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'Literacy Behaviour' And Auditory Processing : Building 'Fences' at the Top of The 'Cliff' In Preference to Ambulance Services at the Bottom

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Literacy, behaviour and auditory processing: Building 'fences' at the top of the 'cliff' in preference to 'ambulance services' at the bottom[1]

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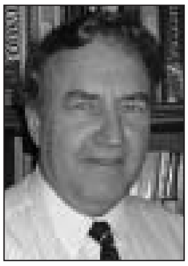
Dr. Rowe's substantive research interests include: developmental assessment; the impact of externalizing behaviour problems and auditory processing difficulties on children's learning outcomes; and the educational/epidemiological implications of Attention-Deficit/Hyperactivity Disorder (AD/HD) and Chronic Fatigue Syndrome (CFS) in children and adolescents. She is in high demand as a keynote speaker/presenter at local and international professional seminars and academic conferences, and undertakes collaborative research and publishes widely with her husband Dr. Ken Rowe (a research program director at the Australian Council for Educational Research).



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Ken Rowe [BA (Hons) PhD Melb, MSc London, DipGenStuds Swin, TPTC, FACEL] is the Research Director of ACER's Learning Processes and Contexts research program. Dr. Rowe's substantive research interests and methodological expertise include: 'authentic' educational and psychological assessment; multilevel, 'value-added', educational and organizational performance indicators, achievement target-setting and benchmarking; teacher and school effectiveness; differential gender effects of schooling in the context of teaching and learning; and the teaching and learning needs of students with learning difficulties. In addition to his research commitments, Ken is a consultant to the Research School of Social Sciences at the Australian National University (since 1991) for whom he conducts training workshops in advanced statistical modelling applications of multilevel and covariance structure analysis of performance indicator data obtained from large-scale monitoring/evaluation/survey projects, as well as in explanatory educational, epidemiological, and psychosocial inquiry.

In addition to attempts to 'keep-up' with three active sons, Ken and his paediatrician wife Dr. Kathy Rowe (at Melbourne's Royal Children's Hospital) are in high demand as keynote speakers related to their separate and collaborative research, and publish widely. Further details about Ken's research are available via ACER's Learning Processes and Contexts research program website at: http://www.acer.edu.au/research/programs/learningprocess/html.

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Abstract: Children who are inattentive or disruptive are at high risk of poor achievement progress, especially in literacy. Approximately 9% of school children have both literacy and externalizing behaviour problems, and the long-term consequences of these are costly emotionally, socially, educationally and economically. Many of these children are referred to paediatricians and psychologists to assess whether learning difficulties or attention deficits are contributing factors to their behaviour problems at school. Similarly, many are referred to audiologists to test 'hearing' in the event that their observed difficulties in listening and following instructions may be due to hearing impairment. However, following audiological screening, most of these children return normal audiograms, but continue to experience functional *auditory processing* (AP) difficulties in terms of reduced *ability to hold, sequence and process accurately what is heard*. In the context of evidence-based research findings, this paper provides: (a) the normative data for more than 10,000 primary school children (5-12 year-olds) in terms of two measured indicators of AP competence, namely, ***digit span*** and ***sentence length***; and (b) key features of practical teaching strategies that have strong positive effects on both boys' and girls' literacy progress, their attentive behaviours in the classroom and general wellbeing. The findings from this research indicate that with common health and educational concerns, growing demands for the provision of 'ambulance services' at the bottom of the 'cliff' become increasingly difficult to justify when 'fences' could and should have first been built at the top.

1.0 Background and Context

Effects of the overlap between students' disruptive behaviour problems at school (particularly *inattentiveness*) and their poor achievement progress in literacy, are highly prevalent and resistant to intervention (Cantwell & Baker, 1991; Hinshaw, 1992; Rowe, 1991, 1997; Purdie, *et al*., 2002; Rowe & Rowe, 1992a,b, 1997a, 1999, 2002; Sanson *et al*., 1996). Approximately 9% of children and adolescents have both literacy and behaviour problems and the long-term consequences of these are costly emotionally, socially, educationally and economically (Barkley, 1995, 1996; Hinshaw, 1994; Rowe & Rowe, 2000; Rutter, 1974, 1985). Moreover, this overlap is problematic to the extent that what are essentially 'education' issues have become major 'health' and 'wellbeing' issues. Increasing numbers of parents and teachers are seeking help from health professionals for their distressed children whose behaviour problems are related to learning difficulties and especially failure to acquire initial and subsequent literacy skills.

The majority of children referred to Melbourne's Royal Children's Hospital (RCH) for assessment of behaviour problems and under-achievement in literacy have also been noted to have ***functional*** difficulties with processing auditory information. Although most of these children who are formally assessed by the Audiology Department at RCH return 'normal' audiograms, many continue to experience functional *auditory processing* difficulties. That is, when such children can hear well in terms of *auditory acuity*, it is recognised that they have a *functional* difficulty in processing what they hear.[2] Thus, *auditory processing* (AP) is defined as the ability to hold, *sequence and process accurately what is heard.* This ability to process auditory information is typically indicated by the number of pieces of information that are recalled accurately (*digit span*) and the length and complexity of a sentence (*sentence length*).

Digit span is used as a surrogate measure of a child's ability to process unrelated verbal information; i.e., the ability to recall accurately digits that are spoken one second apart without variation in voice intonation or 'chunking'. *Sentence length* is used as a surrogate measure for the **amount** of information a child can recall accurately. In contrast to *digit span* that is less dependent on familiarity with language, *sentence length* is not only dependent on familiarity with language, but also developmental age, the ability to listen, concentrate, intelligence, normal variation independent of intelligence, and the ability to process verbal information in the brain (*central auditory processing*; see: Byrnes, 2003; Chermak, 2001; Keith, 2000). However, it is important to note that the two measures of *digit span* and *sentence length* are ***functional*** indicators of a child's ability to process auditory information, rather than a ***diagnosis***.

Despite the lack of reliable normative data on sufficiently large samples for these two indicators of AP, psychologists and speech pathologists commonly use indicators of *digit span* and *sentence length* as part of their assessments for *auditory memory* and for speech and language difficulties. Audiologists also use these indicators for children who demonstrate normal hearing, but who have been referred for assessment when teachers or parents have been concerned about apparent problems with 'listening'. Moreover, paediatricians have noted that many children referred with attentional difficulties for consideration of diagnoses for Attention Deficit Disorder (ADD) and/or Attention-Deficit/Hyperactivity Disorder (AD/HD) commonly have a poor ability to recall a sequence of digits. These professionals frequently observe that children with AP difficulties are disadvantaged in acquiring basic literacy skills, following and complying with verbal instructions, and are 'at risk' of dysfunctional externalizing behaviours (Rowe, Pollard & Rowe, 2003; Rowe, Rowe & Pollard, 2001).

The finding that many children (especially boys) have such difficulties has important practical implications for teaching and learning in the classroom (see Rowe, 2004a). In this context, evidence of a delay in AP development is indicated when a child does not appear 'to listen', and has difficulties in following verbal instructions or

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[2]Whereas the majority of children with AP problems do not have other learning difficulties, children with conditions such as Attention Deficit Disorder (ADD) and/or Attention-Deficit/Hyperactivity Disorder (AD/HD), specific learning difficulties, central language disorders or intellectual disability, often have difficulty with processing verbal information. Likewise, children for whom English is a second language may have a functional difficulty in processing verbal information, but this usually improves with familiarity with spoken English.

directions. In such circumstances, crucial teaching and learning 'milestones' are missed, especially if there is no adjustment to the length of instructions given. Moreover, children with such problems have difficulty acquiring letter-sound links (phonemic awareness) and basic phonological knowledge (Bradley & Bryant, 1983; Dodd *et al.*, 1995; Munro, 1997, 1998, 1999, 2000). Nonetheless, awareness by the parent and teacher of AP difficulties, and taking such difficulties into account when communicating with the child, results in marked improvement in the growth of literacy skills (Rowe, 2004a,b; Rowe, Pollard & Rowe, 2003).[3] Unfortunately, because assistance for many children with AP difficulties is frequently not sought until the later years of primary schooling, these children are distressed, and inevitably exhibit dysfunctional literacy and behaviour problems. Recent increases in referrals of children (mostly boys) with concerns related to poor achievement progress in literacy and inattentive behaviours during the early years of schooling, has highlighted the prevalence of AP difficulties at this earlier stage.

These findings have important implications for pedagogical practice, not merely for the education of boys, but for the experiences and outcomes of schooling by all students, including their psychosocial wellbeing (Rowe, 2003, 2004a; Rowe & Rowe, 2002). In addition to the effects of good 'first wave' teaching strategies for literacy acquisition, with support from an initial intervention program such as *Reading Recovery* (Clay, 1993a; Rowe, 1997), it is important to identify individual children who may require management strategies that can be implemented easily in the classroom. Since children with AP problems have minimal learning difficulties if material is presented in appropriate ways, a means of recognising these children early and preventing on-going difficulties seemed appropriate – albeit somewhat belated.

To this end, beginning in 1999, longitudinal, cross-validation and cross-sectional studies have been undertaken to: (1) assess the utility of a screening tool for administration by teachers to identify those children at school entry who may have AP difficulties; (2) provide normative data for two measured indicators of AP competence, namely, *digit span* and *sentence length*; and (3) assess the impact of teacher professional development on children's literacy achievement and attentive behaviours when appropriate classroom management strategies for AP difficulties are used. Since key findings from the initial longitudinal study have been reported in more detail elsewhere, they are not repeated here (see: Rowe, Pollard & Rowe, 2003; Rowe, Rowe & Pollard, 2001). Nevertheless, a brief outline of the sampling, design and methodological features relevant to the longitudinal, cross-validation and cross-sectional studies is warranted here.

2.0 Key features of the initial trial, longitudinal, cross-validation and cross-sectional studies

2.1 Initial trial study

As part of a trial of school entry screening procedures in Victorian government primary schools during 1999, a standardised screening protocol using a taped voice to measure *digit span* and recall of sentences of varying length (*sentence length*: 3-12 words; later extended to 25 words) were developed in collaboration with speech pathologists. These protocols were administered to 889 children who were in their first year of formal schooling (mean age 5.7 years). This initial 'trial' sample was drawn from 60 classes in 34 schools via a stratified, two-stage cluster-design, with 'probability proportional to size' (PPS).[4] Repeated measures of literacy development (*Concepts About Print*; Clay, 1993b) and behaviour (*Attentiveness*; Rowe & Rowe, 1997b, 1999) were also obtained from this 'trial' sample during November/December 1999, as well as from a matched 'reference' sample ('control') of 705 children drawn from 47 classes in 23 schools. Thus, two waves of literacy and behavioural data (May; Nov-Dec) were obtained for a total of 1604 children (5-6 year-olds). For more specific details of this initial study, including its major findings, see Rowe, Pollard and Rowe (2003).

[3] In this context, the work of educational psychologist John Edwards highlights the negative effects of *ineffective* teaching and learning practices in a typical 'teacher-talk-dominated' classroom that he refers to as 'the sea of blah'. Edwards (2000) claims that there are 'thousands' of students throughout heir primary and secondary schooling who are "bobbing up and down like corks in a sea of classroom and teacher-generated blah" (pp. 4-5).

[4] It should be noted that at the first stage of sampling, government Primary and P-12 schools were selected randomly, but proportional to their enrolment size (PPS) and their representation across all eight Victorian Education Regions. At the second stage of sampling, all School Entry children in at least one class in these selected schools were chosen for participation. The reason for such a sampling design was to ensure that all School Entry children in Victorian government schools during 1999 had an equal probability of selection, and that achieved sample estimates for key marker variables (e.g., *Gender* and *Language Background*) were within 95% confidence intervals for the target population. In contrast, the use of simple random sample of schools would have (by default) yielded a disproportionate number of small schools (see Ross, 1988).

2.2 Sample characteristics of the longitudinal, cross-validation and cross-sectional studies

During the years following the initial trial study (2000-2004), repeated measures, additional cross-validation and cross-sectional AP data have been obtained from a total 10,126 primary school-age children (age 4.7-12 years) for: *digit span, sentence length, behaviour* and *literacy achievement* (see below). Table 2.21 provides the sample characteristics by Year level, child *gender* and *Language Background* from the longitudinal and cross-validation data obtained for 7107 children's AP abilities in 40 schools. Table 2.22 provides similar information for the cross-sectional data obtained for a further 3019 children in the same 40 schools, during the fifth, sixth and seventh years of schooling.[5]

Table 2.21 Sample Characteristics of Longitudinal and Cross-validation Data Obtained for Children's Auditory Processing Abilities in 40 Schools, by Gender and Language Background

Year Level and Mean age	Language Background	Main Sample		Cross-validation sample		Total
		Males	Females	Males	Females	
1st Year (Entry) (Mean age = 5.7 years	ESB*	468	507	423	416	1814
	ESL#	70	73	63	56	262
	Totals	**538**	**580**	**486**	**472**	**2076**
2nd Year (Grade 1) (Mean age = 6.5 years	ESB*	568	620			1188
	ESL#	88	106			194
	Totals	**656**	**726**			**1382**
3rd Year (Grade 2) (Mean age = 7.6 years)	ESB*	566	618	295	279	1758
	ESL#	88	109	51	42	290
	Totals	**654**	**727**	**346**	**321**	**2048**
4th Year (Grade 3) (Mean age = 8.5 years)	ESB*	358	350	360	358	1426
	ESL#	45	56	45	29	175
	Totals	**403**	**406**	**405**	**387**	**1601**
Totals		**2251**	**2439**	**1237**	**1180**	**7107**

* ESB: English-speaking background # ESL: English as a second language

Table 2.22 Sample Characteristics of Cross-sectional Data Obtained for Children's Auditory Processing Abilities in 40 Schools, by Gender and Language Background

Year Level and Mean age	Language Background	Males	Females	Total
5th Year (Grade 4) (Mean age = 9.5 years	ESB*	478	495	973
	ESL#	27	36	63
	Totals	**505**	**531**	**1036**
6th Year (Grade 5) (Mean age = 10.5 years)	ESB*	483	449	932
	ESL#	32	29	61
	Totals	**515**	**478**	**993**
7th Year (Grade 6) (Mean age = 11.5 years)	ESB*	472	465	937
	ESL#	25	28	53
	Totals	**497**	**493**	**990**
Totals		**1517**	**1502**	**3019**

* ESB: English-speaking background # ESL: English as a second language

[5] Further cross-sectional AP data are currently being collected from students in their eighth to tenth years of schooling. To date, data are available for 1240 secondary school students (Grade 7: n = 420; Grade 8: n = 421; Grade 9: n = 399). Since the data from these collections are not complete at this stage, the relevant findings have yet to be reported.

2.3 Methods

As indicated earlier in section 1.0, a key objective of the studies described here was to assess the impact of teacher professional development (PD) on children's literacy achievements and their attentive behaviours when appropriate classroom management strategies for children with AP difficulties are used. Hence, a brief outline of the PD program, the measures used are helpful.

Teacher professional development. Concurrent with the first data-collection phase of the initial study in the 34 'trial' schools, teachers were provided with a one-hour PD program presented by an experienced professional from the Audiology Department of Melbourne's RCH. This program was designed to: (1) raise teachers' awareness of the normative development of children's auditory capacities to process oral/verbal information, (2) provide training in the standardized administration of the two audiological screening protocols, and (3) provide instruction on practical management and intervention strategies for use by teachers in the classroom. For 'control' purposes, teachers in the 23 'reference' schools were not provided with these three 'intervention' elements.

Salient elements of the PD program used in the study with teachers in the 'trial' schools included consciousness raising and training in the following classroom-based strategies:

- Attract the child's attention;
- Use short sentences ('chunked'), maintain eye contact, use visual cues and wait for compliance;
- PAUSE between sentences. If repeats are required, restate simply and provide regular encouragement;
- Monitor the child; e.g., if 'blank look' response, stop and begin instruction again;
- Establish hearing, listening and compliance routines.

2.4 Measured variables

Throughout all phases of the longitudinal, cross-validation and cross-sectional studies, two indicators of children's auditory processing capacities have been obtained by teachers trained in the screening protocols (~ 7 minutes. per child), and teacher-rated measures of their Attentive behaviours in the classroom:

DSPAN — *Digit Span*: Score on a standardized, audiological screening device used to test auditory memory; categorized into four groups: ≤ 2 digits, 3 digits, 4, digits, ≥ 5 digits ($r_{t\text{-}rt} = 0.95$).[6]

SENTL — *Sentence Length*: Score on a standardized, orally-administered protocol, indicating the number of words correctly recalled from a presented sentence. Scores on this continuous variable typically range from 2-12 at School Entry level ($r_{t\text{-}rt} = 0.96$) – see footnote 6.

ATTENT — Score on the *Inattentive-Attentive* scale of the *RBRI 12-Item Teacher Form* (Rowe & Rowe, 1997b, 1999). Continuous scores on this scale range from 1 (min.) to 5 (max), after fitting a one-factor congeneric measurement model to the 4 item-response indicators to compute proportionally weighted factor score regression coefficients for the constituent items; Reliability: $r_c = 0.96$; $\alpha = 0.93$ (for relevant methodological details, see: Rowe, 2002; Rowe & Rowe 1999).

Prior to administration of the auditory screening protocols, each child in their first year of schooling (in both 'trial' and 'reference' schools) was screened for hearing difficulties. If a child's hearing was not adequate, the auditory screening did not proceed and a recommendation was made that the child be referred for formal audiological assessment. In addition to *Language Background* (i.e., ESB–English-speaking background; ESL–English as a second language) and *Gender*, data already available at the schools on the following literacy measures were obtained on two occasions (May and Nov-Dec) for children in both the 'reference' and 'trial' schools:

CAP — *Concepts About Print* (Clay, 1993b): Score on a standardized literacy screening protocol for early school entry. The observed score is a continuous variable with a typical score range 0-24 at this level of schooling (5-6 year-olds); reliability: $\alpha = 0.92$. This measure was also used for children in the early and later stages of their second year of schooling.

[6]The assessment protocols for *Digit Span* and *Sentence Length* are provided in Appendix A (p. 20) and Appendix B (p. 21) of the full paper, available in PDF format from ACER's web site at: http://www.acer.edu.au/research/programs/learningprocess/html.

For children in their subsequent years of primary schooling (as participants in the longitudinal, cross-validation and cross-sectional studies), the following literacy measures (already available at the participating schools) have been used:

TEXTL *Text Level*: Score on the level of graded reading texts capable of being read by a child (Clay, 1993b). This measure was used towards the end of the first year of schooling, and again during the second and third years of schooling.

BURT *Burt Word Reading Test* (Gilmore *et al*., 1981): A continuous score (range: 0-110) providing a measure of reading ability in terms of 'word recognition'; reliability: $\alpha = 0.97$. This measure was used for children in their second to fourth years of schooling.

SA Sp *South Australian Spelling Test* (Fryar, 1997): A continuous score (range: 0-70) for the number of words of increasing difficulty presented orally in sentences that are spelt correctly. This measure was used in the third to the seventh year of schooling.

DART The reading assessment forms from *DART English* (Bodey *et al*., 1997; Forster *et al.* 1994): A continuous score on Rash-calibrated assessment scales for middle and upper primary school children, as well as for early to middle secondary students. These measures are designed to provide developmental and diagnostic information about children's developing achievement progress in reading competence. DART reading measures have been used for children from their fourth to tenth year of schooling.

It should be noted that in instances where two or more literacy measures were used to assess children in any one year of schooling, weighted composite scores for *Literacy* achievement were computed and subsequently normalized as Normal Equivalent Deviates (NEDs) under the Normal distribution. This was done to ensure that the composite scores were scaled on a common metric. For relevant methodological approaches to the computation of such composite variables, see Rowe (2002).

3.0 Summary of major findings

3.1 Age-based norms for *Digit Span* and *Sentence Length*

Given that there is often wide variation in child age at any given Year level of schooling, the following norms for *digit span* and *sentence length* are **age-based**. Moreover, for simplicity and to assist interpretation, the normative data are presented graphically. More detailed tabular versions of these data are given in Appendix C (pp. 22-23) of the full paper.

Figure 3.11 presents the results of fitting a multiple analysis of variance (MANOVA) model to the data on *digit span* and *sentence length* for 9028 children from English-speaking backgrounds (ESB), by gender (4471 males; 4557 females) and eight age groups. [Note that the plots consist of mean-point estimates at each age group, bounded by 95% confidence intervals]. As expected, the MANOVA results for ESB children yielded significant main effects for the 8 levels of **age** [in favour of older children: Wilks lambda (λ) = 0.582; F(14, 16292) = 362.11; $p < 0.000001$] and for the two levels of **gender** [in favour of females: Wilks λ = 0.996; F(2, 9011) = 16.24; $p < 0.00001$]. However, the **age × gender** interaction effect was not significant at the 0.05 α level [Wilks λ = 0.997; F(14, 16292) = 1.581; p = 0.076].

Figure 3.12 presents the corresponding MANOVA results for 1098 children (534 males; 564 females) for whom English is a second language (ESL). The analysis yielded a significant main effect for the 8 levels of **age** [Wilks λ = 0.568; F(14, 2683) = 42.06; $p <$ 0.00001: again in favour of older children], but the **gender** effect was not significant [Wilks λ = 0.999; F(2, 1081) = 0.279; p = 0.756]. Similarly, the **age × gender** interaction effect was not significant [Wilks λ = 0.991; F(14, 2683) = 0.595; p = 0.871].

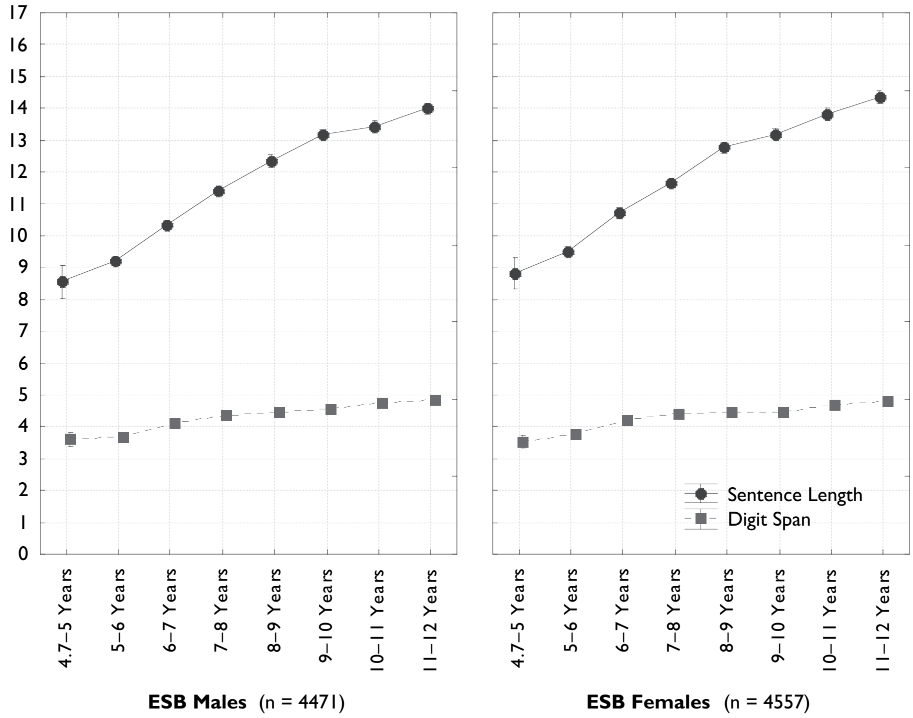

Figure 3.11 Plot of mean-point estimates bounded by 95% confidence intervals for *Digit Span* and *Sentence Length*, by 8 age groups: ESB males and females

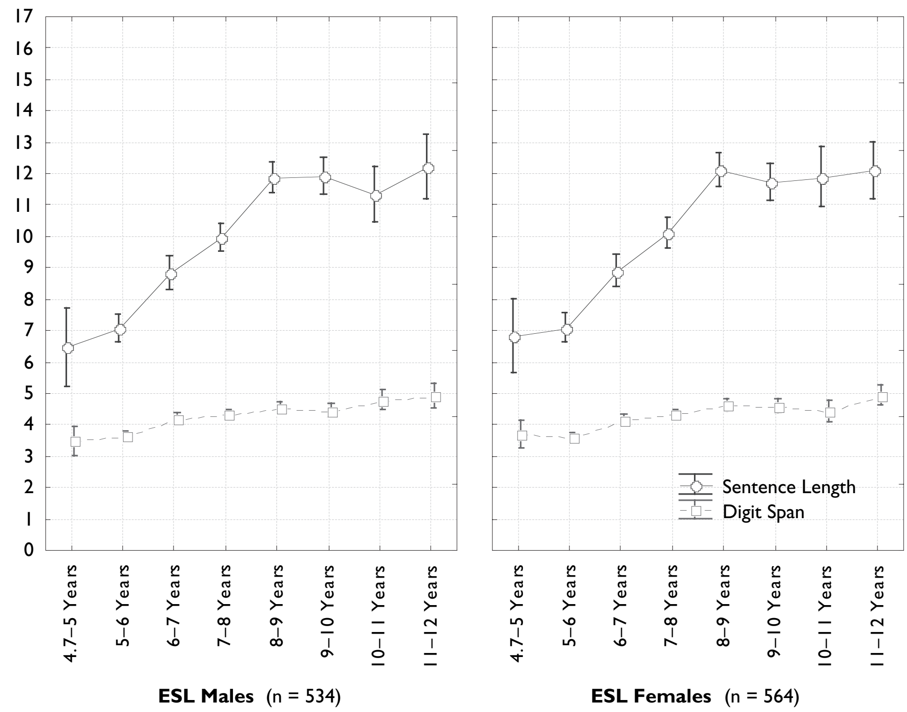

Figure 3.12 Plot of ‘ estimates bounded by 95% confidence intervals for *Digit Span* and *Sentence Length*, by 8 age groups: ESL males and females

An interesting feature of the findings presented in Figures 3.11 and 3.12 is that compared with *sentence length*, the data for *digit span* indicates an almost identical mean pattern of variation across the age groups for both ESB and ESL children. This result underscores the utility of *digit span* for the assessment of *auditory memory* and as an indicator of *auditory processing* (AP) ability that is less dependent on familiarity with spoken English.

As an indication of the relationship between *digit span* and *sentence length*, Figure 3.13 provides a scatter plot of the obtained raw scores for *digit span* and *sentence length* from 10,126 primary school-aged children (age range: 4.7-12 years), together with the regression 'line of bet fit' – bounded by 95% confidence interval bands. Note that the correlation between *digit span* and *sentence length* (r = 0.573; r^2 = 0.328) is significant, accounting for 32.8 % of their mutual variance.

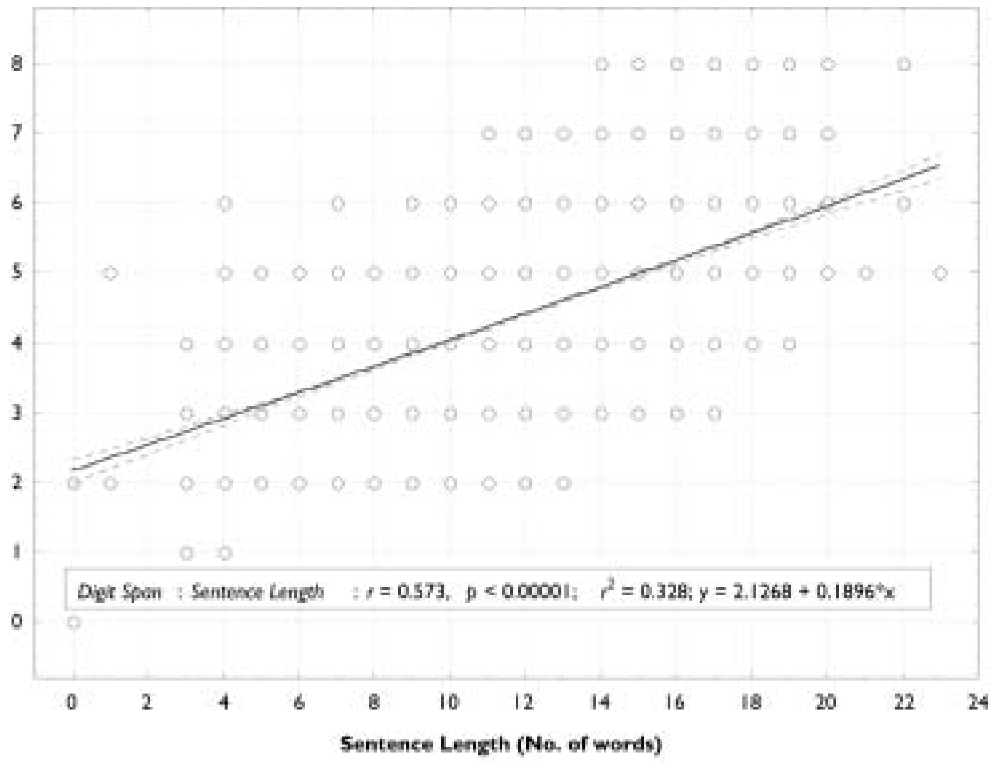

Figure 3.13 Scatter plot of *Digit Span* and *Sentence Length* for 10,126 children age 4.7-12 years, showing the regression 'line of best fit', bounded by 95% confidence interval bands (dotted lines)

To assist educational and health professionals with a straightforward reference to the available normative data for the two AP indicators provided here, Figure 3.14 provides a summary of the percentage cumulative frequencies, by seven age groups, for children from whom complete data for *sentence length* has been obtained.[7] More detailed normative information is presented in Appendix C (pp. 22-23) of the full paper, available from ACER's web site at: http://www.acer.edu.au/research/programs/learningprocess/html.

Table 3.11 provides a summary of the median values (i.e. 50th percentile values) for both *digit span* and *sentence length* across each of the eight age groups.[8]

[7]For simplicity, the data from the 4.7-5 years age group (n = 147) was combined with those from the 5-6 year age group (n = 1929) to create a 4.7-6 years age group (n = 2076), as given in Figure 3.14.

[8]Note that the results of data analyses presented in Section 3, including the graphical representations, were obtained from using *STATISTICA* (2003).

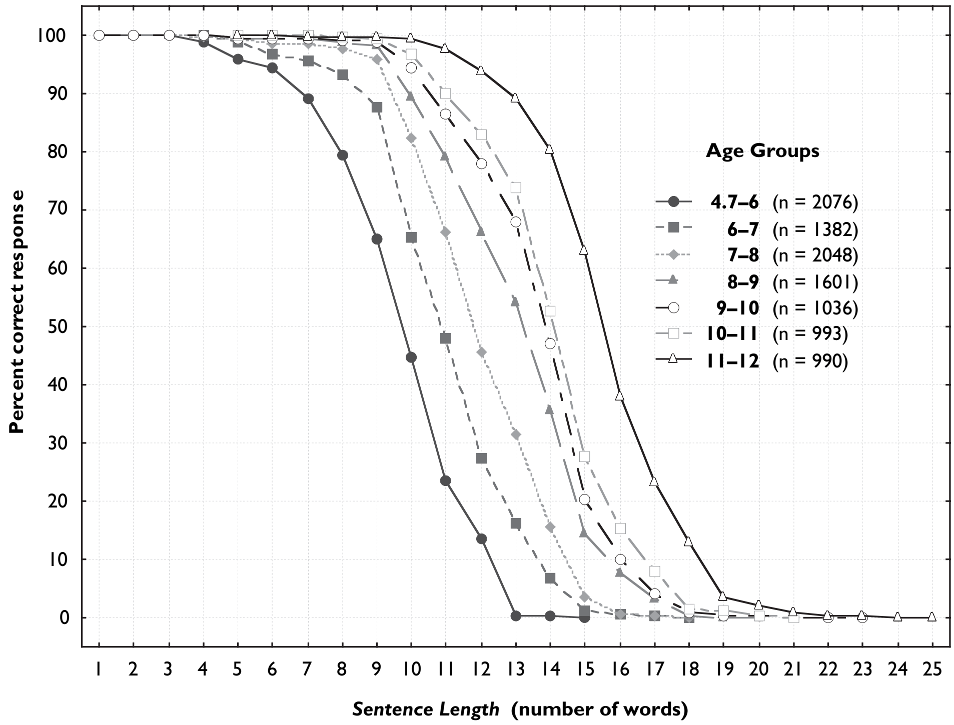

Figure 3.14 Percentage cumulative frequency plots of correct responses for each *Sentence Length*, by seven age groups

An interesting feature of the normative data summarized in Figure 3.14 is that 30% of children in the age groups 4.7-6, 6-7, 7-8, 8-9 and 9-10 years, were unable to accurately process sentence lengths of 9, 10, 11, 12 and 13 words, respectively. Together with the data presented in Table 3.11, these finding have important practical implications for pedagogical practice in the classroom, particularly in respect of the length of sentences that teachers use for communicating verbal instructions and presenting teaching material.

Table 3.11 Median values for *Digit Span* and *Sentence Length* by Eight Age Groups

Age Group	N	Digit Span (Median value)	Sentence Length (Median value)
4.7-5 Years	147	4 digits	8 words
5-6 Years	1929	4 digits	9 words
6-7 Years	1382	4 digits	10 words
7-8 Years	2048	4 digits	11 words
8-9 Years	1601	4 digits	13 words
9-10 Years	1036	4 digits	13 words
10-11 Years	993	5 digits	14 words
11-12 Years	990	5 digits	14 words
Total	**10126**		

3.2 The predictive validity of the AP screening protocols of *digit span* and *sentence length*

The evidence for the predictive effects of the AP screening protocols using *digit span* and *sentence length* for children at School Entry are strong – for both their literacy achievement progress and *Attentive* behaviours during the subsequent years of schooling. To illustrate the predictive validity and utility of AP screening at School Entry, two examples suffice here.

First, Figure 3.21 summarizes the results of fitting a MANOVA model to the repeated measures of *sentence length*, by four categories of *digit span* at School Entry. These data were obtained from a follow-up of 681 children with complete data in the 'trial' schools, from their first to fourth years of schooling. In brief, the results indicated that the effect of *digit span* measured at School Entry was strong predictor of children's ability to process verbal information as measured by *sentence length* during their subsequent three years of schooling [*Digit Span* effect: Wilks lambda (λ)= 0.670, $F(12, 1416) = 19.25$, $p < 0.0001$].

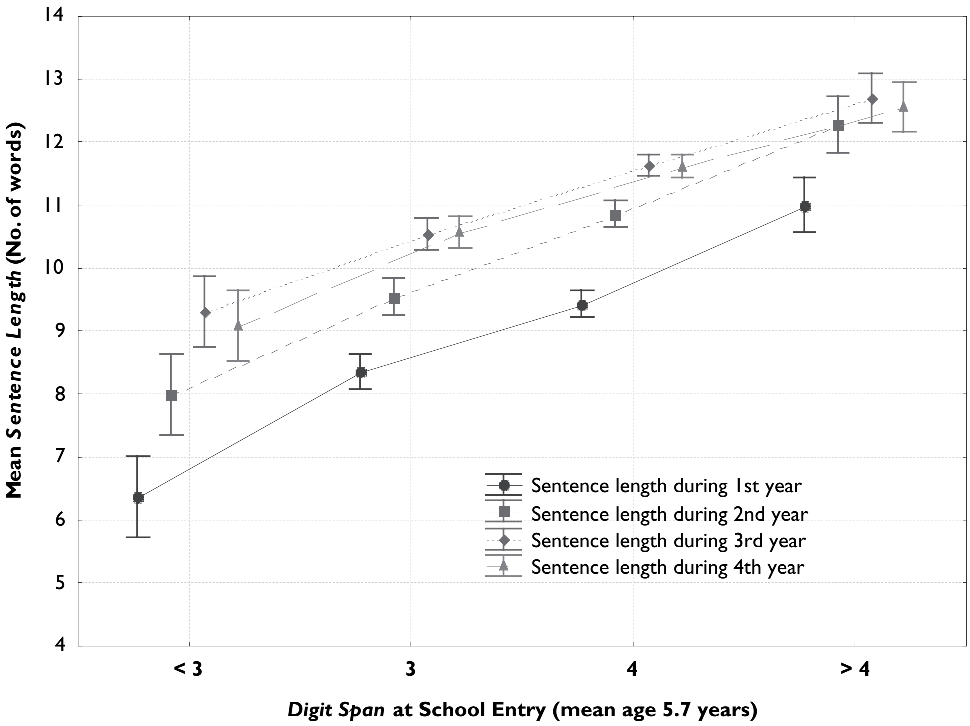

Figure 3.21 Plot of mean-point estimates of sentence length bounded by 95% confidence intervals at the fourth year of schooling, by four levels of digit span at School Entry

Second, the results summarized in Figure 3.22 derive from a multiple analysis of covariance (MANCOVA) model fitted to two literacy achievement measures and *Attentiveness* – obtained from 880 children in the 'trial' schools with complete data during their first four years of schooling, by four categories of *digit span* at School Entry and two categories of Gender. The results (adjusted for age as a covariate) yielded significant main effects on the standardized literacy achievement and *Attentiveness* measures for: ***Digit Span*** at School Entry [in favour of those children with greater AP capacity at School Entry: Wilks $\lambda = 0.845$; $F(9, 1611) = 12.82$; $p < 0.00001$], and for **gender** [in favour of females: Wilks $\lambda = 0.972$; $F(3, 662) = 6.41$; $p < 0.001$]. However, the ***Digit Span*** × **gender** interaction effect was not significant at the 0.05 α level [Wilks $\lambda = 0.992$; $F(9, 1611) = 0.564$; $p = 0.828$].

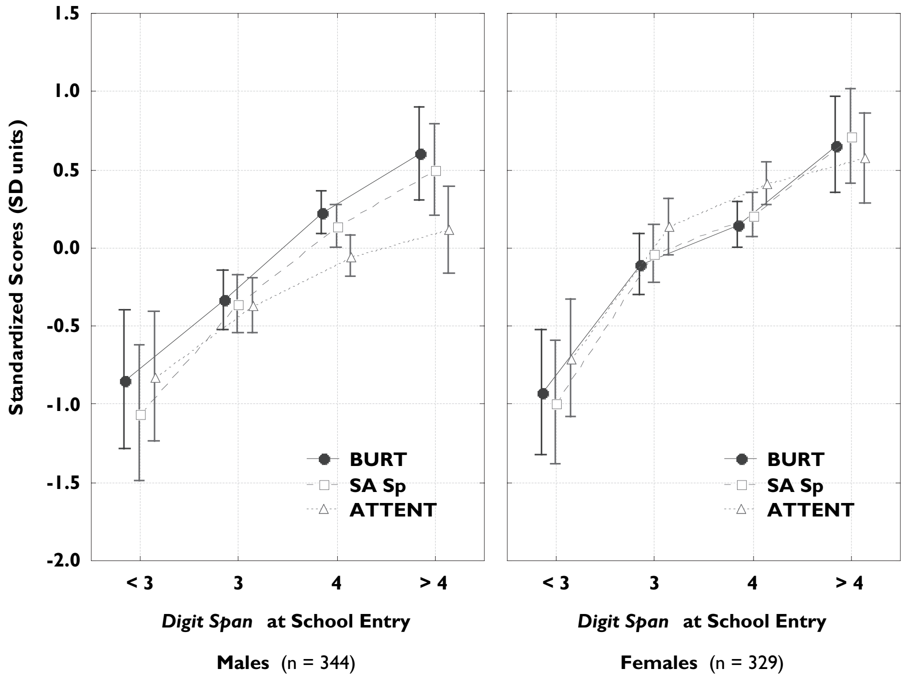

Figure 3.22 Plot of mean-point estimates for *literacy* (BURT, SA Sp) and behaviour (ATTENT) *measures* bounded by 95% confidence intervals at the fourth year of schooling, by four levels of *digit span* at School Entry

In summary, further findings related to the predictive utility of auditory processing (AP) screening at School Entry indicate that:

- At School Entry, 7% of children had a *digit span* of ≤ 2 digits and a *sentence length* of less than 8 words. An additional 15% were 'at risk' of literacy under-achievement during their three subsequent years of schooling since they either had a *digit span* of 3 digits or *sentence length* of ≤ 8 words. Approximately 50% of children with poor literacy outcomes (TEXTL ≤ 3 and/or CAP scores ≤ 12) at the end of their first year of schooling were identified by the AP screening.
- Sixty one percent (61%) of children at School Entry with poor AP scores (i.e., ≤ 3 *digit span* and/or a *sentence length* of < 8 words) had poor literacy achievement and *Attentiveness* scores in their second, third and fourth years of schooling.
- Of those children from ESL backgrounds with poor literacy outcomes at the end of their first year of school, 90% were identified by the AP screening at School Entry. Moreover, 66% of those with poor literacy and *Attentiveness* outcomes in their fourth year of schooling were identified by AP screening at School Entry.
- Children identified with poor AP abilities during their first and second years of school had three times the 'risk'[9] of poor literacy achievement and attentive behaviour outcomes in their two subsequent years (and beyond).

3.3 The impact of teacher professional development

As already noted in sections 1.0 and 2.3, a major objective of the studies described here was to assess the impact of teacher professional development (PD) on children's literacy achievements and their attentive behaviours when appropriate classroom management strategies for children with AP difficulties are used, namely, those outlined in section 2.3 above. Illustrations of the magnitudes of this impact for children's literacy achievements and attentive behaviours are provided in Figures 3.31 to 3.33.

[9]The index of ***Relative Risk* (RR)** used here is commonly used by epidemiologists. In the present context, the index is calculated as the **ratio** of the prevalence of poor literacy and behaviour outcomes in children with AP difficulties, to the prevalence of poor outcomes in children who do not have AP difficulties. For specific computational details and applications, see: Kleinbaum *et al*. (1982).

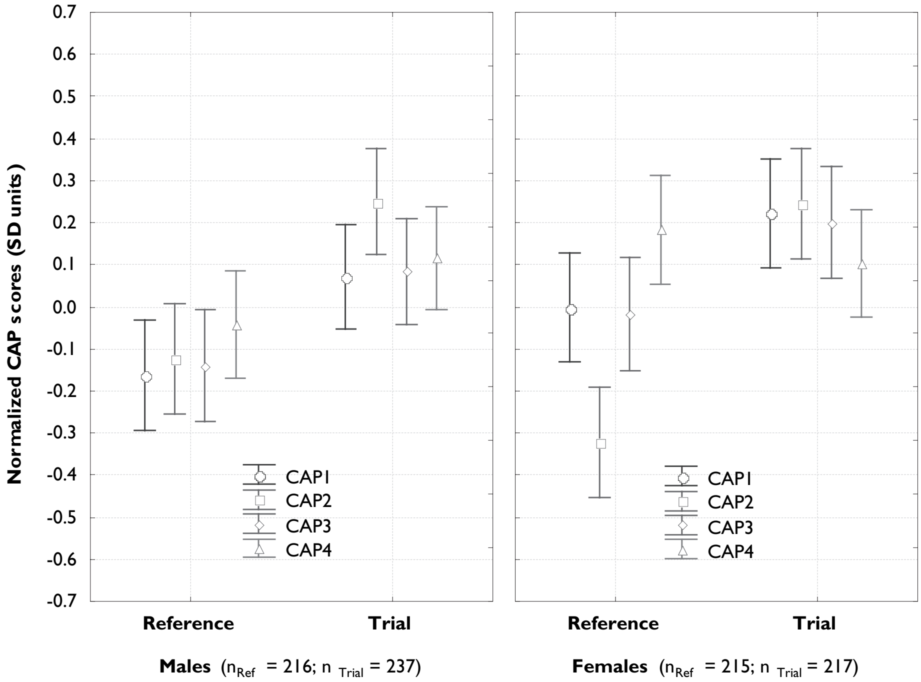

Figure 3.31 Plot of mean-point estimates for 4 repeated measures of CAP for males and females, bounded by 95% confidence intervals, from children in 'reference' and 'trial' schools

The findings summarized Figure 3.31 were obtained from a multiple analysis of variance (MANOVA) model fitted to the 4 repeated measures of *Concepts About Print* (CAP) – obtained from 885 children in the 'trial' and 'reference' schools with complete data during their first three years of schooling. The results (adjusted for age as a covariate) yielded significant main effects on the CAP literacy achievements for: **Trial/Ref** groups [in favour of those children in the 'trial' schools whose teachers had received AP professional development: Wilks $\lambda = 0.936$; $F(4, 878) = 15.11$; $p < 0.00001$] and for **gender** [in favour of females: Wilks $\lambda = 0.983$; $F(4, 878) = 3.81$; $p < 0.01$]. Furthermore, the **Trial/Ref** × **gender** interaction effect was also significant at the 0.05 α level [Wilks $\lambda = 0.989$; $F(4, 878) = 2.40$; $p < 0.05$].

Despite the 'flattening out' of the CAP scores by children in their third year of school (CAP4) due to an expected 'ceiling effect' of CAP for children at this stage of schooling, the results clearly indicate the positive effects of teacher PD related to children's AP processing capacities during the first three years of schooling – particularly for boys.

Similar analyses of the data obtained from repeated administrations of the *Burt Word Reading Test* (BURT) to 1386 children in the 'trial' and 'reference' schools during their third and fourth years of schooling. The results of fitting a MANCOVA model to the obtained data are summarized in Figure 3.32.

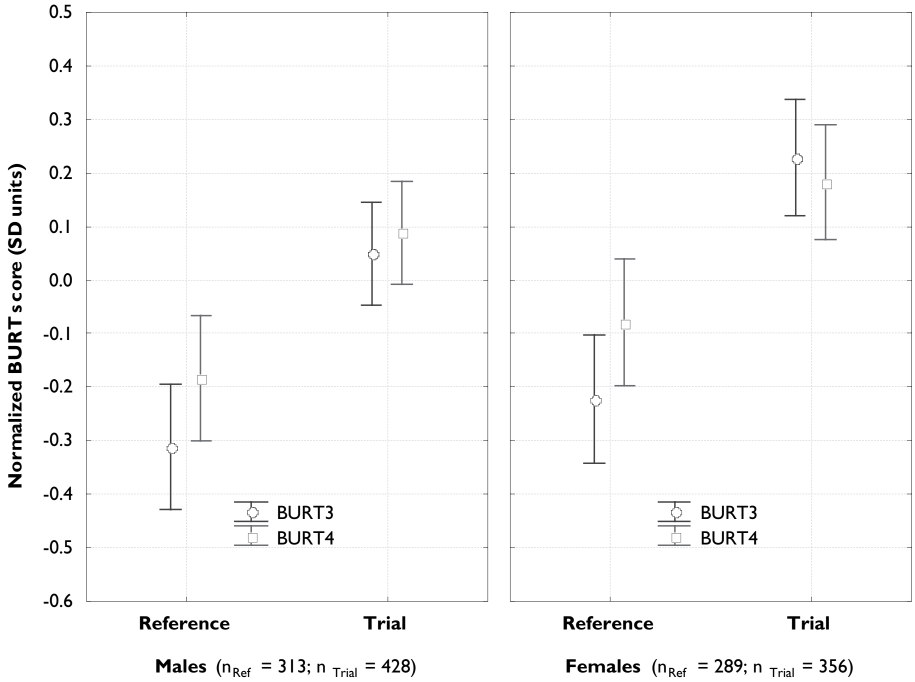

Figure 3.32 Plot of mean-point estimates for 2 repeated measures of BURT for males and females, bounded by 95% confidence intervals, from children in 'reference' and 'trial' schools

The results (adjusted for age as a covariate) yielded significant main effects on the BURT scores for **Trial/Ref** groups [in favour of those children in the 'trial' schools whose teachers had received AP professional development: Wilks $\lambda = 0.975$; $F(2, 1381) = 17.45$; $p < 0.00001$] and for **gender** [in favour of girls: Wilks $\lambda = 0.995$; $F(2, 1380) = 3.19$; $p < 0.05$]. However, the **Trial/Ref** × **gender** interaction effect was not significant.

A further MANCOVA model was fitted to the four repeated measures for *Attentiveness* – the results of which are presented in Figure 3.33. The results (adjusted for age as a covariate) yielded significant main effects on the ATTENT scores for **Trial/Ref** groups [in favour of those children in the 'trial' schools whose teachers had received AP professional development: Wilks $\lambda = 0.990$; $F(4, 1681) = 3.92$; $p < 0.05$] and for **gender** [in favour of girls: Wilks $\lambda = 0.925$; $F(4, 1681) = 34.03$; $p < 0.00001$]. The **Trial/Ref** × **gender** interaction effect was not significant.

Three further results are of interest. First, there were significant differences in the improvements in literacy progress and attentive behaviours for both ESL and ESB children in the 'trial' schools compared with their counterparts in the 'reference' schools. Second, variation the literacy achievements for children in the 'trial' schools decreased over time compared with those of children in the 'reference' schools.

Third, after adjusting for children's intake factors (i.e., age, gender, Language Intake and initial achievement), the effect on children's literacy achievement progress of being in a 'trial' school (compared with being in a 'reference' school) was a significant + **0.31** standard deviations (SDs). These results were obtained from fitting an explanatory two-level model [i.e., children (level-1) within schools (level-2)] to the weighted composite literacy achievement data for children in their fourth year of school, adjusted for their initial achievement on *Concepts About Print* (CAP1) and intake factors, followed by a multilevel analysis of school-level residuals. For outlines of such procedures, see Goldstein (2003) and Rowe (2004c). A graphical presentation of these results is given in Figure 3.34, using *MLwiN* (Rasbash *et al*., 2003).

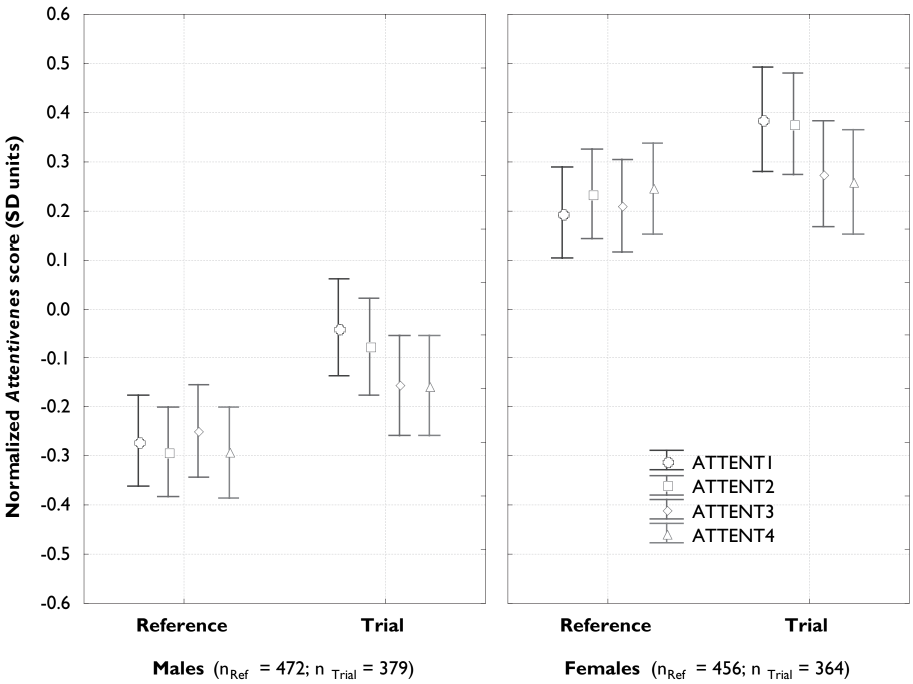

Figure 3.33 Plot of mean-point estimates for 4 repeated measures of Attentiveness (ATTENT) for males and females, bounded by 95% confidence intervals, from children in 'reference' and 'trial' schools

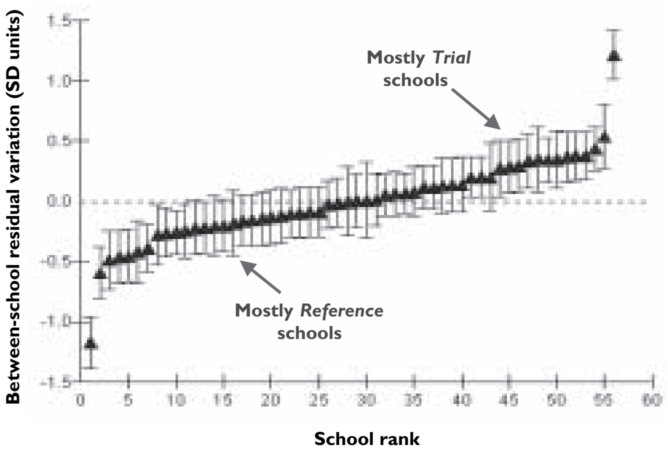

Figure 3.34 Plot of adjusted mean-point school-level residuals for literacy achievement, bounded by 95% confidence intervals

These results indicate that the auditory processing PD and AP screening procedures undertaken by teachers in the 'trial' schools had significant **value-added** effects on children's literacy achievement progress. Interestingly, teachers in the 'trial' schools who received the PD were generally unaware of this aspect of child development and that it has such a strong, positive impact on children's literacy achievement progress, as well as their attentive behaviours in the classroom. Indeed, teachers found it particularly enlightening to observe the responses of children exposed to the AP screening procedures, and were challenged to consider the implications for presentation of verbal instructions and teaching materials in the classroom.

4.0 Summary of key findings

- **Auditory processing is important for literacy and behaviour.** Children's auditory processing capacities are strongly linked to their initial and subsequent literacy progress, as well as to their attentive behaviours in the classroom.
- **Auditory processing screening and related teacher PD works!** Data obtained from administration of the AP screening protocols have strong predictive validity and utility. The evidence indicating significant improvements in children's literacy progress between 'trial' and 'reference' schools – for both ESL and ESB children – emphasises the importance of building pedagogical capacity in teachers as an integral part of their initial education and training, as well as via on-going strategic professional development. Compared with children in the 'reference' schools, variations in literacy achievement progress for children in the 'trial' schools decreased significantly over a 6-month period, and beyond. In the absence of such screening and PD (in the 'reference' schools), the attentive behaviours of under-achieving boys deteriorated. **Follow-up of 'at-risk' children is crucial**.
- **Auditory processing screening by teachers was well accepted and recommended for inclusion in School Entry Assessment procedures.** Teachers strongly endorsed the value of the AP professional development, since many claimed to be unaware of typical variations in children's auditory processing abilities and the implications for classroom practice. The screening for auditory processing at school entry was well accepted by the teachers and the information gained in association with the professional development had a marked effect on literacy outcomes for the whole class. Furthermore, auditory processing ability at School entry was a strong predictor for both literacy achievement and behaviour, and the general effect of the PD intervention was particularly marked for ESL children and for boys' attentive behaviours in the classroom.[10]

5.0 Concluding comments

The findings arising from this study have important implications for initial teacher education and training, as well as for teacher in-service professional development. Likewise, the findings should have important influences on shaping educational policy and practice for the early and middle years of schooling. In this regard, an important outcome of the study to date has been an *Auditory Processing Assessment Kit* produced jointly by the Department of Education and Training and the Royal Children's Hospital, Melbourne (Victoria, 2001). The initial version of this was distributed to Victorian government primary schools in the first week of February 2001. The kit contains audio and video materials designed to support early years teachers to administer the *Auditory Processing Assessment Procedure* as part of 'Prep-Entry Assessment' protocols. In particular, the materials consist of a step-wise procedure for assessing children's auditory processing capacities, a teacher professional development component with background information, and practical classroom management strategies (as summarized above).

An up-dated version of this kit is currently being developed jointly by researchers at the Royal Children's Hospital (Melbourne) and the Australian Council for Educational Research. This version (expected to be completed by early December 2004) extends the AP screening protocols for use by teachers of students from the first to the tenth years of schooling (i.e., 5-15 year-olds).

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[10] It is interesting to note that **Recommendation 5** from the report of the parliamentary *Enquiry Into the Education of Boys* (Commonwealth of Australia, 2002, pp 107) reads:

The Committee recommends that:

(a) all State and Territory health authorities ensure that kindergarten children are fully tested for hearing and sight problems; and

(b) the Commonwealth and State and Territory governments jointly fund the implementation of the strategies used in the Victorian study on auditory processing in primary schools throughout Australia. Implementation should include:
- professional development for all primary school teachers to raise awareness about the normal development of auditory processing in children;
- the provision of the relevant auditory screening tests and training to equip teachers to administer preliminary tests with referral to specialised support where needed; and
- professional development for teachers in practical classroom management and teaching strategies to address the needs of children with auditory processing difficulties.

The research work of neurophysiologists at the Australian National Acoustic Laboratories is worth noting here. In particular, the findings of LePage and Murray related to ***auditory capacity*** derive from ***otoacoustic emission tests*** on 3000 clinic referred persons aged 2-80 years (see: LePage, 2002; LePage & Murray, 1998, 2002, 2004; Murray & LePage, 1993). [Note that an *otoacoustic emission test* measures the reaction time of an ear; i.e., how quickly the ear responds to streams of sounds such as speech]. Analyses of the available data indicate that although there is a notable decline in auditory processing ability with age for both males and females, after the age of four years males have significantly less ability than females to process auditory 'streams' of sound such as speech. LePage (2002) notes:

> The overwhelming fact … is that from about the first decade of life the ears of boys are effectively older than the ears of girls. They process sounds more slowly and provide less information to the brain to be analysed. … We are saying that, given our findings, it is not reasonable to expect that boys, on average, will absorb class teaching material as readily as girls (cited in Commonwealth of Australia, 2002, pp. 104-105).

Whereas this evidence has yet to be confirmed with children and adolescents from the 'normal' population, it raises several issues requiring further investigation.

Finally, in the context of common health, wellbeing and educational concerns with children, growing demands for the provision of 'ambulance services' at the bottom of the 'cliff' become increasingly difficult to justify when 'fences' could and should have first been built at the top. Clearly, such 'fences' **can best** be achieved by **building teachers' pedagogical skills** and **capacities** that meet the developmental and learning needs of their students. But these capacities and skills will not be realized until teachers are at least in receipt of quality initial education and training, as well as strategic professional development support that are commensurate with the invaluable contributions they are able make to the enrichment of students' wellbeing and 'life chances' (see: Ingvarson, 1998, 2003; Rowe, 2003, 2004a,b). In the interests of children's educational progress, emotional and social wellbeing, as well as cost effectiveness, it is vital that education and health policies/practices be based on the evidence reported here.

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