INTERNATIONAL JOURNAL OF PSYCHOLOGY, 1991, *26* (4), 471–483

Reading Rates and Digit Span in Bilinguals: The Superiority of Mother Tongue

Amâncio da Costa Pinto

Universidade do Porto, Porto, Portugal

Several studies have shown a negative linear relationship between speech rate and memory span. This relationship has implications for bilingual studies, as span could be larger in a bilingual's secondary language provided that pronunciation rate is faster than in the mother language. The purpose of this study was to investigate the effects of digit word length on digit span in bilinguals. Experiment 1 tested the effects of digit syllable length on speech rate in five different bilingual groups. Results revealed that digit-reading rates were significantly faster in all mother languages. Experiment 2 examined more closely the correspondence between speech rate and digit span with Portuguese–English bilinguals. Results showed that digit-reading rates were faster and digit span larger in the mother language even if the mean number of syllables per digit was higher. The superiority of mother tongue was discussed according to the view that digits are subject to massive practice in one's native language with a strong tendency to be abbreviated, thus reducing its spoken duration.

Certaines études ont montré une corrélation négative entre le nombre moyen de syllables par chiffre et l'empan de mémoire. Cette corrélation a des implications au niveau du bilinguisme, étant donné que l'empan peut-être plus élevé dans la langue secondaire du bilingue si la vitesse d'articulation est plus rapide que celle de la langue maternelle. Cette étude prétend rechercher des effets de la longueur des syllabes par chiffre dans l'empan de mémoire chez des sujets bilingues. La première expérience a analysé les effets de la longueur des chiffres sur la vitesse de lecture chez des sujets bilingues de cinq pays européens différents, aussi bien en anglais que dans leur langue maternelle. Les résultats ont révélé pour chaque groupe que la vitesse de lecture était significativement plus rapide dans la langue maternelle que dans la langue secondaire. La deuxième expérience a analysé plus en détail la relation entre la vitesse de lecture des chiffres et l'empan de mémoire chez des bilingues portugais-anglais. Les résultats ont montré non seulement que la vitesse de lecture était plus rapide, mais aussi que

Requests for reprints should be sent to Amâncio da Costa Pinto, Faculdade de Psicologia, Universidade do Porto, R. das Taipas, 76, 4000 Porto, Portugal.

This research was supported by a Nato scholarship, while the author was at the MRC Applied Psychology Unit, Cambridge, working for a PhD. I thank Graham Hitch, J. Alegria, Alan Desrochers, and the anonymous reviewers for their criticisms and helpful comments.

l'empan de mémoire était plus élevé dans la langue maternelle, même quand le nombre moyen de syllables par chiffre était plus grand. Quant à l'explication de cette supériorité, il a été considéré que les chiffres sont un matériel massivement utilisé dans la langue maternelle et révélant, de ce fait, une forte tendance à être abrégés, réduisant ainsi le temps d'articulation.

INTRODUCTION

Several studies have observed a negative linear relationship between speech rate and memory span tasks. Baddeley, Thomson, and Buchanan (1975) were the first to show that pronunciation rate affected the size of memory span for words. Data from several studies have shown that measures of rehearsal speed, as assessed by reading verbal items aloud, correlated quite highly with span scores. Within a specific language this finding was obtained both with university students (e.g. Schweickert & Boruff, 1986; Standing et al., 1980), and in developmental studies (e.g. Hitch, Halliday, & Littler, 1989; Hulme et al., 1984).

Most interestingly Ellis and Hennelly (1980) reported that the word-length effect had implications for bilingual studies. They have observed that digit span for Welsh children tested on the Welsh Children's Intelligence Scale was reliably lower than the span of American children tested on a similar procedure of the Wechsler Intelligence Scale Children (WISC). Ellis and Hennelly (1980) suggested that these differences could be due to the word-length effect, as Welsh digit names tend to have longer vowel sounds than in English and thus take longer to articulate.

Results obtained in cross-language studies have shown that span was longer whenever the items took less time to read (e.g. Naveh-Benjamin & Ayres, 1986; Stigler, Lee, & Stevenson, 1986). In Stigler et al.'s paper a study carried out on Chinese and American university students revealed that number words were read faster in Chinese than in English and that memory span was concomitantly larger for Chinese students. Likewise, Naveh-Benjamin and Ayres (1986) showed that groups of university students from an Israeli university, whose native language was English, Spanish, Hebrew, and Arabic, have larger memory spans in the languages where digit-reading rates were faster.

This negative association between reading rates and span differences has important implications for theoretical and practical reasons. This relationship is theoretically interesting because it is in accordance with the idea that memory span involves subvocal rehearsal of information in a rapidly decaying articulatory store (Baddeley, 1986; Baddeley & Hitch, 1974). From a practical point of view this negative association between reading and span is also important as subjects could be penalized in the digit memory task, as assessed by the WISC scale (Wechsler, 1949), if digit words of a given

language have longer durations than in another language. In fact Ellis and Hennelly (1980) suggested that the inferiority of Welsh children as compared with their American counterparts in the WISC could be due to the articulation effect related with longer vowel sounds in Welsh. If this explanation has some merit then analogous differences should be observed between American and the European languages, where adjusted norms for the WISC have been obtained.

In this regard an inspection was made of the mean digit-span raw scores of the American, Portuguese, Brazilian, Spanish, Italian, French, and German version of the WISC. Except for the Italian version, data presented in Table 1 consistently indicate reductions at several age levels in European children speaking different languages, as compared to U.S. children. As far as the Portuguese normalization of the WISC is concerned (Marques, 1969), a clear decrement was obtained in almost all age levels considered, and these differences were replicated by the Brazilian version of the WISC (Lemgruber & Paine, 1981), where Portuguese is also the mother language.

Following Ellis and Hennelly's hypothesis, the inferiority of Portuguese-speaking children on the WISC digit span might have been due to the word-length effect. In fact there are six disyllabic digit words from 0 to 9 in Portuguese. However, similar reductions were observed in the WISC span where the number of disyllabic digit words is much smaller, such as in German (1-disyllabic digit) (Hardesty & Priester, 1966) and French (2-disyllabic digits) (Wechsler, 1965) and no differences were registered in the Italian WISC (Falorni, 1956) where there are eight disyllabic digit words.

Presumably the explanation behind these results is very complex and takes into account other factors besides digit-reading rates for a given language

TABLE 1
Digit Span Scores (Forward Plus Reversed) for Several Countries at Different Age Levels Tested on the WISC Procedure

	Age (Year.Month)										
Country	*6.3*	*7.3*	*8.3*	*9.3*	*10.3*	*11.3*	*12.3*	*13.3*	*14.3*	*15.3*	*15.10*	
U.S.A.	6	7	8	9	9	10	10	10	11	11	11	[a]
Portugal	4	6	7	8	8	8	9	9	10	10	11	[b]
Brazil	6	6	7	7	8	8	8	9	9	9		[c]
Spain	6	7	8	8	8	9	9	10	10	10		[d]
France	6	7	8	8	8	9	9	10	10	10	10	[e]
Italy	6	7	8	9	9	10	10	10	11	11	11	[f]
Germany	5	7	8	8	9	9	9	10	10	10	10	[g]

Note. [a] Wechsler (1949); [b] Marques (1969); [c] Lemgruber and Paine (1981); [d] Wechsler (1982); [e] Wechsler (1965); [f] Falorni (1956); [g] Hardesty and Priester (1966).

(e.g. Dempster, 1981). However, previous studies have shown that reading performance is a serious candidate when accounting for differences in digit span and therefore the first study was designed to test if samples of French, German, Italian, Portuguese, and Spanish bilinguals did or did not read digit words at different rates in English and in their mother tongues. In each of these languages the total number of phonemes, the number of two-syllable digits and the mean number of syllables per digit on digits from 0 to 9 respectively is French: 40—2—1.2; English 40—2—1.2; Portuguese 41—6—1.6; Italian 42—8—1.8; German 43—1—1.1; Spanish 43—7—1.7.

EXPERIMENT 1

In this experiment bilinguals were required to read digit lists both in their mother tongue in order to examine the digit-length effect and in English in order to obtain a comparative measure of reading fluency. Reading was obtained both in sequential order from 0 to 9, as in counting fast events in daily situations, and in a random order, a condition closer to a span task presentation. Thus, the major purpose of Experiment 1 was twofold: (1) to observe if there was a relationship between digit-reading rates and syllable length in a bilingual's mother language across different languages. In this case digit reading should be faster in German and French than in Spanish and Italian, if the mean number of syllables per digit is taken into account; (2) if digit-reading rates are independent or not of the bilingual's spoken language. As the mean number of syllables per digit in English is similar to French and German and much lower than in Portuguese, Spanish, and Italian, it seems tempting to examine whether, for instance, French and German bilinguals do or do not read at the same rate both their native and English languages.

METHOD

Subjects

Sixty postgraduate students and scholars, whose mother language was French, German, Italian, Portuguese, Spanish, and English were selected. There were 10 subjects in each language and all of them were attached to different departments of the University of Cambridge, U.K., for at least 18 months. All foreign subjects started learning English when they were at least 11 years old and all assessed their English proficiency on a 10-point self-rating scale between 7 and 10 with an average of 8.5. Subject's age range was between 23 and 31 years and most were females.

Task and Procedure

Subjects were required to read 50 digit figures as fast as possible but keeping the reading intelligible. Reading time was recorded by the same person and measured by a stop-watch in units of $\frac{1}{10}$ of a second from the command three in the sequence: "one, two, three", until the pronunciation of the last digit in the list. There were two factors: (1) Test language: Mother tongue and English; and (2) Digit order presentation: Sequential and random. Ten digits were typed in five rows in a sequential order from 0 to 9, or the same row digits in a random order. Sequential always preceded random presentation, but within each presentation, language was counterbalanced. There were three trials in each of the four conditions. U.K. subjects only performed the reading task in English.

RESULTS AND DISCUSSION

Mean reading rates for digits in a sequential order and in a random order, both in one's mother tongue and in English, are presented in Table 2. A three-factor ANOVA, 1-between (groups) and 2-within (test language and task), showed that the effects of test language, $F(1, 45) = 53{,}81$, $P < 0.001$ and task $F(1, 45) = 400.69$, $P < 0.001$ were highly significant. The group factor was not significant: $F(4, 45) = 1.92$, $P > 0.12$. Results revealed that digit reading was always faster in the mother tongue than in the secondary language (English), both in sequential order and random order, regardless of the language spoken. Further analysis also indicated that within sequential or random presentation there were no statistical differences between the language groups, except when subjects were asked to read digits in sequential

TABLE 2
Mean Reading Rates for 50 Digits both in the Mother Tongue and when Translated to English

	Portugal	*Spain*	*Italy*	*France*	*Germany*	*U.K.*	*Total Means*
	(a) *Sequential Order*						
Mother	8.01	9.99	10.17	7.63	9.06	8.45	8.89
English	9.44	10.51	11.26	9.28	10.47	—	10.19
	(b) *Random Order*						
Mother	13.90	13.59	14.20	13.41	14.20	14.28	13.93
English	16.52	17.29	17.39	15.36	16.10	—	16.53

presentation in their mother tongue, $F(5, 54) = 4.02$, $P < 0.01$. *Post hoc* analysis (Scheffé F-test) showed that the only significant mean differences in reading rates were between French and Italian ($P < 0.05$) and that none of the other differences were significant.

Results also revealed that digit-reading rates are slower, on average 1.3 sec in sequential presentation and 2.6 sec in random presentation, when non-U.K. subjects are required to read digits in the secondary language, as compared with U.K. subjects reading English digits. Despite the high familiarity these non-U.K. subjects had with the English language, their reading rates were systematically slower in English than in their native languages.

These results suggest that as far as digit word length is concerned, the number of letters or syllables digits have in the languages tested do not produce any substantial differences in reading rates in random order.

However, some support for the word-length effect across languages was obtained in the sequential presentation, the only experimental condition where the language groups were statistically significant. In fact, French and English with two disyllabic digits each, and Spanish and Italian with seven and eight, formed two groups of languages with the fastest (Mean, 7.7 sec) and slowest (Mean, 9.8 sec) reading rates. Also, when subjects were required to read sequences of random digits in the secondary language there was a positive trend between the mean number of syllables per digit and reading rates. These results are plotted in Fig. 1, with reading scores as a function of mean number of syllables per digit in each of five languages. Pearson correlation was respectively: $r = 0.885$, $P < 0.05$. Again, partial support was obtained for the digit-length effect across five different languages. These results seem to replicate a similar reading trend obtained by Naveh-Benjamin and Ayres (1986), for English, Spanish, Hebrew, and Arabic.

These results seem to suggest that there are some experimental conditions, particularly reading digits in sequential order in one's native language, where digit length is associated with different reading rates. However, the condition in this experiment that mostly resembles digit-span presentation, where digits are presented in one's native language in a random order, revealed that subjects read at similar rates. Therefore, it is tempting to suggest that digit span would not be much different in any of the six languages considered for the subjects tested. Yet in the absence of empirical data on digit span this is only a hypothesis derived from Baddeley et al.'s (1975) correspondence between reading rates and digit span. Unfortunately, data on digit span for the samples tested could not be obtained due to difficulties in subject's time availability. Nevertheless, these results may suggest that the negative consequences of digit word-length effect on digit span, as implied by Ellis and Hennelly (1980) and Naveh-Benjamin and Ayres (1986) may have been exaggerated. The aim of Experiment 2 is to study more closely this implication.

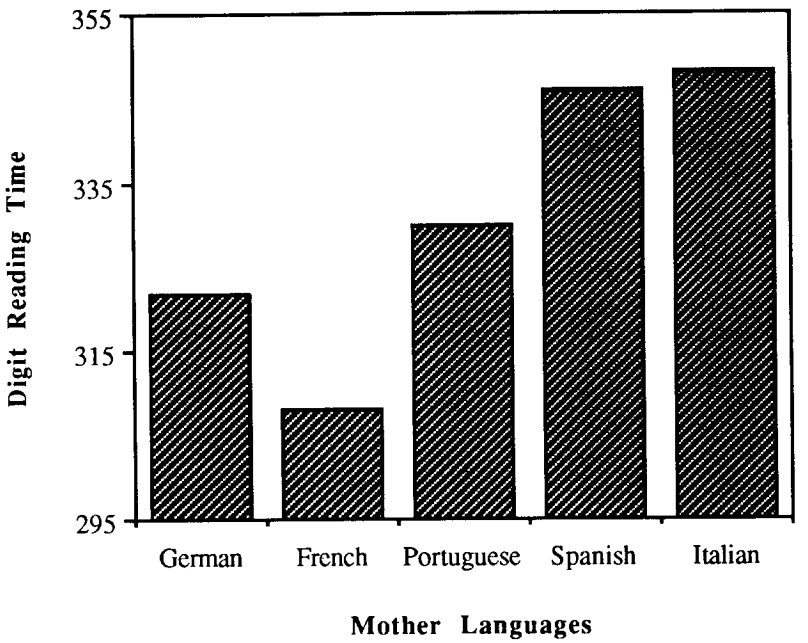

FIG. 1. Digit reading rates in English by bilinguals from five European languages as a function of the mean number of syllables per digit in their native languages. German (1.1); French (1.2); Portuguese (1.6); Spanish (1.7); Italian (1.8). Time units in milliseconds.

EXPERIMENT 2

The purpose of Experiment 2 is to determine which of the two bilingual's languages is the support for the relationship between digit length, reading rates and span performance. Ellis and Hennelly (1980) showed that there was a clear relationship between reading and span favouring the language with shorter durations, even if it was the secondary language. Other researchers (e.g. Zhang & Simon, 1985) found that this relationship was only obtained with the mother language. However in Zhang and Simon's (1985) study the language used was Chinese, and the mean number of syllables per digit in Chinese is shorter than in English. Faced with these results, what would be the outcome if bilinguals have a mother language with longer syllable durations than their secondary language? According to Ellis and Hennelly's study the relationship between reading and span would favour the language with shorter durations, and that one would be the secondary language in such case. However, results from Experiment 1 indicated that such a relationship is likely to favour the mother tongue.

Experiment 2 is a within-subject design and was designed in much the same way as Ellis and Hennelly (1980) had done. Portuguese–English

bilinguals, whose mother language was Portuguese, were selected. In these languages the mean number of syllables per digit is respectively 1.6 and 1.2. Differences in digit length are thus extensive and it seemed valuable to test if span is larger when examined in the bilingual's mother tongue despite digit length,[1] or in the secondary language where digit word length is shorter.

Digit reading and span were the tasks selected. Span was also obtained under conditions of articulatory suppression. If there is a digit-length effect on span for Portuguese and English, such effect would be eliminated under conditions of articulatory suppression, at least for visual presentation. According to the working memory model, suppression has a selective effect on the articulatory loop through disrupting subvocal rehearsal (Baddeley, 1983).

METHOD

Subjects

Twelve Portuguese female subjects in the 21–23 age range and attending the English course of the University of Oporto, Portugal, were selected. All of them started learning English as their second main language when they were between 10 and 12 years old, and most of them had improved their proficiency in English language by attending private classes in British Council schools. Subjects were selected if they estimated their fluency in the English language on a 10-point self-rating scale with a minimum value of 6. The estimations ranged from 6 to 9, with an average of 7.6. As Rose (1975) obtained high correlation values between subjective reports and objective measures of bilingualism, and Fishman and Cooper (1969) found that subjective reports about secondary language proficiency were the best predictable measures of bilingualism, it was assumed that the sample selected approached the level of bilingualism for the type of materials concerned. Subjects were paid for their services.

Tasks and Procedures

Two tasks were performed: (1) Reading lists of 200 digit symbols and 200 digit words both in Portuguese and in English; (2) Determining in both languages the auditory digit span and the visual digit span under an articulatory suppression condition. Therefore, within a task there were four conditions. Within each task the order of presentation was counterbalanced.

[1] The Portuguese digit words from 0 to 9 are: *zero*, *um*, *dois*, *três*, *quatro*, *cinco*, *seis*, *sete*, *oito*, *nove*. The underlined digits have two syllables.

Subjects performed the reading task first. In each condition there were three trials.

In the reading task, subjects were required to read 200 digit figures (4, 9, . . .) and 200 digit words (four, nine, . . .) as fast as possible in Portuguese and in English, but keeping the reading intelligible. Digit figures and digit words were typed on an A4 sheet with 10 different digits per line in a random order. Reading time was measured in the same way as in Experiment 1.

In the span task, digit strings from three to ten were presented auditorily and visually. In the auditory presentation, digit strings were tape-recorded both in Portuguese and English. Subjects were instructed to repeat each string in the language of presentation. In visual presentation digit words were presented in a memory drum and subjects were required to articulate "A, B, C, D" continuously during the length of the string and until a question mark appeared. At this point subjects stopped articulating "A, B, C, D" and repeated back the string in the language of presentation. In both span tasks digits were presented at 1-sec rate, and the task ended when subjects made three consecutive errors.

RESULTS

Each subject's reading average of 200 digit figures and digit words in Portuguese and English in all three trials was scored. Results are presented in Table 3. A two-factor repeated measures ANOVA was performed and the results obtained revealed that the main factors and the interaction were highly significant. Results thus showed that reading speed is faster in the mother tongue than in English: $F(1, 11) = 235.5$, $P < 0.001$; that reading digit names is faster than reading digit figures: $F(1, 11) = 17.1$, $P < 0.01$; and an interaction between language and type of symbols to be read was observed: $F(1, 11) = 230$, $P < 0.001$. *Post hoc* analysis (Tukey test) showed that mean reading differences were not significant in the mother tongue, but only in the secondary language ($P < 0.05$).

TABLE 3
Mean Reading Rates for Digit Figures and Words, and Auditory Digit and Visual Span under Articulation Suppression, both in the Mother Tongue and in English

	Reading 200 Digits (sec)		*Forward Digit Span*	
	Figures	*Words*	*Auditory*	*Visual*
Mother Tongue	57.2	58.0	7.0	4.3
English	81.4	65.4	6.0	3.6

Data on digit span were scored according to the procedure proposed by Woodworth and Schlosberg (1954). Thus, span was equal to a basal sequence length, where all trials were correct, plus 0.33 for each single longer correct sequence. Data on the auditory digit span and on visual span under articulatory suppression in Portuguese and in English are also shown in Table 3. In order to test the differences observed in each language and modality, a two-factor repeated measures ANOVA was performed. Results showed that span was higher in the mother language than in the secondary language: $F(1, 11) = 26.1$, $P < 0.001$; that span was higher in auditory than in visual presentation under conditions of articulatory suppression: $F(1, 11) = 146.06$, $P < 0.0001$. The interaction was not significant: $F(1, 11) = 1, 36$, $P > 0.26$. *Post hoc* analysis (Tukey test) showed that span differences among the means were all significant at $P < 0.01$. Although data confirmed the relationship between reading rates and digit span observed by Baddeley et al. (1975), this association occurred in the language where digit word length, measured either in syllables or phonemes, was morphologically longer.

GENERAL DISCUSSION

Results from Experiment 1 showed that reading rates were faster in a bilingual's native language than in their secondary language, despite differences in word length, measured in syllables or phonemes. Experiment 2 revealed a span superiority in a bilingual's native language, despite longer word lengths. However, it could be argued that the sample tested in Experiment 2 was not truly bilingual. On the one hand, it is very difficult to determine what constitutes the relevant variables for selecting a group of balanced bilinguals, when a highly familiar type of materials, such as digits, are chosen for a bilingual experiment. It could be suggested that there is not a category of truly balanced bilinguals, either in general (e.g. Cutler, Mehler, Norris, & Segui, 1989), or more specifically when counting is concerned (e.g. Dornic, 1969; Kolers, 1968).

On the other hand, in Ellis and Hennelly's (1980) study, Welsh–English bilinguals had lower spans in their native language (Welsh) than in English, and even those who consider themselves more competent in Welsh. However, this study could be a particular case of bilingualism, as Ellis and Hennelly (1980, p. 49) admitted: "Welsh speakers do on occasion preferentially use English number names." This fact may have contributed to faster reading rates and longer spans in English than in Welsh.

Therefore, even if the sample is not entirely balanced, results indicated that digit span depends more on articulation rate than on word length when measured in syllables or phonemes. However, articulation rate does not seem to account for all the variance observed on digit span, as under articulatory suppression conditions there is still a significant difference between mother

tongue and secondary language (see also Tehan & Humphreys, 1988). Familiarity effects may be responsible for such a significant difference due to the massive practice digits are subjected to in one's native language, with a strong tendency for digits to be abbreviated, perhaps more so than any other familiar words. Kolers (1968) and Dornic (1969) argued that verbal responses to digits are more deeply rooted in the subject's native language than in the non-dominant one and also that digit abbreviations rather than full forms of words are used for voiceless counting. Thus, the more often a word has been employed in one's previous experience, the further and easier it is abbreviated into the inner verbal code.

Thus, the lower scores of Portuguese children in the WISC span task (Marques, 1969) could be the result of employing poorer digit abbreviations than adults due to less practice. As children get older and become more familiar with counting they gain more practice with digits and presumably employ abbreviations more often than full forms of digits (e.g. Hitch et al., 1989; Hulme et al., 1984). Therefore, differences in digit span should decrease from childhood to youth. In fact Table 1 shows that by 16 years of age, Portuguese and American subjects have an equivalent WISC digit span. This result may suggest that by that age Portuguese subjects may have enough practice to reduce digit word length to a level that is similar to English common practice.

Yet this explanation does not work for French and German children who displayed similar decrements in several age periods as Portuguese children did. Alternative explanations to account for such results might consider the fact that the WISC span is a composite score of forward and backward spans with backward span apparently playing a major role in cross-language differences (Stigler et al., 1986). Also, the WISC scores could be due to procedural differences in subject's testing. Although this hypothesis may well be theoretically uninteresting, there is some evidence to suggest that on occasions it can be true (e.g. Naveh-Benjamin & Ayres, 1986; Russell, 1988).

Finally, if digits are subject to massive practice and are frequently abbreviated, it could be argued that digit articulation rates would not be much different across languages, at least for most European ones. However, even if results of some conditions of Experiment 1 support this hypothesis, it is doubtful that digit span obtained in cross-language studies would be equivalent, as there is some variance in reading rates that is not accounted for on memory span (e.g. Dempster, 1981; Naveh-Benjamin & Ayres, 1986). Nevertheless, this study endorses the assumption that bilingual subjects are likely to have a larger digit span in their native language than in their secondary language, even if digit length is longer when measured in syllables or phonemes.

Manuscript received October 1990
Revised manuscript accepted February 1991

REFERENCES

Baddeley, A.D. (1983). Working memory. *Philosophical Transactions of the Royal Society of London, 302B*, 311–324.

Baddeley, A.D. (1986). *Working memory*. Oxford: Clarendon Press.

Baddeley, A.D. & Hitch, G.J. (1974). Working memory. In G.H. Bower (Ed.), *The psychology of learning and motivation: Advances in research and theory* (Vol. 8, pp. 47–89). New York: Academic Press.

Baddeley, A.D., Thomson, N., & Buchanan, M. (1975). Word length and the structure of short-term memory. *Journal of Verbal Learning and Verbal Behavior, 14*, 575–589.

Cutler, A., Mehler, J., Norris, D., & Segui, J. (1989). Limits on bilingualism. *Nature, 340* (6230), 229–230.

Dempster, F.N. (1981). Memory span: Sources of individual and developmental differences. *Psychological Bulletin, 89*, 63–100.

Dornic, S. (1969). Verbal factor in number perception. *Acta Psychologica, 29*, 393–399.

Ellis, N.C. & Hennelly, R.A. (1980). A bilingual word-length effect: Implications for intelligence testing and the relative ease of mental calculation in Welsh and English. *British Journal of Psychology, 71*, 43–51.

Falorni, M.L. (1956). *Scala Wechsler per fanciulli*. Firenze: Organizzazioni Speciali.

Fishman, J.A. & Cooper, R.L. (1969). Alternative measures of bilingualism. *Journal of Verbal Learning and Verbal Behavior, 8*, 276–282.

Hardesty, F.P. & Priester, H.J. (1966). *Handbuch für den Hamburg–Wechsler Intelligenztest für Kinder*. Bern: Huber.

Hitch, G.H., Halliday, M.S., & Littler, J.E. (1989). Item identification time and rehearsal rate as predictors of memory span in children. *The Quarterly Journal of Experimental Psychology, 41A*, 321–337.

Hulme, C., Thomson, N., Muir, C., & Lawrence, A. (1984). Speech rate and the development of short-term memory span. *Journal of Experimental Child Psychology, 38*, 241–253.

Kolers, P.A. (1968). Bilingualism and information processing. *Scientific American, 218*, 78–86.

Lemgruber, V. & Paine, P.A. (1981). Adaptação brasileira da escala verbal do WISC. *Arquivos Brasileiros de Psicologia, 33*, 32–56.

Marques, J.H.F. (1969). *Estudos sobre a escala de inteligência de Wechsler para crianças: Sua adaptação e aferição para Portugal*. Lisbon: Ramos, Afonso e Moita.

Naveh-Benjamin, M. & Ayres, T.J. (1986). Digit span, reading rate and linguistic relativity. *The Quarterly Journal of Experimental Psychology, 38A*, 739–751.

Rose, R.G. (1975). Introspective evaluations of bilingual memory processes. *The Journal of General Psychology, 93*, 149–150.

Russell, E.W. (1988). Renorming Russell's version of the Wechsler memory scale. *Journal of Clinical and Experimental Neuropsychology, 10*, 235–249.

Schweickert, R. & Boruff, B. (1986). Short-term memory capacity: Magic number or magic spell? *Journal of Experimental Psychology: Learning, Memory and Cognition, 12*, 419–425.

Standing, L., Bond, B., Smith, P., & Isely, C. (1980). Is the immediate memory span determined by subvocalization rate? *British Journal of Psychology, 71*, 525–539.

Stigler, J.W., Lee, S., & Stevenson, H.W. (1986). Digit memory in Chinese and English: Evidence for a temporally limited score. *Cognition, 23*, 1–20.

Tehan, G. & Humphreys, M.S. (1988). Articulatory loop explanations of memory span and pronunciation rate correspondences: A cautionary note. *Bulletin of the Psychonomic Society, 26*, 293–296.

Wechsler, D. (1949). *Wechsler intelligence scale for children: Manual*. New York: The Psychological Corporation.

Wechsler, D. (1965). *Echelle d'intelligence de Wechsler pour enfants (WISC). Etalonage Français: Manuel*. Paris: Centre de Psychologie Appliquée.

Wechsler, D. (1982). *Escala de inteligencia de Wechsler para niños: Manual.* (5th edn.). Madrid: TEA Ediciones.

Woodworth, R.S. & Schlosberg, H. (1954). *Experimental psychology*. London: Methuen.

Zhang, G. & Simon, H.A. (1985). STM capacity for Chinese words and idioms: Chunking and acoustical loop hypothesis. *Memory & Cognition, 13*, 193–201.