Child Spacing and Birth Order: Effect on Intellectual Ability in Two-Child Families

Abstract. *The effect on intellectual ability of the spacing of the birth of siblings was studied in two series of young men from two-child families: (i) 535 pairs of brothers and (ii) 1511 unrelated firstborn and secondborn. Birth-order effect and level of ability were not influenced by length of interval between firstborn and secondborn.*

In a previous study of nationwide data for the Netherlands, we found a consistent birth-order effect on intelligence in favor of those who were early in the family birth order, and we suggested that the length of the interval between births might be a factor (*1*). Under some circumstances close spacing has had adverse effects on maternal health and on the newborn (*2*); close spacing has been presumed to be deleterious to children's personality or ability (*3*).

Interest in the relation of spacing and intelligence was revived with the work of Zajonc (*4*), who hypothesized that the association of birth order with intelligence is a reflection of differences in the spacing between siblings. He postulated that the advantage of the firstborn is present when the intervals are short, and that it is reduced, even eliminated or reversed, with longer intervals. He further proposed that "long intervals enhance intellectual growth" of both the earlier and the later born. Although in his general model the lastborn is at a specific intellectual disadvantage, in the case of two-child families he postulates explicit benefits for the IQ's of second children who are born after a long interval. More recently two papers reported an absence of association between spacing and ability, one based on inferential data concerning spacing (*5*) and the other on relatively small numbers of cases across many family sizes (*6*).

We offer here, with data from two-child families, a test of two propositions relevant to Zajonc's model: proposition 1, that as spacing increases, the birth-order effect on intelligence ceases to favor the firstborn and may even come to favor the secondborn; and proposition 2, that as spacing increases, ability improves in both firstborn and secondborn.

The samples for study were drawn as follows:

From a large population source consisting of some 400,000 anonymous coded records pertaining to the health, psychological, educational, and social status of 19-year-old men born between 1944 and 1947 in the Netherlands who were examined for military service (*7*), we identified a subsample of men from two-child families who were resident in Amsterdam at the time of examination. For this subsample we obtained additional information about age of mother, spacing of the siblings, and test scores (*8*). The subsample consists of firstborns born in 1944, secondborns born in 1947, and any of their brothers who had been inducted into military service.

Within the subset of records from Amsterdam we have defined two series, a brothers series and a population series. The brothers series is composed of 535 pairs of brothers, at least one of whom is in the population series (that is, was born in 1944 or 1947). The population series consists of firstborns from the 1944 birth cohort and secondborns from the 1947 birth cohort, a total of 1511 men.

We present findings for men in manual and nonmanual social classes separately (basing social class on father's occupation). Age of mother at the birth of the first child is considered as an antecedent control variable (*9*). Mean maternal age (range of means = 26.4 to 27.3 years) did not differ significantly by series, social class, or year of birth of the firstborn. For level of intellectual ability (the dependent variable) we used the sum of all the ratings assigned to the raw scores on each of five psychometric tests (*8*); we call this the total "ability score." As expected (*1*), there was a significant difference ($P = 0.5$ or better) in mean ability score in favor of the firstborn in both series.

Table 1 shows the mean birth intervals in the two series for each social class and birth order. The average interval was four or more years in both series. In the brothers series mean spacing is similar in the two social classes. In the population series the mean interval varies with year of birth; it was significantly shorter for the firstborn, who were born in 1944, than for the secondborn, born in 1947. For secondborn the mean interval was significantly higher in the manual social

Table 1. Spacing of children by social class, in the brothers series and the population series.

Social class	Birth order	N*	Months between siblings		
			Mean	S.D.	Range
		Brothers series			
Manual	1 and 2	228	49.6	30.7	12 to 147
Nonmanual	1 and 2	307	47.7	29.2	11 to 152
		Population series			
Manual	1	339	48.8	35.9	11 to 209
	2	351	62.5	43.0	9 to 221
Nonmanual	1	401	48.4	32.9	13 to 194
	2	420	56.0	37.6	11 to 223

*Number of pairs in brothers series and of single individuals in population series.

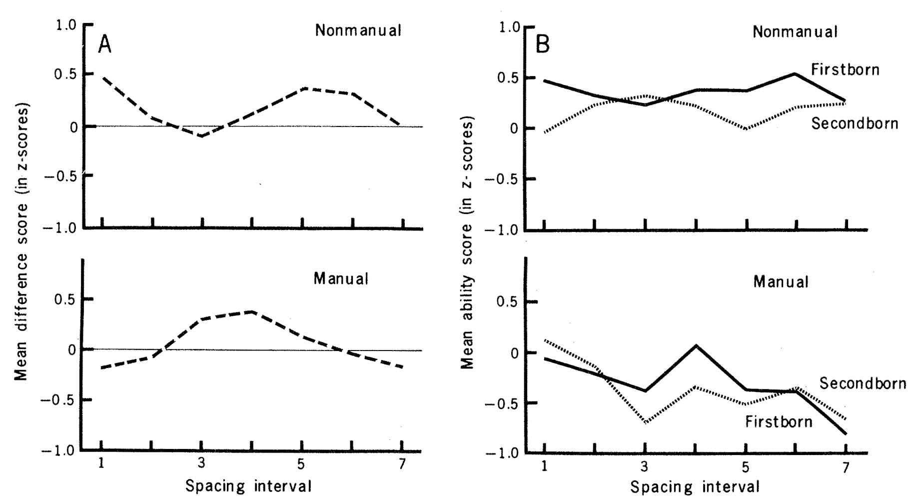

Fig. 1. Mean difference score (A) and ability score (B) by seven spacing intervals for the two social classes (brothers series). Difference score is the ability score of the firstborn minus that of his brother. The range, in months, for each interval category: 1 = 11 to 18; 2 = 19 to 24; 3 = 25 to 36; 4 = 37 to 48; 5 = 49 to 72; 6 = 73 to 96; and 7 = 97 to 152. Number of brother pairs in each category, nonmanual and manual, respectively: 1 = 30 and 14; 2 = 36 and 28 + 3 = 72 and 60 + 4 = 54 and 40; 5 = 63 and 37; 6 = 27 and 28; and 7 = 25 and 21.

0036-8075/78/1201-0995$00.50/0

class than in the nonmanual. These variations presumably reflect population changes in childbearing patterns.

The first proposition was tested in the brothers series. This proposition suggests that the difference score (firstborn score minus secondborn score) should be negatively related to spacing. As is apparent in Fig. 1A, in a simple linear regression the association is not different from zero (*10*).

The second proposition was tested in the brothers series and the population series. It suggests that there should be a positive relation between spacing interval and the ability scores of the firstborn and of the secondborn in both series and also the average ability scores of brother pairs ("average ability score" was used to retain the paired status of brothers within given intervals). None of the relationships were statistically significant, in either the brothers series or the population series (*10*). This is shown for ability score in the brothers series in Fig. 1B.

Thus neither proposition was upheld. Increased spacing was not an advantage for secondborn (brothers series) nor was it systematically related to improved ability among brothers or in firstborn and secondborn individuals (population series).

There was a positive association between mother's age at the birth of the first child and ability. On the other hand, there was a negative association between mother's age and spacing in that among older mothers the interval between the two children tended to be shorter. Maternal age therefore could have suppressed the effects of spacing. To test this possibility, a multiple-regression analysis (*11*) was done for the two series. In the brothers series, the two dependent variables, average ability level and difference score, were used. The independent variables were mother's age, mother's age squared, interval, and interval squared. There was a statistically significant relation between average ability and mother's age and mother's age squared, accounting for between 5 and 10 percent of the variance. Average ability was not related either to interval or interval squared. Difference score was related neither to mother's age nor to interval.

In the population series, too, the relation of ability score to mother's age and mother's age squared was statistically significant and accounted for about 3 percent of the variance. Ability score was not related to interval or to interval squared.

We conclude that in two-child families the interval between the children does not explain the birth-order effect on their adult intelligence. It remains possible that the spacing of births could contribute to such advantage in larger families.

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References and Notes

1. L. Belmont and F. A. Marolla, *Science* **182**, 1096 (1973).
2. R. R. Puffer and C. V. Serrano, *Bull. Pan. Am. Health Organ.* **10**, 131 (1976); D. Wolfers and S. Scrimshaw, *Popul. Stud.* **29**, 479 (1975); J. D. Wray, in *Rapid Population Growth: Consequences and Policy Implications*, R. Revelle, Ed. (Johns Hopkins Press, Baltimore, 1971), vol. 2, pp. 403–461.
3. H. M. Breland, *Child Dev.* **45**, 1011 (1974); E. A. Chittenden, M. W. Foan, D. M. Zweil, *ibid.* **39**, 1223 (1968); J. W. B. Douglas, J. M. Ross, H. R. Simpson, *All Our Future* (Davies, London, 1968); B. G. Rosenberg and B. Sutton-Smith, *Dev. Psychol.* **1**, 661 (1969); S. M. Schoonover, *J. Educ. Psychol.* **50**, 143 (1959).
4. R. B. Zajonc, *Science* **192**, 227 (1976).
5. D. J. Davis, S. Cahan, J. Bashi, *ibid.* **196**, 1470 (1977).
6. H. D. Grotevant, S. Scarr, R. A. Weinberg, *Child Dev.* **48**, 1699 (1977).
7. This material was originally made available for a study of the effects of the Dutch famine of 1944–45: Z. A. Stein, M. Susser, G. Saenger, F. Marolla, *Famine and Human Development: The Dutch Hunger Winter of 1944/45* (Oxford Univ. Press, New York, 1975).
8. The military supplied us with names for the military registration numbers we selected from our original data set; this information was forwarded to the Amsterdam registrar, who searched the local population register for the year of birth of the individual's mother, the birthdate and sex of his sibling, and, for a male sibling, his military ID number if available. (There are no further data for sisters.) This information was made anonymous again before being sent to us. As a second step, we obtained photocopies of the actual military examination records of all young men for whom we had information on spacing interval and maternal age. From these we abstracted the raw scores on the five tests administered as part of the preinduction procedure (Bennett Test of Mechanical Comprehension, Raven Progressive Matrices—Dutch modification, and tests of arithmetic, language and grammar, and clerical aptitude). The Dutch rated raw scores on a scale of 1 to 6. We applied the same rating standard to all raw scores of those in the brothers series. Intercorrelations among the tests ranged from .348 to .732 [F. A. Marolla, thesis, New School for Social Research, New York (1973)]. Correlations of the individual tests with total score ranged from .647 to .853.
9. M. Susser, *Causal Thinking in the Health Sciences* (Oxford Univ. Press, New York, 1973).
10. Correlations with spacing were as follows. For statistical significance, all correlations, except for difference score, should be positive in sign.

	r	*t*	d.f.
Brother series			
Difference score			
Manual	.07	1.01	226
Nonmanual	−.01	−.13	305
Average ability			
Manual	−.12	−1.89	226
Nonmanual	−.01	−.26	305
Firstborn ability			
Manual	−.14	−2.10	226
Nonmanual	−.01	−.17	305
Secondborn ability			
Manual	−.07	−1.08	226
Nonmanual	−.02	−.28	305
Population series			
Firstborn ability			
Manual	.03	.48	337
Nonmanual	−.07	−1.35	399
Secondborn ability			
Manual	.03	.64	349
Nonmanual	−.01	−.29	418

11. J. Cohen and P. Cohen, *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences* (Erlbaum, Hillsdale, N.J., 1975).
12. We thank the Ministry of Defense of the Netherlands and the office of the Registrar of Amsterdam for their help in providing us with the additional data. This study was supported in part by grants HD 06808, HD 07040, and HD 06751 of the National Institute of Child Health and Human Development.

28 April 1978; revised 18 September 1978

Long-Latency "Subthreshold" Collicular Responses to the Constant-Frequency Components Emitted by a Bat

Abstract. *A previously undescribed response pattern has been observed in certain single units in the posterior colliculus of* Pteronotus suapurensis. *These units, constituting about one-third of those tuned to the region of the dominant constant-frequency (CF) components of the orientation sounds, respond to a tone pip with a burst of spikes at a latency of 3 to 6 milliseconds, within the frequency-intensity domain of a normal V-shaped response area. In these units, however, as intensity is dropped below threshold for this response, a response of 5- to 10-milliseconds longer latency appears and persists throughout another 10 to 30 decibels of attenuation. These late responses can be very vigorous, are sharply tuned to frequencies at or just above the CF components of the signal, and are often strongest and of lowest threshold at stimulus durations of 1.5 to 3 milliseconds—approximately the duration of the CF component. These properties imply that the late responses are concerned with analysis of the CF components of echoes, apparently in ways not as prominent in other bats.*

Different species of bats emit different types of echolocation sounds and exhibit auditory specializations appropriate for the signals used (*1*). It is of special interest to examine auditory adaptations in two species of the same genus that use very different orientation sounds. The Neotropical genus *Pteronotus* offers such an opportunity. *Pteronotus parnellii* emits 15- to 25-msec constant-frequency (CF) pulses with a dominant component of approximately 61 to 62 kHz, terminating in a 1- to 2-msec sweep to about 55 kHz. From the level of the cochlea (*2*)

0036-8075/78/1201-0996$00.50/0