use, at particular ages, have become available. Finally, the similarities between the groups, as defined here, are striking: predominance of consonant errors and consistency of word production.

**Differences between the groups**

Children classified as having a speech disorder performed less well than the delayed group on measures of consonant accuracy, cognitive flexibility, and rule abstraction. Accuracy scores, like PCC in nonword repetition at 3 years of age is a poor predictor of performance at 4 or 6 years (Dollaghan & Campbell, 2009). In contrast, Tyler, Lewis, and Welch (2005) reported that consistency of errors accounted for 31.6% of the variance in PCC change after intervention, indicating that the type of errors might be a more salient
marker than accuracy. Counting the number of consonant errors may then provide limited information about intelligibility.

One reason why children with disorder might be less accurate than children with delay is that disordered error patterns often affect syllable structure as opposed to phonemes (see Table 3 for a description of the most frequently used of the disordered error patterns observed). If a child deletes all syllable initial consonants (ICD), that must give rise to more errors than stopping of fricatives on the same set of words from the DEAP's phonology test. Table 3 lists three syllable structure processes for the disordered group (marking consonant clusters with a bilabial fricative, ICD, and assimilation (where only one consonant marks all consonants in a syllable/word), whereas the delayed group exhibited only limited final consonant deletion (of 1 or 2 phonemes e.g., /t/ and /k/), cluster reduction (where only one of the two members would be counted as an error), and weak syllable deletion (where the number of weak syllables tested was limited). Accuracy, then, may be an artifact of type of error pattern rather than a clinically useful way of classifying speech impairment.

Another way of characterizing the differences between the groups tested, rather than delayed and disordered, is as “late talkers” and “long-term phonological delay.” Williams and Elbert (2003) reported a longitudinal study of five children, identified as late talkers at 22 or 31 months of age, who were followed-up monthly for 10 to 12 months. Three children resolved their delayed acquisition of phonology by 33 months in that they performed within normal limits on measures of phoneme inventory, number of errors and type of errors, and consistency. In contrast, the phonology of two children who had persisting difficulty was characterized by “smaller phonetic inventories, less diverse and complex syllable structures, and lower PCC scores... Qualitative variables that also appeared to be important in predicting phonological outcomes at 33 months... included sound variability, atypical error patterns, and little change in development across time” (Williams & Elbert, 2003, p. 150).

Cognitive flexibility is defined as an aspect of human intelligence that allows children to integrate new information when learning (Déak, 2003). One perspective on children’s acquisition of speech is that they listen to, and gradually become aware of, the phonological patterns around them (Williams, 1993). For example, exposure to different languages results in children using different error patterns (e.g., see Zhu, 2002, for the acquisition of Mandarin). Phonological development requires flexible cognition as children need to dynamically construct and modify their “representations and responses based on information (i.e., similarities, cues, relations) selected from the linguistic and nonlinguistic environment” (Déak, 2003, p. 275).

One previous study (Crosbie, Holm, and Dodd, 2009) compared three groups of

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**Table 3.** Speech error patterns associated with phonological delay and disorder

<table>
<thead>
<tr>
<th>Delay</th>
<th>Disorder</th>
</tr>
</thead>
<tbody>
<tr>
<td>Final consonant deletion (limited)</td>
<td>Backing of bilabial and palatal stops [gɛd] /bɛd/</td>
</tr>
<tr>
<td>Cluster reduction (2 member clusters)</td>
<td>Word or syllable initial consonant deletion [if] /ɪf/</td>
</tr>
<tr>
<td>Fronting of velars and fricatives</td>
<td>Stops substituted by fricatives [vuk] /buk/</td>
</tr>
<tr>
<td>Weak syllable deletion</td>
<td>Clusters marked by bilabial fricatives [φi]/θri/</td>
</tr>
<tr>
<td>Stopping of fricatives and affricates</td>
<td>Vowel errors e.g., [wɛb] for /web/</td>
</tr>
<tr>
<td>Voicing errors</td>
<td>Sounds preference e.g., all fricatives are [s] [sæn]/væn/</td>
</tr>
<tr>
<td></td>
<td>Intrusive vowels e.g., [uai]/ɛg/</td>
</tr>
<tr>
<td></td>
<td>Extensive assimilation [bi]/pɪg/</td>
</tr>
</tbody>
</table>
five-year-old children on the FIST (Jacques & Zelazo, 2001): typically developing, consistent speech disorder, and inconsistent speech disorder. The children with consistent speech disorder performed significantly less well than the other two groups on both Selections 1 and 2. The children with an inconsistent speech disorder performed similarly to their typically developing peers. Poor performance on a measure of cognitive flexibility is not, then, always associated with severe speech disorder.

The findings reported here suggest that children who consistently use atypical error patterns also perform less well on the FIST 2 than those who have delayed speech development. Although the groups do not differ on their ability to identify one way in which two pictures are similar, children with disorder showed less cognitive flexibility than the delayed group. They were less able to identify a second way three items might be associated, revealing a difficulty in shifting attention between conceptual domains and inhibiting their first choice. Lack of cognitive flexibility was also apparent in the rule-learning task. Children with speech disorder who learned the first rule usually persisted in its use. That is, having learned the rule that touching the red shape revealed the animations, they continued to push the red shape for many trials, despite that action no longer revealing the animation. The results clearly indicated that the disordered group learned fewer rules that the delayed group.

An impaired ability to abstract and then implement the subtle constraints of the phonological system fits with evidence concerning the characteristics of disordered children’s errors (pervasive error patterns that affect syllables like “all syllable final consonants delete except nasals”) and their lack of spontaneous change when no intervention is available (Dodd, Zhu, & Shatford, 2000). The results are also consistent with previous research indicating that children with consistent speech disorder later develop literacy difficulties, irrespective of whether their speech disorder has been resolved through intervention.

The findings may provide evidence supporting the idea that speech impairment is often because of cognitive-linguistic factors rather than input and output limitations. The cognitive processes involved in phonological acquisition may involve integrating information to derive phonological constraints using the processes of rule abstraction, memory, selective attention, flexible use of feedback, and inhibition (Singer & Bashir, 1999; Deák, 2003). Intervention for disordered, as opposed to delayed, speech development, should target, in that case, their impaired ability to derive rules and to integrate information to exhibit cognitive flexibility in rule abstraction and implementation for both spoken and written phonology.

**Speech disorder, literacy, and intervention**

Children with speech disorder do not reorganize their phonological system without intervention (Dodd et al., 2000), and evidence supports treatment targeting the speech-processing deficit underlying a child’s speech disorder as the approach that can result in efficient systemwide change (Stackhouse & Wells, 1997). For example, intervention targeting phonological contrasts has been shown to be a more effective approach for consistent disorder than a core vocabulary therapy (Dodd & Bradford, 2000). Both delayed and consistently disordered speech impairment can be successfully treated by explicitly teaching the phonological constraints that a child has failed to acquire (Howell & Dean, 1994; Gierut, 1998). Learning that phonemes contrast a difference in meaning and that these contrasts need to be pronounced to avoid misunderstanding facilitates organization of phonemes into classes and phonotactically legal sequences (Grunwell, 1997). The problem with this approach is that literacy difficulties characteristic of consistent speech disorder may not be addressed by therapy that teaches spoken phonological rules (Gillon, 2004).

Despite attaining age appropriate spoken phonology, many children with speech
disorder have difficulty acquiring written language later and perform less well on phonological awareness tasks (Gillon, 2004; Raitano, Pennington, Tunick, Boada, & Shriberg, 2004). One study (Nathan, Stackhouse, Goulandris, & Snowling, 2004) reported that at age 6:9, 47% of children with a pure speech disorder fell outside the normal range on standardized literacy assessments as compared with 28% of the control group. Children with persistent and severe speech impairment were at risk particularly for literacy difficulties. It might be argued that intervention for children with consistent speech disorder should aim to address both spoken and written aspects of the children’s phonological processing impairment by targeting deficits in cognitive flexibility and rule abstraction.

A recent study (Holm & Dodd, 2010) has provided preliminary evidence for a novel approach to intervention for children with consistent speech disorder. Ten children received sixteen, 45-min, twice-weekly intervention sessions. Each session was split into three 15-min activities focusing on rules and patterns, with explicit links being made between the three activities: pattern recognition, sorting, and manipulation; language rules and word patterns (e.g., plurality, tense, phonological awareness); and phonological output using minimal pairs. Results showed significant enhancement of performance on two standard assessments of cognitive flexibility and phonological awareness. In addition, the children’s mean PCC increased by 27% (SD 10), not differing statistically from a previous therapy trial (Dodd et al., 2008) where the same amount of intervention, consisting solely of minimal pair therapy, had been provided (PCC increase 23%, SD 13). Follow-up assessments, in 2 year’s time, will investigate the literacy acquisition of these two groups of children.

CONCLUSION

The findings of the study reported here indicate that children with speech delay differ from those with consistent disorder both in terms of severity and in the deficits in speech processing that might underlie their speech difficulties. Previous research suggests that the two groups also differ in their profile of associated abilities. Consequently, it seems important that intervention research begins to compare the outcomes of different types of therapy for these two groups of children with speech impairment.

REFERENCES


