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Running Head: DYSLEXIA AND SLI: THE OVERLAP

Speech and language difficulties in children with and without a family history of
dyslexia

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dyslexia

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Abstract

Comorbidity between SLI and dyslexia is well documented. Researchers have variously argued that dyslexia is a separate disorder from SLI, or that children with dyslexia show a subset of the difficulties shown in SLI. This study examines these hypotheses by assessing whether family history of dyslexia and speech and language difficulties are separable risk factors for literacy difficulties. Forty-six children with a family risk of dyslexia (FRD) and 36 children receiving speech therapy (SLT) were compared to 128 typically developing children. A substantial number (41.3%) of the children with FRD had received SLT. The nature of their difficulties did not differ in severity or form from those shown by the other children in SLT. However, both SLT and FRD were independent risk factors in predicting reading difficulties both concurrently and six months later. It is argued that the results are best explained in terms of Pennington's (2006) multiple deficits model.

Dyslexia and speech and language difficulties: Exploring the nature of the overlap

There is both anecdotal and scientific evidence that speech and language difficulties and dyslexia are closely associated. Many children with speech and language difficulties develop literacy difficulties, and many children with literacy difficulties show signs of broader difficulties in speech and language.

Estimates of rates of comorbidity between the disorders vary widely, depending on a range of factors. McArthur, Hogben, Edwards, Heath, and Mengler (2000) found that around 50% of children recruited with specific reading difficulties showed criteria that would warrant inclusion in a group of children with specific language impairment (SLI), and vice versa. Catts, Adlof, Hogan, and Weismer (2005) found a rate of dyslexia in their sample of SLI children of between 17% and 35%, depending on the criteria used and the age at which dyslexia was assessed. Conversely, the rate of kindergarten SLI in their sample of children with dyslexia varied between 14% and 19.5%. This is probably the most reliable estimate of the overlap currently available, since this is a longitudinal study in which full standardised measures were used to diagnose the disorders, and the sampling procedure was based on stratified sampling, with weightings to take account of possible sample biases.

SLI is an umbrella term and can encompass a range of difficulties. Children may show difficulties in semantics and syntax, and/or difficulties in producing speech sounds, either because of difficulties in motor planning and articulation, or because of phonological processing difficulties. It could therefore be useful to consider the types of speech and language difficulties shown by these children and whether any difficulties in particular are more closely linked to literacy difficulties.

Difficulties in phonological processing are implicated in both SLI and dyslexia, and it is a short step to hypothesise that the phonological processing deficit in both disorders is similar, or at least linked. With this in mind, researchers have also examined the overlap between phonological or speech sound disorders and dyslexia or reading difficulties. There is actually only limited evidence that children with pure speech sound disorders show increased risk of literacy difficulties. For example, Bird, Bishop, and Freeman (1995) found that the phonological awareness and literacy progress of a group of children with speech sound disorder was below average as a group, though they also highlighted the high level of heterogeneity within this group of children.

Other research highlights that many of these children do not show long term literacy difficulties. Leitaó, Hogben, and Fletcher (1997) argue that only children who make non-developmental speech errors (rather than errors indicating speech delay) tend to have literacy difficulties. Nathan, Stackhouse, Goulandris, and Snowling (2004) examined a sample of children who were receiving therapy for speech difficulties. Only those children who showed additional language difficulties or difficulties with input phonology showed lower literacy. Similar results were shown by Raitano, Pennington, Tunick, and Boada (2004), who found that only children with either persistent phonological impairment or additional language difficulties showed difficulties on phonological awareness and literacy related tasks. The links between speech and language difficulties and dyslexia may not, therefore, be straightforwardly explained in terms of speech processing difficulties.

Catts et al. (2005) outline three possible alternative views of the association between SLI and dyslexia. The first is that both stem from an underlying phonological processing difficulty, and that dyslexia is a milder manifestation of the difficulties

shown in SLI. The second is that both disorders are caused by a phonological processing deficit, but SLI occurs when that deficit is combined with deficits in other areas of processing. The final model includes two separate causes of SLI and dyslexia, with the overlap between the disorders being explained in terms of comorbidity of two separate disorders. In other words, some children have both disorders, to varying extents, but the two disorders are not caused by a single underlying factor.

Catts et al. (2005) assessed the phonological awareness and nonword repetition ability of children with SLI only, dyslexia only, and both SLI and dyslexia. The presence of several individuals with SLI but without literacy difficulties argues against Model 1, in which dyslexia is a mild form of SLI. They found that all three groups showed early deficits in phonological awareness, but that the SLI only group overcame these difficulties and showed normal performance from grade 2 onwards, while the two groups with dyslexia showed continued poor performance. On the nonword repetition task, the performance of the SLI only group fell between that of the two groups with dyslexia and the control group. Catts et al. argue that the relatively small overlap between the disorders fits most closely with Model 3, in which dyslexia and SLI are separate but comorbid disorders.

A fourth potential explanation of the relationship between the disorders is provided by the 'multiple deficits' model proposed by Pennington (2006). In this model, most developmental disorders are considered as occurring as a result of multiple co-occurring deficits, and comorbidity occurs because one or more of these deficits is shared between two disorders. In the case of SLI and dyslexia, both disorders involve difficulties in phonological processing, but in addition both disorders involve further deficits. In the case of SLI it is likely to be difficulties in

using syntax and semantics, while in the case of dyslexia it is likely to be a deficit along the lines of linking written and verbal information efficiently. For example, Tunick (2004, cited in Pennington, 2006) shows that, while children with reading difficulties and children with speech sound disorder both show difficulties in phonological awareness, those with speech sound disorder show more severe nonword repetition difficulties, and those with reading difficulties show more severe difficulties on a rapid serial naming task.

Bishop and Snowling (2004) summarised the evidence concerning the overlap between language impairment and dyslexia. They conclude that a two factor model in which phonological and non-phonological language skills are separated provides a good explanation of the data. This would be approximately equivalent to Catts et al.'s Model 2. Typically, children with SLI will show difficulties in both phonological and non-phonological language skills, whereas children with dyslexia will show problems only in phonological skills. These difficulties in phonological skills are associated with difficulties in reading accuracy. Bishop and Snowling further argue that children with SLI may show a different profile of reading difficulties to children with dyslexia, with difficulties in both reading accuracy and reading comprehension.

Larkin and Snowling (2008) examined the phonological processing profiles of children diagnosed with dyslexia or SLI (with or without literacy difficulties). Both groups show difficulties on a phoneme deletion measure and in producing phonetically plausible spellings. The authors argue that rather than SLI and dyslexia being separate, some children with SLI demonstrate a 'dyslexia plus' profile; they show classic dyslexic difficulties in phonological processing, with additional difficulties in vocabulary.

Studies comparing children with SLI and dyslexia often have strict inclusion or exclusion criteria for each group based on performance on given reading and language measures. While this is a useful way to create ‘clean’ samples, there are a few reasons why it might not be the most effective way to assess comorbidity. First, this approach artificially reduces the variation seen within groups. Children with mild difficulties are likely to be excluded from every group, including the control group. Children with complex or additional difficulties may also be excluded, despite the fact that they are often exactly the children of interest. Second, since reading and language are correlated in the general population, selecting a group based on their reading skills and assessing their language level (or vice versa) is likely to result in a sample with increased language difficulties purely on a statistical basis. Finally, dyslexia is normally diagnosed in the school years, while SLI is at its peak in the preschool years. In particular, many children have early speech and language difficulties which resolve by age six. For example, Stothard, Snowling, Bishop, Chipchase, and Kaplan (1998) found that 30 children in their sample of 84 speech and language impaired children recruited at 4 years old showed no speech and language difficulties at six years old. However, some of this group of ‘resolved’ children showed literacy difficulties at age 15, suggesting that a history of speech and language difficulties may be an important factor in predicting literacy difficulties. It is therefore important to consider transient speech and language difficulties in addition to persistent difficulties.

For all of these reasons, it could be useful to select children on the basis of risk factors rather than to determine group membership on reading or language tests. This will create more inclusive groups, in which many members will not have current difficulties, but in which a wider range of abilities is measured. Possible risk factors include a family risk of dyslexia (FRD) and a history of speech and language therapy.

Between 30% and 50% of children with FRD go on to become dyslexic themselves (Snowling, Gallagher & Frith, 2003), while around 63% of children in speech therapy at age four show long term language difficulties (Stothard et al, 1998).

Given the typical time-course of speech and language difficulties, and the co-heritability between speech and language difficulties and dyslexia (Tunick & Pennington, 2002), examining young children with FRD is a potentially interesting avenue to allow exploration of the overlap between SLI and dyslexia. One way to differentiate between Model 2 and Model 3 as proposed by Catts et al (2005) would be to consider the speech and language development of children who go on to be dyslexic. If some children develop dyslexia with no history of even slight speech and language difficulties, this then argues against Model 2, in which children with dyslexia show a subset of the symptoms of SLI.

Typically, in samples of children at genetic risk of dyslexia, around a quarter of the sample has a history of attendance at speech and language therapy. Gallagher et al (2000, cited in Tunick & Pennington, 2002) found 25% of their at-risk sample had been referred for speech therapy, while Pennington and Lefly (2001) found that 28% of the parents of their at-risk sample had concerns about their child's speech and language development, as did Tunick and Pennington (2002).

There is evidence that children who later become dyslexic show below average speech and language in the preschool years, though their language at later ages is generally within normal limits. Scarborough (1990) found that children with FRD who went on to be dyslexic showed less accurate speech (in terms of consonant errors in spontaneous speech) and used a narrower range of syntactic structures at 30 months than controls. They also showed lower receptive and expressive vocabulary scores at 42 months of age. Snowling et al. (2003) found that children with FRD who

went on to become dyslexic showed difficulties both in phonological recoding (phonological awareness and letter knowledge tasks) and in broader language skills (receptive and expressive vocabulary and productive syntax) in the preschool years. In contrast, the children with a family risk who progressed well showed milder difficulties in phonological recoding and no difficulties in broader language skills.

Lyytinen, Poikkeus, Laakso, Eklund and Lyytinen (2001) examine the early language development of children with a family risk of dyslexia. While the groups did not show increased levels of language difficulties at two years of age, at three and a half years the children with FRD had lower average scores than controls on expressive language tasks, including maximum sentence length, object naming ability, and use of inflectional morphology. Perhaps most interestingly, late talkers in the FRD group (defined by expressive measures at two years old), were no more common than in the control group, but they were more likely to have long term difficulties than late talkers in the control group. There are several possible explanations for this finding, one being that language difficulties in children with FRD tend to be of a somewhat different nature to language difficulties in typically developing children. Another possible explanation is that the language difficulties are similar in both groups, but children with FRD are less likely to have compensatory strengths that allow them to overcome early weaknesses in language-related tasks (c.f. Snowling et al. (2003)). If this is the case, we may find additional weaknesses in the FRD group as a whole that are not explained in terms of speech and language difficulties.

The current study examines the nature of the speech and language difficulties shown by FRD children in comparison to typically developing controls and children who are receiving speech and language therapy (SLT) but have no FRD. The research will provide information as to whether the speech and language difficulties shown in

children with FRD are qualitatively different to children who do not have FRD, and whether children with FRD have additional weaknesses not explicable by their speech and language difficulties. As described above, this is an inclusive approach assessing potential risks, rather than a study comparing rates of impairments in diagnosed samples.

The study aims to answer the following four questions:

1. How much overlap is there between children with FRD and those who have ever experienced speech and language therapy?
2. How much overlap is there between children with FRD and children showing current speech and language difficulties?
3. What are the characteristics of children with a FRD who have received speech and language therapy? Do they tend to show a particular pattern of impairments?
4. Do children with FRD but no speech and language difficulties show a risk of literacy difficulties?

Answering these questions will help us to understand whether the speech and language difficulties shown by children with FRD are unusual, and whether children with FRD have additional risk factors in addition to difficulties in language development. This information will in turn elucidate the nature of the overlap between the disorders.

Method

Participants

Two hundred and ten children in the first three years of formal schooling were recruited. The majority of the children (188) were in either reception or year 1 (first

two years of schooling). Forty-six children were recruited because of a family risk of dyslexia. In this case, either a parent or sibling had diagnosed dyslexia. Most of these children were recruited through local Dyslexia Action centres, screening in mainstream classes or through general advertising in schools and public places. Thirty-six children were recruited because they were receiving, or had received, speech and language therapy. These children were recruited mainly through screening in mainstream classes and general advertising, though some were recruited through Speech and Language Therapists (Speech-Language Pathologists). Speech and Language Therapists were asked to refer children who showed speech or phonological difficulties, with or without additional language difficulties. Ten children in this group were recruited in a school with a specialist speech and language unit. Since the risk groups were not selected according to ability, one would expect the full range of abilities in these groups. It is therefore important to have a control group that reflects the full range of ability in order to provide a fair comparison of rates of difficulties, and as such children were not excluded from the control group for showing reading or language difficulties. The typically developing children (128) were largely recruited through mainstream classrooms in Warwickshire, UK. Twelve children (10 control children and 2 children from the at-risk groups) did not complete the *Picture Naming* or *Mispronunciation Detection* tasks due to time constraints. Three children were lost to the study between the two test points. Their data from Time 1 is included in the Time 1 analyses.

Children with English as a second language ($n = 6$) were included in the control group if they had language skills within the average range for their age, but no children with English as a second language were included in the at-risk groups. Six control children and five at-risk children had some history of hearing difficulties

because of ear infections, with 7 of them having had grommets fitted. Only one child (in the control group) showed current hearing difficulties because of glue ear, and none showed hearing difficulties for other reasons. Only one child (in the control group) had diagnosed ADHD. Two of the children in the SLT group had a diagnosis of Global Developmental Delay, but no others had a diagnosis of a developmental disorder.

Tasks

Language. Four subtests of the Clinical Evaluation of Language Fundamentals Preschool 2nd UK edition were used: *Sentence Structure*, *Word Structure*, *Expressive Vocabulary* and *Recalling Sentences*. These measures assess receptive and expressive language at the word level and the sentence level. The first three measures combine to give a single Core Language measure. The therapists of seven children asked us not to complete some or all of the CELF subtests as they needed to do the assessments themselves. These therapists provided data for the children as follows; *Sentence Structure* (7 children), *Word Structure* (3 children) and *Expressive Vocabulary* (3 children). Data is therefore missing for four children on two of the CELF subtests and therefore the *Core Language* score, and for three children on the *Recalling Sentences* measure.

Speech production. The children were asked to complete two speech production tasks, the *Diagnostic Evaluation of Articulation and Phonology* (DEAP), and a non-standardised *Picture Naming* task scored for percentage consonants correct. The DEAP has a brief screening measure in which children are asked to name ten pictures twice, and asked to produce in isolation any sound which they pronounce incorrectly

(with the exception of age-appropriate errors, such as /f/ for /th/). If they can correctly produce at least one of these mispronounced sounds in isolation, the Phonology subtest is carried out. If they cannot correctly produce at least one of the sounds tested in isolation then the Articulation subtest is conducted. In practice this means that many children complete both the Phonology and Articulation subtests, because they can correctly produce some, but not all of the mispronounced sounds in isolation. There is an additional Inconsistency subtest to the measure, but only four of the children showed enough inconsistency on the screening measure to warrant completing this task, and none showed enough inconsistency to be classified as showing inconsistent speech disorder. Forty-seven of the 210 children completed the Articulation task and 167 completed the Phonology task. These tasks involve further picture naming and sound production to provide a profile of each child's error patterns. The phonological errors that can be explained by difficulties in articulating a sound in isolation are excluded. Error patterns are awarded if a child shows five examples of a particular error type (e.g. fronting, gliding or cluster reduction). These error patterns were classified as to whether they are age-appropriate, developmentally delayed or disordered. Children were then classified according to their worst error pattern (e.g., if a child showed both delayed and disordered error patterns, they would be classified as having disordered speech). It was decided that five examples of disordered errors needed to be given for a disordered error to be classified (this is not specified in the manual). Dodd (personal communication) suggested eliciting other items as necessary from the child to assess if a disordered pattern is evident. Therefore errors made on the *Picture Naming* task were also used for error classification if necessary. The speech tasks were all recorded and transcribed by the second author. An experienced speech and language therapist independently scored

5% of the sample, and achieved inter-rater reliability of 99% on the screener, 93% on the Phonology task and 95% on the Articulation task.

The children completed an additional non-standardised *Picture Naming* task. The words used were 2-4 syllables long, and contained several consonant clusters, in contrast to the relatively simple words used on the DEAP. This task was scored in terms of percentage consonants correct of the pictures children spontaneously named correctly. Inter-rater reliability was 97%.

Literacy Tasks. Two types of tasks were included: *Reading* and *Spelling*. Two reading tasks were used: *British Abilities Scales II Word Reading* and *Reception Reading Words*. Both tasks are single word reading tasks in which children are asked to read words aloud. The *British Abilities Scales II Word Reading* task is one in which the words become increasingly difficult and the task is discontinued if children make eight or more errors in a block of ten. The *Reception Reading Words* task presents the 45 key sight words that were expected to be known by children at the end of their first year in school in the UK under the previous National Literacy Strategy. This is therefore a sensitive measure for children at the earliest stages of learning to read. A total reading measure was created by calculating the z-scores of both measures and adding them.

In the *Spelling* task, children were shown eight pictures and asked to spell the words corresponding to each of them. Rather than a dictation exercise the children were encouraged to spell the words from their own pronunciation. The spellings were scored as conventionally correct, and also according to a phonetic spelling system described in Caravolas et al (2003). According to this system, children are awarded four points for a correct representation of a phoneme, and three points for a

representation that differs in a single phonetic feature. For example, the spelling attempt 'tuk' for 'duck' would score 11/12, as /u/ and /k/ are correctly represented, and /d/ is represented by a sound that differs only in voicing. A total spelling score was created by calculating the z-scores of both measures and adding them.

Phonological processing. The children were asked to complete three tasks measuring phonological processing: *Nonword Repetition*, *Phonological Awareness* and *Mispronunciation Detection*. The Nonword Repetition task contained 30 nonwords from two to five syllables in length. These words were taken from the Children's Nonword Repetition Test (Gathercole, Willis, Baddeley & Emslie, 1994). The task was recorded and scored offline. Each word was given a single correct/incorrect score, giving a total score out of 30. Certain speech errors which were phonetically very close to the target sound scored as correct (specifically ng-n, th-f, th-v and r-w). Inter-rater reliability was 86%.

The *Phonological Awareness* task was a two alternative initial sound matching task. The children were shown three pictures, a cue and two alternative responses. They were asked which of the two alternative responses began with the same sound as the cue word. There were two practice items, for which children were given feedback, and ten test items. The items were taken from Byrne and Fielding-Barnsley (1993) and were controlled for overall phonological similarity, meaning that children using global phonological strategies would be unlikely to be successful.

The *Mispronunciation Detection* task assesses children's sensitivity to slightly mispronounced words. It was presented on a laptop using DirectRT. The child sees a picture and hears it named, either correctly or incorrectly. The child is asked to say whether or not the word was correctly pronounced. They received feedback on their

response. Half of the words were correctly pronounced and half were incorrect. The incorrect words had either a consonant deleted (e.g. ‘cocodile’ for ‘crocodile’) or had two consonants transposed (e.g. ‘crocolide’ for ‘crocodile’). There were five practice trials and 48 experimental trials. Total scores for each of the three conditions (correct, deletion or transposition) were calculated and D prime sensitivity scores were calculated to take account of any biases in responding.

Procedure.

The children who were recruited through mainstream classrooms were assessed over a few weeks, completing a few short tasks each day. For the children recruited through other means it was not possible to work in this way, especially as they were from a wide geographical area. Younger children completed four 30 minute sessions. This involved 2 testing days with a break between each session. Children in year 1 and 2 were tested on one day for two 1 hour long sessions with a break in between. All children were tested individually by the first or second author. A report was produced for parents, teachers and therapists detailing information about children’s performances.

Approximately six months after the first test point the children were retested on an abbreviated battery of tasks, including *Recalling Sentences*, the *DEAP Diagnostic Screener*, *Picture Naming*, *Nonword Repetition*, *Phonological Awareness* and all of the literacy tasks.

Standardisation of Scores

Given the relatively wide age range included within the sample, scores standardised for age were used. The DEAP and CELF tasks were already

standardised. The other measures, excluding Picture Naming, were residualised for age and then standardised with respect to the typically developing children so that the control group had a standard score of 100 and a standard deviation of 15 for each measure.

Classification of Speech and Language Difficulties

A child was classified as having a speech difficulty if they showed an error pattern that was not appropriate for their age on the *Phonology* test (defined as making five errors that could be attributed to a particular error type, such as cluster reduction or gliding, and was not explained by difficulties in articulating that phoneme in isolation). A child was classified as having a language difficulty if they achieved a Core Language score which was more than 1 SD below the control group. Statistically, this entails that approximately 16% of the control group would also be defined as having a language difficulty.

Results

Table 1 shows the extent of overlap between the two groups. Just over 40% of the children with a family history of dyslexia had received speech or language therapy, and around a third of those receiving therapy had a family history of dyslexia. There is a significant association between the two groups ($\chi^2(1) = 6.96$, $p < .05$).

Children were placed in the SLT group if they had ever received speech or language therapy: many of the children were no longer receiving regular therapy. Table 2 shows the proportion of the SLT group in comparison to the FRD group who were currently receiving speech and language therapy. A similar proportion of each

group were currently receiving therapy, and there was no association between presence of FRD and past versus current therapy (Fishers Exact Test = 1.86, $p = ns$).

Speech and Language Difficulties of the groups

The groups could also be assessed in terms whether they showed speech only, language only, or both speech and language difficulties. This is shown in Table 3. The FRD group showed significantly more impairments than the control group (Fishers Exact Test = 13.42, $p < .01$). The SLT group and the FRD group showed similar patterns of impairment. A slightly larger proportion of the FRD group showed no difficulties, but there was no significant association with type of impairment when comparing the SLT and FRD groups ($\chi^2(3) = 2.01$, $p = ns$).

Table 4 shows the number of the children in the sample that made different types of speech errors. The FRD group showed significantly more impairments than the control group (Fisher's exact test = 14.53, $p < .01$). Again, there was no significant association between group membership and type of speech error made ($\chi^2(3) = 1.50$, $p = ns$). Children with FRD had a similar proportion of children with disordered and delayed speech to children in speech therapy. There is therefore no evidence in terms of classification systems that the children with FRD are more likely to show a particular form of speech and language difficulty. Their difficulties seem to be of a similar range and frequency to other children who have received speech and language therapy, but do not have a family risk of dyslexia.

Scores on the Speech and Language Measures

Table 5 shows the means and standard deviations for each group on the language and speech tasks. In order to examine the independent effects of the two risk factors (FRD and SLT), a 2x2 MANOVA was carried out. A main effect of FRD would indicate that the FRD only and combined groups scored lower than the other

groups. A main effect of SLT would indicate that the SLT only and combined groups scored lower than the other groups, while an interaction would indicate that the combined group showed lower scores than would be expected given that they had both risk factors.

For each measure, there was a main effect of SLT ($F(4,196) = 9.06, p < .01, \eta^2 = .16$), but no main effect of FRD ($F < 1$) and no interaction between the two ($F < 1$). This result was borne out by similar results on the individual tasks, in which there were consistent effects for SLT (Sentence structure: $F(1,199) = 4.57, p < .05, \eta^2 = .02$; Word Structure: $F(1,199) = 29.10, p < .01, \eta^2 = .13$; Expressive Vocabulary: $F(1,199) = 14.27, p < .01, \eta^2 = .07$; Recalling Sentences: $F(1,199) = 26.76, p < .01, \eta^2 = .12$), but no effect of FRD (Sentence structure: $F < 1$; Word Structure: $F < 1$; Expressive Vocabulary: $F(1,199) = 1.66, p = ns$; Recalling Sentences: $F < 1$). There were also no significant interactions between SLT and FRD. This indicates that the children with a history of speech and language therapy had lower language scores than the other groups, regardless of their FRD status.

Similar patterns were shown on the speech measures. On the DEAP diagnostic screening measure, there was a main effect of SLT ($F(1,206) = 44.20, p < .01, \eta^2 = .18$), but no effect of FRD ($F < 1$) or interaction ($F < 1$). The pattern on the Picture Naming task was the same (SLT: $F(1,194) = 46.70, p < .01, \eta^2 = .19$; FRD: $F(1,194) = 1.15, p = ns$; interaction: $F(1,194) = 1.44, p = ns$). There is therefore no indication that the children with FRD show different strengths and weaknesses as a group on these tasks in comparison to the SLT children.

The Literacy Scores of the four groups

Poor reading outcome was defined as reading more than 1SD below the mean for the control group. As with the language impairment criteria, this entails that

approximately 16% of the control group will be regarded as having literacy difficulties. There was a significant association between group membership and reading outcome; 16% of the control group, 34.3% of the children with SLT only, 28% of the children with FRD only, and 55.6% of the children with both FRD and SLT were below average readers. In a logistic regression predicting reading group, both SLT and FRD were significant independent predictors of group membership (SLT: OR = 0.59, CI = 0.41-0.84, $p < .01$; FRD: OR = 0.68, CI = 0.46 -0.98, $p < .05$).

Continuous measures of literacy were also examined, and mean scores are shown in Figure 1 for control children, children with FRD only, SLT only and both SLT and FRD. For each of the three measures a 2x2x2 ANOVA was carried out, with time point as a within subjects variable and SLT and FRD as between subjects variables. For reading there was a main effect of SLT ($F(1,201) = 9.56$, $p < .01$, $\eta^2 = .05$) and a main effect of FRD ($F(1,201) = 4.96$, $p < .05$, $\eta^2 = .02$) and no interaction between SLT and FRD ($F < 1$). There was also a marginal effect of time ($F(1,201) = 3.33$, $p = .07$, $\eta^2 = .02$), indicating that the risk groups showed a drop in standard scores between the two test points, and an interaction between FRD and time ($F(1,201) = 4.59$, $p < .05$, $\eta^2 = .02$), indicating that standard scores in reading dropped most sharply in the group with FRD. There was no two-way or three-way interaction with SLT.

For spelling, mean scores are shown in Figure 2. A parallel 2x2x2 ANOVA was carried out. There was a main effect of SLT ($F(1,202) = 23.65$, $p < .01$, $\eta^2 = .11$) and a main effect of FRD ($F(1,202) = 7.47$, $p < .01$, $\eta^2 = .04$) and no interaction between the two ($F < 1$). There was a main effect of time of testing, reflecting a slight drop in scores over time ($F(1,202) = 3.94$, $p < .05$, $\eta^2 = .02$), but no interactions with time point.

The children with FRD but no SLT therefore do not escape literacy difficulties. These children show scores slightly lower than the typically developing group, and there are some signs that they drop further behind controls over time.

The Phonological Processing Skills of the four groups

The four groups were compared, using 2x2 ANOVAs, on the three phonological processing measures. Mean scores for each group are shown in Figure 3. On the Nonword Repetition task, there was a main effect of SLT ($F(1,205) = 85.33$, $p < .01$, $\eta^2 = .29$); no main effect of FRD ($F < 1$), and no significant interaction ($F(1,205) = 2.87$, $p = .09$).

On the Mispronunciation Detection task, there was a main effect of SLT ($F(1,188) = 17.06$, $p < .01$, $\eta^2 = .08$), no main effect of FRD ($F(1,188) = 2.71$, $p = .10$), but a significant interaction between the two ($F(1,188) = 4.91$, $p < .05$, $\eta^2 = .03$). Similarly, on the Phonological Awareness task, there was a main effect of SLT ($F(1,206) = 20.99$, $p < .01$, $\eta^2 = .09$), no main effect of FRD ($F(1,206) = 2.82$, $p = .09$), but a significant interaction between the two ($F(1,206) = 4.80$, $p < .05$, $\eta^2 = .02$). On two of the three phonological processing measures, the children in the combined group showed particularly low scores. It seems that these children may show a more severe form of phonological processing difficulty.

Discussion

There was a substantial overlap between the groups of children with a family history of dyslexia and those who had received speech and language therapy. Around 40% of the FRD group had some history of speech and language therapy. In addition, the nature of the difficulties shown was similar in the FRD and SLT groups. It was

not the case, for example, that the children with a history of FRD were more likely to show disordered speech errors, or difficulties on a particular language task.

In terms of literacy development, there were significant effects of both SLT and FRD, showing that the increased risk of literacy difficulties in FRD is not solely accounted for in terms of increased risk of speech and language difficulties. Some additional factors are influencing literacy development in this sample.

The extent of the overlap was higher than has been found in previous studies; 40% of the FRD group had received speech and language therapy in comparison to around 28% in previous studies. There are several possible reasons for this finding. One is that the sample was recruited in an area in which the speech and language therapy departments are relatively active and work closely with local schools. All primary schools in this area have a speech therapist linked to the school that will visit regularly and observe children who might qualify for therapy, meaning that relatively few children with difficulties should be overlooked. Another possible explanation lies in the recruitment of the children. The children were not recruited systematically, but through parental referral. It may be that parents were more likely to want their child to take part in the study if the child had both FRD and a history of SLT. It is difficult to know whether this is the case. Speech therapists were also aware of the nature of the study and might be more likely to refer children with reading difficulties. However, in practice only a minority of children were recruited through therapist referral, and so this is unlikely to affect the results. The majority of children with SLT were recruited through forms sent to parents of every child in a mainstream classroom, thus increasing possible generalisability.

The results suggest that children with dyslexia do not show a specific form of speech and language difficulties that can be separated from the types of speech and

language difficulties shown by children with no family history of dyslexia. While the risk of speech and language difficulties was increased in the FRD group, these children showed a wide range of difficulties. This argues against the idea that dyslexia could be thought of as a specific form of SLI.

There was also some evidence for both SLT and FRD as independent risk factors for literacy difficulties. Both risk groups showed increased rates of reading difficulties in comparison to controls, and the group with both risk factors was at particularly high risk for difficulties. Similar results were found using the continuous measures of reading and spelling; SLT and FRD were independent risk factors.

These results therefore do not completely fit any of Catts et al (2005)'s models. The presence of several children with speech and language difficulties but good literacy argues against Model 1, in which dyslexia is a mild form of SLI. The separable risk factors of SLT and FRD argue against Model 2, in which children with SLI have the difficulties inherent in dyslexia, but with some additional risk factors. If this was the case, then one would not expect FRD to be an additional risk factor once SLT had been controlled. Finally, the results are not completely in line with Model 3, in which the two disorders are separable but comorbid. If this was the case, it is unclear why children with both FRD and SLT should have an increased risk of reading difficulties in comparison to the FRD alone group.

It seems that the pattern fits most closely the model of Pennington (2006). In this model, both disorders are characterised by some shared factors and some independent factors. SLI is characterised by difficulties in semantic and syntactic aspects of language as well as phonological deficits, while dyslexia is characterised by phonological and visual-verbal association difficulties. This hypothesis fits with earlier research implicating visual-verbal association difficulties as a core feature in

reading difficulties (e.g. Hulme, Goetz, Gooch, Adams & Snowling; Vellutino, Steger, Harding & Philips, 1975). In the present data, the SLT individuals showed difficulties on the CELF tasks that were not shown in the FRD group, but unfortunately measures assessing visual-verbal associations (such as rapid serial naming) were not included.

Despite finding that FRD status did not alter the type or severity of speech and language difficulties shown in the groups, the combined group showed particularly poor phonological processing. This indicates that the two risk factors are not independent in this respect; together they are likely to cause a more severe phonological processing impairment. While the two disorders both have independent and overlapping effects, they also seem to interact. Given the well documented reciprocal relationship between phonological awareness and knowledge of grapheme-phoneme correspondences, it could be that the more severe phonological processing difficulties shown in this group stem from additional difficulties in mapping phonemes to graphemes.

There are of course limitations in the interpretation of these results. In the first place, this analysis is aimed at finding general risk factors across a group, and as such is likely to underestimate the role of individual differences and the many factors that play a role in any developmental disorder. Second, other untested measures (such as working memory or rapid serial naming) may well be involved in the development of these disorders. Finally, there are differences in recruitment between the groups. Many of the children in the FRD groups were recruited through private dyslexia organisations, while the children in the other groups were recruited largely through mainstream classrooms. This limits the generalisability of the results to some extent, though there were no significant group differences in the language, reading and

phonological processing scores between children recruited through private dyslexia organisations and those recruited through mainstream classrooms or general advertising.

Overall, the results are consistent with the theory that SLI and dyslexia are separable but linked disorders. They share some risk factors and deficits, but each has additional specific deficits. Further research is now needed to investigate how these deficits link and interact, and how the manifestation of each disorder changes over time.

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Table 1: The extent of the overlap between the two groups

		First degree relative with dyslexia	
		No	Yes
Has received	No	128	27
speech or language			
therapy	Yes	36	19
			(41.3% of FRD group)
			(34.5% of SLT group)

Table 2: Proportion of the sample currently receiving speech and language therapy.

Group	Past therapy	Current therapy
SLT	17 (47.2%)	18 (50%)
FRD	8 (42.1%)	11 (57.9%)

Table 3: Association between group membership and speech and language difficulties

Recruitment group	No difficulties	Speech difficulties	Language difficulties	Speech and Language difficulties
Control	108 (84.4%)	5 (3.9%)	11 (8.6%)	4 (3.1%)
SLT	15 (44.1%)	5 (14.7%)	7 (20.6%)	7 (20.6%)
FRD	27 (60.0%)	5 (11.1%)	6 (13.3%)	7 (15.6%)

Table 4: Association between group membership and type of speech difficulty

Recruitment group	No difficulties	Articulation difficulties	Speech delay	Speech disorder
Control	112 (87.5%)	10 (7.8%)	6 (4.7%)	0 (0%)
SLT	20 (55.6%)	5 (13.9%)	7 (19.4%)	4 (11.1%)
FRD	31 (67.4%)	4 (8.7%)	8 (17.4%)	3 (6.5%)

Table 5: Mean scores (with standard deviations in parentheses) of the four groups on the speech and language tasks

	Control	SLT only	FRD only	SLT and FRD
CELF sentence structure ^a	9.43 (2.24)	8.81 (2.41)	9.33 (2.09)	8.16 (2.79)
CELF word structure ^a	11.95 (2.88)	8.76 (2.84)	11.63 (2.34)	8.94 (2.69)
CELF expressive vocabulary ^a	11.23 (2.49)	9.78 (2.49)	11.19 (2.66)	8.79 (2.80)
CELF recalling sentences ^a	10.98 (2.34)	8.75 (2.77)	11.30 (2.97)	8.63 (2.52)
DEAP phonology ^{a,b}	9.10 (2.35)	6.57 (2.37)	9.48 (1.88)	5.61 (2.43)
Picture Naming ^c	95.29 (3.83)	86.63 (12.11)	95.48 (3.80)	83.13 (20.39)

Notes: a: scale score with an average of 10 and a standard deviation of 3; b: only children who made some errors on the screening measure completed this task, hence scores tend to be slightly below average; c: percentage consonants correct.

Figure 1: standardised reading scores for the four groups over time

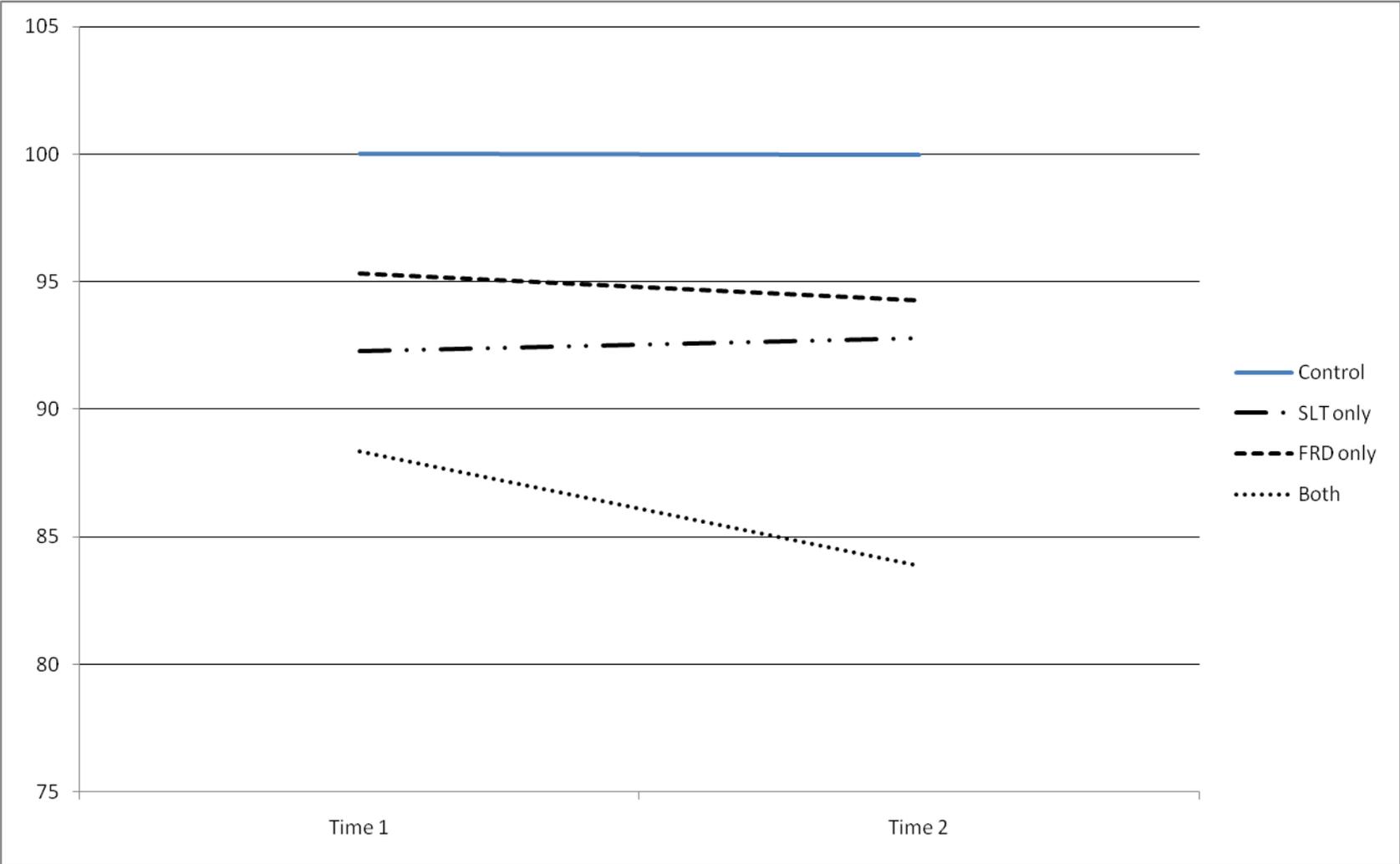


Figure 2: Standardised spelling scores for the four groups over time

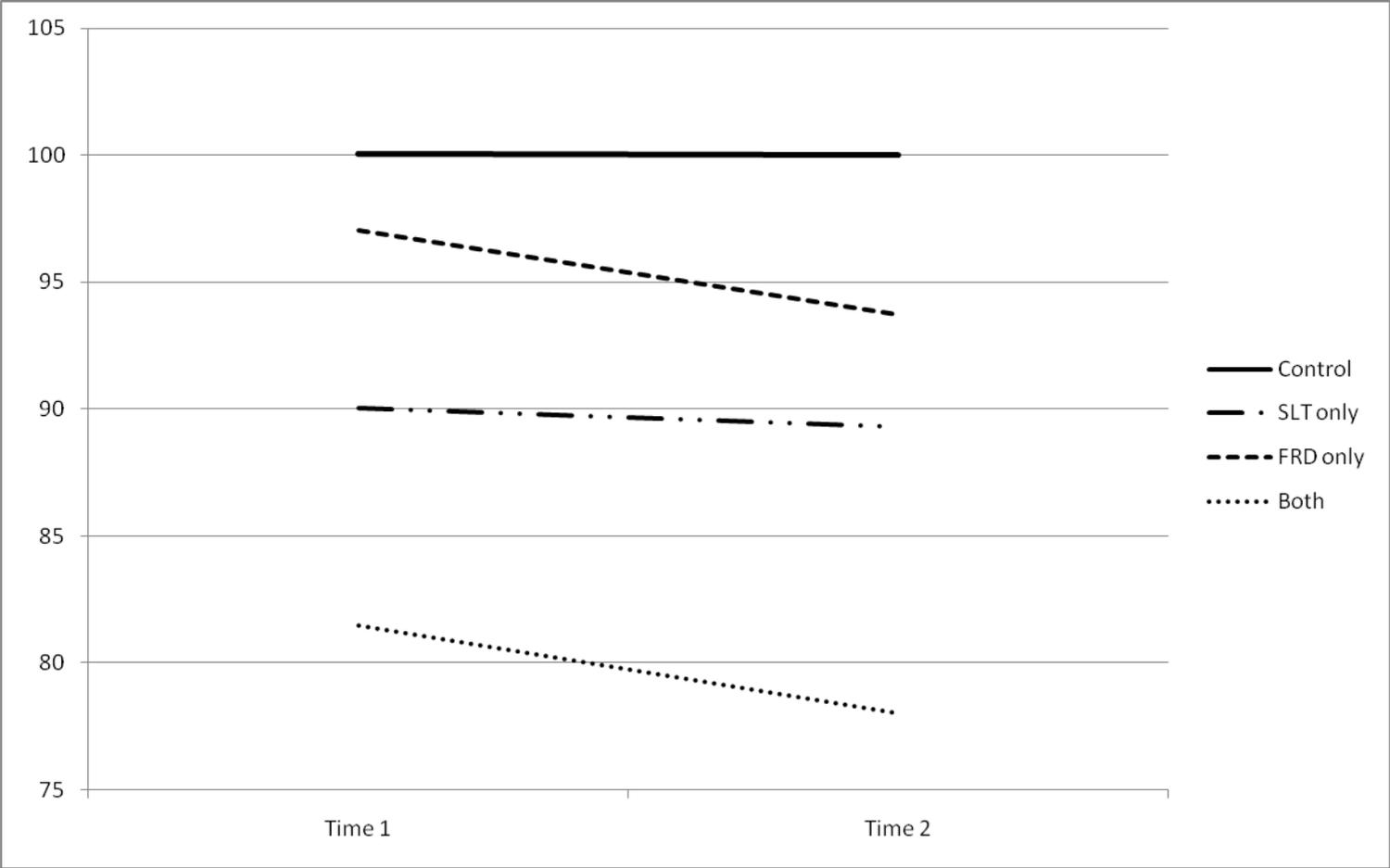


Figure 3: Standardised phonological processing scores for the four groups

