Birth order as a quantitative expression of date of birth

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Publications on birth order mostly differ in their findings. In 1874 Galton¹ stated that firstborn dominated among eminent men. Thirty years later, Pearson² claimed that society was corrupted through the defects of firstborn. Surveys^{3–9} covering hundreds of books and articles give a remarkably inconsistent picture of the influence of sibling position on physical and psychological development. In 1913 Weinberg¹⁰ showed that methodological slips are an important source of confusing results. One such slip is the idea that the number of older siblings (earlyborn) and the number of younger siblings (lateborn) should balance in the population.

If a total sibship is considered as a unit, beginning at 0 with the oldest sibling and ending at 1 with the youngest one, it is obvious that 0.5 is the exact mean position of its members. The same statement is true for any sample of total sibships but not for a sample consisting of members of different sibships. In fact, Cobb,¹¹ as early as 1914 pointed to circumstances that might fundamentally distort birth order balance in the general population, but his warnings were not taken seriously. The consequences have been devastating. Those who have studied the influence of sibling position on disease, character, performance, or fate have mostly used methods based on the Greenwood-Yule model,¹² with its erroneous assumption of a balanced birth order distribution in the general population. If a researcher found that a group of trait-carriers contained more lateborn than earlyborn, or the reverse, he asked whether the ratio deviated significantly from a 50 : 50 distribution. If so he felt entitled to state that the trait and the skewed distribution ("overrepresentation") had something to do with each other.

Empirical models

Some investigators have taken the precaution of comparing their *propositi* with trait-carriers of other types¹³ or with "social twins"¹⁴ in order to keep as many variables as possible under control. These authors, however, did not look for the reasons why the birth order distribution of their comparison group tended to deviate in a similar manner as that of their *propositus* group. This remarkable fact cannot be

explained by random deviations but indicates regular influences causing a characteristic skewness of birth order distribution in both groups.

Balanced models rejected

A survey of more than 400 studies¹⁵ discovered only four authors who have tackled the question why lateborn and earlyborn surge in powerful and seemingly spontaneous waves in cohorts of the general population. Half a century after Cobb, in 1969, Hare and Price¹⁶ started publishing a series of studies where they presented logical analyses of factors (birth rate, marriage rate, family size) which were expected to influence changes in birth order distribution. Hypotheses concerning the direction of such changes within small and large families, as well as among the unskilled and the more skilled classes, were confirmed by means of a representative sample ($n = 10\,053$) of the adult population of Great Britain.¹⁷ In 1971 Birtchnell¹⁸ explicitly refuted the idea of a 0.5 model. He showed that there were no significant differences between the birth order distribution (corrected for age) of 6000 psychiatric patients and that of 3224 individuals representing the corresponding general population. His findings are the more convincing as he used a non-parametric method for testing significances.

Applying branching process mathematics to the birth order problem, Jagers¹⁹ concluded, among other things, that total populations contain more lateborn than earlyborn. He remarked that the contribution of statisticians to the unhappy history of birth order studies had not been very glorious.

A quantitative model of skewness

In 1959, when surveying 607 cases of alcoholism, I found that older alcoholics were mainly older siblings, younger alcoholics chiefly younger siblings. This led to the idea that parents had devoted themselves to bringing forth more earlyborn in the 1890s, more lateborn in the 1920s. An analysis of the logical plausibility of the idea made it possible to formulate a numerical model describing not only that the distribution is skewed, but also why, in what

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direction, and to what extent. The model was further tested on a group of doss-house guests.²⁰

In 1960, in a survey of 722 cases with various psychiatric diagnoses, Holmgren²¹ performed another cross-validation of the model. His findings confirmed the underlying hypotheses, with one exception: patients aged 17–28 were unexpectedly often ($p = 0.07$) lateborn. Similarly, in a sample I collected in 1973 the numerical predictions agreed closely with the mean positions of 671 patients, except in quite young problem cases who were often ($p = 0.24$) lateborn.

A detailed description of the logical analysis and its numerical form is given in the monograph *Regular skewness of birth order distribution*.¹⁵ The results may be summarised as follows. When birth cohort size or family size increase, many earlyborn are produced. A decrease of cohort size or family size entails many lateborn. The model is further dependent on a gross estimation of the average sibling interval that characterises a certain chronological period. These three statistics (number of live births, mean family size, average sibling interval) form the sole basis of the model. The result is an independent estimate of mean sibling position as a measure predicting the ratio of lateborn in the corresponding cohort of the general population. The higher the value rises, the more lateborn are to be expected in the cohort. A low index value, say 0.46, indicates a pronounced excess of earlyborn, 0.51 a slight excess of lateborn, and 0.54 a pronounced overweight of lateborn. By using

only general demographic sources, the model circumvents the laborious and expensive selection of controls and concentrates on the forces that rule the skewness of sibling distribution. One may then well ask how it can have any validity at all. One answer to the question is the rather close agreement between the predictions of the model and the mean positions observed in a series of subgroups among 2000 problem cases. The observed position of a person with rank r among s children is expressed as $(r - \frac{1}{2})/s$. This index²⁰ differs somewhat from Slater's²² index $(r - 1)/(s - 1)$, according to which the mean position of a sample does not include the position of only children.

The curve of predicted mean sibling positions for each of the decades 1890–1949, together with the observed mean positions among the problem cases and among 302 university students, was published as fig 7 : 9 in the monograph¹⁵ and is reproduced here as fig 1. The model, however, would be still more convincing if it could be shown that its predictions are fulfilled also by values found in cohorts of the general population.

Predictive power of the quantitative model

I therefore decided to select 600 controls from the general population. They were born at intervals of 18 days during 30 years 1920–49. All controls were resident in Gothenburg, about 50% of them born in the town, the rest in other parts of Sweden, a few even abroad. The controls were randomly chosen from the official register of the town and approached by telephone, by letter, or by personal visit. More than 90% answered readily, about 4% refused, and about as many were not available. In such cases the families of the controls had to be checked in parish registers from their birth until their mothers were 45 years old. It has thus been possible to account for 100% of the controls. The findings were separately tabulated for women and men over the periods 1920–9, 1930–4, 1935–9, 1940–4, 1945–9. Computations followed the pattern outlined in the monograph in table 5 : 3,¹⁵ and the main results appear here in table 1, where sexes have been pooled. Whereas the 1920–9 findings were registered as a single decade, I decided to divide the next two decades into five-year periods

Fig 1 Mean sibling positions 1890–1950. Predicted positions compared with observed positions in 2000 sociomedical patients and in 302 university students.

Table 1 Observed mean sibling position and mean family size in cohorts of the general population

Cohort	No	Mean position	Mean family size
1920–9	200	0.5444 ± 0.0193	2.89 ± 0.28
1930–4	100	0.5030 ± 0.0261	2.15 ± 0.22
1935–9	100	0.4566 ± 0.0275	2.30 ± 0.21
1940–4	100	0.4617 ± 0.0248	2.16 ± 0.20
1945–9	100	0.4993 ± 0.0266	2.45 ± 0.21

i = (1 later earlier) point of time. $\bar{s}$ = Mean sibship size. w = Average sibling interval. N: Number of live births. t: Period between j and i. Gbg = Gothenburg; Sw = Sweden.

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Table 2 Predicted mean sibling position in cohorts of the general population

[illegible]

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Fig 2 Mean sibling positions 1920–50. Predicted decade positions and five-year positions, compared with observed positions in 600 controls from the general population. Dots in brackets: predicted positions under the assumption of family size 2.16 in 1935 and 2.53 in 1945.

Discussion

The standard deviation of any sibling position is 0.28 or somewhat less, so that a mean sibling position in 100 siblings has an error of about 0.028 and in 200 siblings an error of about 0.020, as in table 1. A comparison with table 2 shows that the largest difference between observed and predicted decade means occurs in the 1940s—namely, 0.48–0.47, or about five-tenths of the error. During the thrilling months of sampling when new findings slowly accumulated, means changed considerably up to the end. Actually, one single person may move the mean sibling position in 200 persons by one-tenth of the standard error. Hence the vital necessity to ensure complete response.

The present finding of swift and extensive variations of mean sibling position from cohort to cohort makes it necessary to account for birth cohorts in a detailed manner when discussing birth order problems. Differences may rapidly become significant. In our case a difference larger than 0.056 between two decade means ($n = 200$), or larger than

0.068 between a decade mean and a five-year mean ($n = 100$), is significant at the 5% level. The situation occurs when we compare the observed mean of the 1920s with that of the 1930s or the 1940s, as well as with that of the 1935–9 period or the 1940–4 period. If we use the predicted, not the observed, mean of the 1920s for comparison we attain to the 0.001 level of significance.

Another question seems to be nearing its solution: the finding that problem cases aged 17–28 were remarkably often lateborn. A group of 80 youngsters from the 1930 cohort had a mean position of 0.5351, thus deviating by 0.0515 ± 0.0291 from the predicted mean. The present investigation allows us to state with some confidence that the prediction model really represents general population values. The supposition that lateborn yield more quickly to their problems therefore seems strengthened. One is reminded of Galton's statement in 1874 that firstborn tend to be more enduring and persevering which has found better support than most other alleged birth order differences. Firstborn develop their intelligence somewhat better than others.²³ University students show a real overrepresentation of firstborn when compared with other members of their birth cohort.

No conclusion in the field of birth order study can be valid without knowledge of the cohort variations of birth order distribution in the corresponding general population. The model discussed here will facilitate this task.

Appendix

Since the background of table 2 is rather complicated, the following information may be useful.

In the 1925 column, for example, the precise point of time is the first day of 1925 (j), in the 1930 column, the first day of 1930 (i), j and i defining the period 1925–9 (t).

Mean sibship size at a certain moment ($\bar{s}_i$) is determined by interpolation from population values of adjacent periods. If values from appropriate general populations are not available, one has to fall back on cohort values of the sample, despite their large errors (cf table 1).

The average sibling interval may be estimated by means of intervals characteristic of sibships of different size. Such intervals tend to remain fairly constant. I have used a list of Swedish intervals, reproduced in table 3. If a cohort sample contains, say, 34 people from families with four children, the relative number of such families in the sample is $n/s = 34/4$, each family covering $(s - 1) = 3$ intervals with the average length (w_s) of 3.26 years. The sum of interval lengths in these sibships of four is

Table 3 Empiric average sibling intervals in 530 Swedish sibships

Sibship size, s siblings	2	3	4	5	6	7	8-10	≥11
Average sibling interval, w_s years	4.72	4.21	3.26	3.12	2.95	2.60	2.34	2.11

$w_s(s-1)n/s = 3.26 \times 3 \times 34/4 = 83.13$ years. The sum total for all family sizes, $\Sigma[w_s(s-1)n/s]$, is finally divided by the total number of intervals in the sample, $\Sigma[(s-1)n/s]$, in order to arrive at an estimate of the average interval of the period, w_i . The average interval at a certain moment, w_i , is then estimated by interpolation.

N_i Gbg is the mean number of live births a year in Gothenburg characterising the moment i . For the first day of 1925 all births occurring in the four years 1923-6 are summed and divided by four and this smoothed mean entered into the table. N_i Gbg simply registers the total number of live births in Gothenburg for the corresponding period—for example, 1925-9.

In the expression $(\Sigma_j w_j N_j - \Sigma_i w_i N_i)/N_i$ the j -values apply to 1925, the i -values to 1930, the t -values to 1925-9, thus for Gothenburg $(2.61 \times 3.18 \times 3816 - 2.39 \times 3.27 \times 3217)/16740 = 0.3901$. The rationale behind the expression, as well as behind the multiplier 0.108, is complicated. It is discussed in detail in chapter 7 of the monograph.¹⁵

Since roughly 50% of the studied population are natives of the town, half the Gothenburg value, 0.3901, and half the general Swedish value, 0.3202, are ultimately combined and weighted by 0.108, forming the predicted deviation from 0.5000 of the mean sibling position in the 1925-9 cohort.

References

- Galton F. *English men of science*. London: Macmillan, 1874.
- Pearson K. *On the handicapping of the first-born*. London: Cambridge University Press, 1914.
- Hsiao H. The status of the first-born with special reference to intelligence. *Genet Psychol monogr* 1931; **9**: 3-118.
- Jones HE. Order of birth in relation to the development of the child. In: Murchison C. *Handbook of child psychology*. Worcester, Mass: Clark University Press, 1931; 204-41.
- Murphy G, Murphy LB, Newcomb TM. *Experimental social psychology*. New York: Harper, 1937: 348-67.
- Chen E, Cobb S. Family structure in relation to health and disease. *J Chron Dis* 1960; **12**: 544-67.
- Sampson EE. The study of ordinal position: antecedents and outcomes. *Progress in experimental personality research*. New York: Academic Press, 1965; **2**: 175-228.
- Miley CH. Birth order research 1963-67, bibliography and index. *J Individ Psychol* 1969; **25**: 67-70.
- Vockell EL, Felker DW, Miley CH. Birth order literature 1967-71, bibliography and index. *J Indiv Psychol* 1973; **29**: 39-53.
- Weinberg W. *Die Kinder der Tuberkulösen*. Leipzig: Hirzel, 1913.
- Cobb JA. The alleged inferiority of the first-born. *Eugenics Review* 1914; **5**: 357-9.
- Greenwood M jr, Yule GU. On the determination of size of family and of the distribution of characters in order of birth from samples taken through members of the sibships. *Journal of the Royal Statistical Society* 1914; **77**: 179-99.
- Norton A. Incidence of neurosis related to maternal age and birth order. *British Journal of Social Medicine* 1952; **6**: 253-8.
- Inghe G. *Fattiga i folkhemmet*. Uppsala: Almqvist and Wiksell, 1960.
- Berglin C-G. Regular skewness of birth order distribution. *Scand J Soc Med* 1981; suppl 23. (Contains a bibliography of 434 works.)
- Hare EH, Price JS. Birth order and family size: bias caused by changes in birth rate. *Br J Psychiatry* 1969; **115**: 647-57.
- Hare EH, Price JS. Birth order and birth rate: findings in a representative sample of the adult population of Great Britain. *J Biosoc Sci* 1974; **6**: 139-50.
- Birtchnell J. Birth rank and mental illness. *Nature* 1971; **234**: 485-7.
- Jagers P. *How probable is it to be firstborn? And other branching process applications to kinship problems*. *Mathematical Biosciences* 1982; **59**: 1-15.
- Berglin C-G. Femtio härbärgesklienter med socialhjälp. *Socialmedicinsk tidskrift* 1960; **37**: 295-9.
- Holmgren L. *Om syskonplacering, syskonantal och social missanpassning*. Gothenburg: Graduate School for Social Work and Public Administration, 1960.
- Slater E. Birth order and maternal age of homosexuals. *Lancet* 1962; **i**: 69-71.
- Zajonc RB, Markus GB. Birth order and intellectual development. *Psychol Rev* 1975; **82**: 74-88.