Intelligence 70 (2018) 61–72

Contents lists available at ScienceDirect

Intelligence

journal homepage: www.elsevier.com/locate/intell

The effect of birth order on the probability of university enrolment

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ARTICLE INFO

Keywords:
Firstborn
Family constellation
Birth-order effect
Schooling

ABSTRACT

The birth order influences various psychological characteristics ranging from personality traits to sexual behaviour. Yet while many studies suggest that firstborn children are likely to achieve a higher educational level than their siblings, other studies reported no such effect, which may be due to various modulating factors such as sex and family size. In the present study, we have therefore tested the effect of birth order on the probability of university enrolment while taking these possibly modulating factors into consideration.

We collected birth-order data from two cohorts of biology students (Study 1: students from 1990 to 1995, $N = 271$; Study 2: students from 2011 to 2017, $N = 2049$) at the Charles University, Prague, Czech Republic. The proportion of firstborns in both cohorts was compared to population data obtained from the Czech Statistical Office and controlled for sex and family size.

In both groups of students, we found a significantly higher proportion of firstborns than in the general population as represented by the official population data. In Study 1, based on general population data we expected firstborns to form 44.8% of the cohort. The actual proportion was found to be 63.1%. In Study 2, the expected proportion of firstborns was 48.1%, while the proportion actually found was 64.0%. We have also observed a considerable influence of family size on the size of the birth-order effect. In particular, the size of the birth-order effect on educational achievements of the firstborn children positively correlated with family size. Comparison between the two cohorts had also shown that over the last two decades, overrepresentation of firstborns had significantly declined, which probably reflects a decrease in the stringency of entrance examinations to the Faculty of Science over the past two decades.

Our results support previous findings regarding the advantage of firstborns in educational achievements and show that the birth-order effect is not just an epiphenomenon of family size. By comparing the two cohorts 20 years apart, this study also offers a unique opportunity to evaluate the birth-order effect in relation to sociodemographic changes over a certain time period. In particular, our study demonstrates that the birth-order effect is robust enough to withstand the dramatic changes in university attendance in present-day Czech Republic.

1. Introduction

1.1. The influence of birth order on intellectual outcomes

A family in which a person grows up significantly influences various psychological characteristics, many of which then remain relatively stable throughout adult life. Nevertheless, experience of the individual offspring often varies, primarily due to differences in parental treatment and relationships with other siblings. It has been shown that such family-related experiences are systematically linked to the siblings' birth-order.

Scholars usually differentiate between ordinal and functional birth order (Carette, Anseel, & Van Yperen, 2011; Eckstein et al., 2010). Ordinal ('biological') birth order is the actual sequence in which children were born to a particular mother. Functional ('psychological') birth order, on the other hand, takes into account specific relations between a child and its siblings. For instance, if the oldest child lives in another household, the secondborn child becomes functionally firstborn. In most cases, however, the ordinal birth order matches the functional one. Due to lack of detailed information about family relationships, ordinal birth order is frequently used as a proxy for the functional birth order. Furthermore, it is often assumed that the main

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https://doi.org/10.1016/j.intell.2018.08.003
Received 13 February 2018; Received in revised form 16 July 2018; Accepted 24 August 2018
0160-2896/

difference in family-related experiences is between the firstborn child and laterborn children, meaning that secondborn and thirdborn children etc. are all merged into a category of laterborn children, although previous research also pointed out significant differences of youngest or middleborn children (e.g., C. Salmon, 2003; C. A. Salmon & Daly, 1998). And last but not least, single children (the only children in a family) are frequently subsumed into the firstborn category.

Effects of the birth order on various dimensions of human personality and behaviour have been extensively studied. Birth order influences many aspects of human personality, but also behaviour and performance (for general review see e.g., Plomin & Daniels, 2011). A number of early studies found that the birth order has an impact on various intellect-related dimensions (e. g., Adams, 1972; Altus, 1966; Schachter, 1963; Zajonc & Markus, 1975; Zajonc, Markus, & Markus, 1979). These studies had shown that firstborns tend to have higher intellectual abilities than laterborn individuals. For instance, they achieve higher scores in tests that require divergent thinking (Runco & Bahleda, 1987) and they perform better in abstract reasoning as measured by the Raven Progressive Matrices (Belmont & Marolla, 1973) as well as in other tests that measure intellectual performance or intelligence (Adams, 1972; Bonesronning & Massih, 2011; Chittenden, Foan, Zweil, & Smith, 1968; Karwath, Relikowski, & Schmitt, 2014; Zajonc, 1976; Zajonc et al., 1979). Several studies have also focused exclusively on a possible relationship between the birth order and the IQ. Their results, however, are rather mixed. While most such studies found a higher IQ in the firstborns (Black, Devereux, & Salvanes, 2011; Glass, Neulinge, & Brim, 1974; Kanazawa, 2012; Nuttall et al., 1976; Rohrer, Egloff, & Schmukle, 2015; Schachter, 1963), the actual effect seems to be relatively small (1–3 IQ points per one birth-order level) (Black et al., 2011; Damian & Roberts, 2015a), and several other studies failed to find any birth-order effect on the IQ (Holmgren, Molander, & Nilsson, 2003; Retherford & Sewell, 1991; Rodgers, Cleveland, van den Oord, & Rowe, 2000).

A similar pattern of birth-order effect has also been observed in educational achievements. For instance, it has been repeatedly reported that firstborns are overrepresented in elite schools and universities (Bayer, 1966; Bernstein & Grambs, 1976; Farley, Smart, & Brittain, 1976; Powell & Steelman, 1993). This effect seems to be stronger in firstborns who have a larger number of siblings (Altus, 1966). On average, firstborn children achieve higher education more frequently, spend more years in school (Behrman & Taubman, 1986; Black, Devereux, & Salvanes, 2005; Booth & Kee, 2009; de Haan, 2010; Fergusson, Horwood, & Boden, 2006; Harkonen, 2014; Isungset, Lillehagen, & Ugreninov, 2017; Kantarevic & Mechoulan, 2006; Karwath et al., 2014; Kristensen & Bjerkedal, 2010; Young-Joo, 2009), tend to have better grades (Adams, 1972; Chittenden et al., 1968; Schulze & Preisendorfer, 2013), are overrepresented among prominent scientists and scholars (Schachter, 1963), and are more likely to apply to and graduate from medicine and engineering programs (Barclay, Hallsten, & Myrskyla, 2017). It has also been shown that firstborns report higher educational aspirations (Bu, 2016), which may at least in part explain their higher educational achievements. It should be noted, however, that a number of other studies did not find any influence of the birth order on the form and level of achieved education (Cho, 2011; Hauser & Sewell, 1985; Hayes & Bronzaft, 1979; Kuo & Hauser, 1996; Marteleto & de Souza, 2013).

1.2. The role of sex and family size

The effects of birth order may be modulated by various factors, including intensity and frequency of real contacts between the siblings and parents, their age, parenting experience, socioeconomic status, and culture. With respect to the effect of birth order on educational achievement, it is the sex and number of siblings (family size and composition) that appear to be of key importance. Previous studies have shown that the effect of birth order seems to differ in relation to sex (Brim Jr., 1958; Daniels, 1986; Sulloway, 1997), whereby it is stronger in women (Black et al., 2005; Kristensen & Bjerkedal, 2010), and that the birth-order effect in women – but not in men – is influenced by the sex of their siblings (Dayioglu, Kirdar, & Tansel, 2009). Specifically, the strongest firstborn advantage was found in female same-sex sibships (Brim Jr., 1958; Hornbostel & McCall, 1980), which might be due to lower rivalry between opposite-sex siblings (Conley, 2000; Kuo & Hauser, 1996; Minnett, Vandell, & Santrock, 1983).

It has been reported that a higher number of siblings negatively corresponds with mental abilities (Kuo & Hauser, 1997; Page & Grandon, 1979). A similar effect was also observed in IQ testing (Bjerkedal, Kristensen, Skjeret, & Brevik, 2007; Holmgren et al., 2003; Rodgers et al., 2000) and a negative influence of family size on educational achievement has been confirmed in numerous other studies (Black et al., 2005; Booth & Kee, 2009; Cáceres-Delpiano, 2006; Conley & Glauber, 2006; Hauser & Sewell, 1985; Park & Chung, 2012). Many other studies, however, found no effect of the family size on children's educational achievements (Bonesronning & Massih, 2011; Dayioglu et al., 2009; de Haan, 2010; Kantarevic & Mechoulan, 2006). It is thus possible that at least some of the abovementioned inconsistencies might be due to the modulating effects of sex and family size which were not controlled for in most previous studies.

1.3. Aims of the current study

The main aim of our study was to investigate a possible influence of birth order on the probability of university enrolment while taking into account some modulating factors such as family size and sex of children. Vast majority of existing studies in this area is based on samples from the U.S. and West European countries. We have therefore started by testing whether the previously reported overrepresentation of firstborns among university students can be extended into Central European settings. For this purpose, we investigated the proportion of various types of birth order among the enrolled students in a selective university programme. We used a set of data gained from biology students at the Faculty of Science of Charles University in Prague, which is considered the most prestigious university in the Czech Republic and enrolment to the undergraduate programme in biology is highly selective (even now, only about 30–40% of applicants are accepted). In line with previous research, we had expected that the birth-order effect would be stronger in larger sibships.

Secondly, and most importantly, our aim was to evaluate possible changes to the predicted birth-order effect over the past two decades. Over the past almost three decades, the Czech population had experienced significant sociodemographic changes, which might have influenced manifestation of the birth-order effect. On the one hand, natality between the two sampling periods had significantly dropped (Sobotka, Stastna, Zeman, Hamplova, & Kantorova, 2008). We expected that this would lead to an increase in the absolute representation of firstborns in Study 2. On the other hand, profound changes in the Czech, and generally European, educational system (due to the ‘Bologna Process’ which was launched in 1999) resulted in a rapid increase in the number of university students (and consequently also in a lowering of the threshold for passing the entrance exams for attractive subjects including biology). The gross enrolment ratio shows that in 1990, only about 16% of Czech population aged 18–23 were university students, whereas in 2010 the proportion of university students within this age group reached 68% (source: UNESCO; http://data.uis.unesco.org/). Based on the results of previous studies, we had therefore expected that in Study 2, overrepresentation of firstborns would be less prominent than in Study 1.

2. Material and methods

2.1. Participants

We collected data from two cohorts of biology students at the Faculty of Science, Charles University, Prague, the Czech Republic. Study 1 was performed in 1990–1995 and consisted of 271 individuals (49% women; mean age of women = 20.29, SD = 1.84; mean age of men = 20.95, SD = 2.56). Study 2 was performed in 2011–2017 and included 2049 individuals (73.4% women; mean age of women = 20.88, SD = 2.03; mean age of men = 21.32, SD = 2.41). A total of 33 respondents who were born from multiple pregnancies or have a sibling born in the same year were excluded from all subsequent analyses because based on the available data, it was not possible to determine their birth order. The final sample thus consisted of 2016 individuals (73.4% women). We have also excluded all data about stepsiblings (in total $N = 722$) in order to match the second sample with the data from the Study 1.

All participants were informed about the aims of the study, that the study is anonymous, all obtained data would be used exclusively for research purposes, and that their participation is voluntary and they have the right to terminate it at any time. The project, including the use of anonymised data from the previous study, was approved by the Institutional Review Board of the Faculty of Science, Charles University – No. 2015/30.

2.2. General population data

The observed birth-order values were compared with reference values for the general population in the Czech Republic. Data about family size for the relevant years were obtained from the Czech Statistical Office (https://www.czso.cz/csu/czso/casova_rada_demografie).

Respondents from Study 1 were born in 1963–1977, respondents from Study 2 in 1975–1999. Data from the Czech Statistical Office indicate that proportions of firstborn children during these years fluctuated by approximately 5%. In order to compute the expected proportion of firstborns in the general population, we have thus employed weighted averages based on the number of respondents born in a particular year. Data about the proportion of the firstborn males and females in the general population were not available for the period of 1975–1999, which is why a separate analysis could not be performed. Similarly, data for the proportion of single children in the population were not available from the Czech Statistical Office, because it was expected that women could bear more children in subsequent years. This precluded us form running the analysis for firstborns without the single children.

2.3. Questionnaires

Participants were asked to fill in questionnaires which contained family-related questions including detailed information about the respondent's birth order.

In Study 1, we asked the participants about their birth order in a binary form, i.e., whether they are firstborn or laterborn. We have also asked about the number and sex of their full siblings (i.e., those who have the same biological parents).

In Study 2, we collected more detailed data including the year of birth of respondents' siblings. In this way, we collected information about the particular position which respondents occupy among their siblings (i.e., firstborn, secondborn, thirdborn, etc.). Study 2 was part of a larger project which focused primarily on testing various hypothesis from evolutionary psychology and parasitology. In the present study, we used only information about the respondents' and their siblings' sex and birth order.

2.4. Statistical analysis

For statistical testing, we used IBM SPSS Statistics 21.0 and statistical package 'R'. Deviation of the number of firstborns in our sample from distribution of firstborns in the general population was tested by Pearson's chi-squared test and the effect sizes were expressed in form of Cramer's V (in text used as "V").

First, we analysed both samples by the birth order and sex of respondents. In Study 1, we distinguished 3 separate categories of birth order: single children, firstborns, and the laterborn children. In Study 2, we collected more detailed data about the birth order and were therefore able to distinguish the following categories: single children, firstborn children, secondborn children, and respondents born third or later in the sequence of siblings. Moreover, since results may be influenced by the family size, we have subsequently performed analyses separately for various family sizes (e.g., two-child families and birth-order proportions).

3. Results

3.1. Birth-order distribution

3.1.1. Study 1

In total, 12.9% of the participants were single children and 50.2% were firstborns (who had at least 1 younger sibling). The joint category of the firstborns including single children represented 63.1% of the sample (64.5% for men, 61.7% for women), whereby difference between the sexes was not significant ($\chi^2 = 0.23$, df = 1, $p = 0.63$, V = 0.03).

The proportion of firstborns, including single children, in the general population was 44.8%. In our sample we found 63.1% of firstborns, which constitutes a statistically significant difference ($\chi^2 = 37.70$, df = 1, $p < 0.001$, V = 2.23). A similar pattern was observed in the analyses of men and women separately (i.e., the difference is statistically significant in both sexes), although the effect size (Cramer's V) was somewhat higher in male participants (1.73 versus 1.41). Overrepresentation of the firstborns is visualised in Fig. 1.

An overview of all observed and expected values for all types of birth orders as well as testing of overrepresentation in the sample in Study 2 is presented in the Appendix in Table A1.

3.1.2. Study 2

In total, 29.2% of the participants were single children and 34.8% were firstborns (with younger siblings). The joint category of firstborns including the single children represented 64.0% of the sample (67.1% men, 62.8% women), whereby difference between the sexes was not significant ($\chi^2 = 3.11$, df = 1, $p = 0.08$, V = 0.04).

As in Study 1, we compared the proportion of the firstborns with data about the general population. The proportion of firstborns (including single children) in the general population was 48.1%, while the observed representation in Study 2 was 64.0% (results are presented in Fig. 2). Such an overrepresentation of the firstborns is highly statistically significant ($\chi^2 = 203.86$, df = 1, $p < 0.001$, V = 4.54). Similar results were found when the two sexes were analysed separately, and although the proportion is slightly higher among men than among women, the effect sizes are very similar (V = 3.35 in men and V = 3.35 in women).

In Study 2, we have also performed a comparison between the individual categories of laterborn children (the secondborn and the group of children higher up the birth-order). In general, we found a lower proportion of the laterborn children than expected (the χ^2 test is significant in all cases).

Furthermore, we observed that underrepresentation seemed to positively correlate with higher birth-order sequence (i.e., secondborn

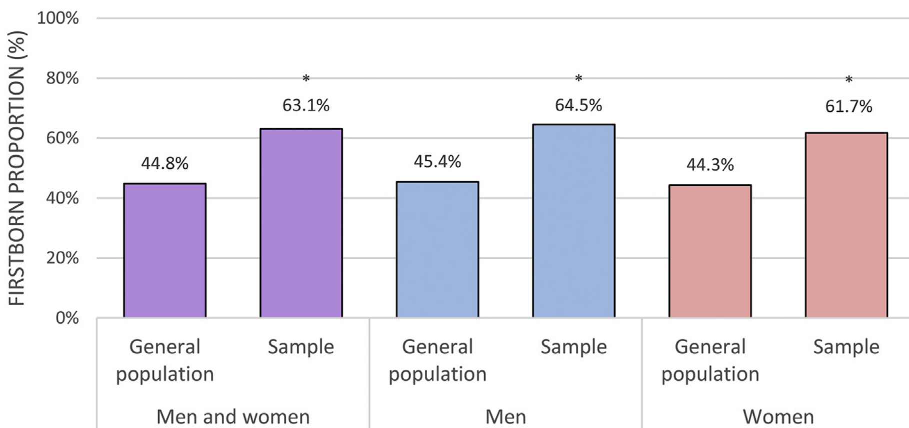

Fig. 1. Participants 1990–1995: Comparison of proportion of firstborns in the sample and in general population by participants' gender. Note: Asterisks denote statistically significant overrepresentation in comparison to data pertaining to the general population. (probably a 1.5 or 2-column fitting image; preference for colour – online only)

children were less underrepresented that thirdborn children etc.). The proportion of secondborn persons in the general population was 36.9%, while in our sample they constituted only 30.5% of the sample ($\chi^2 = 35.95$, df = 1, $p < 0.001$, V = 0.80). For men it was 26.7%, for women 31.9%, whereby difference between the sexes was significant ($\chi^2 = 4.93$, df = 1, $p < 0.03$, V = 0.05). And finally, the proportion of the third- and later born children in general population was 15.0%, while in our sample they were represented by 5.6% of the sample ($\chi^2 = 141.04$, df = 1, $p < 0.001$, V = 3.14). For men it was 6.2%, for women 5.3%, whereby difference between the sexes was not significant ($\chi^2 = 1.01$, df = 1, $p = 0.32$, V = 0.02).

An overview of all the observed and expected values for all types of birth orders and the testing of overrepresentations for the sample in Study 1 is found in Appendix in Table A2.

3.1.3. A comparison between the samples

The proportion of firstborns did not significantly vary between the two samples (63.1% in Study 1 vs. 64.0% in Study 2: $\chi^2 = 0.08$, df = 1, $p = 0.77$, V = 0.01). On the other hand, one ought to take into account a variation in the proportion of the firstborns (including single children) in the general population. The expected proportion of firstborns was 44.8% in Study 1 and 48.1% in Study 2. In Study 1, firstborns were overrepresented by 18.3%, while in Study 2 by 15.9%. This represents a 3.3% decrease in the overrepresentation of firstborns among biology students ($\chi^2 = 4.07$, df = 1, $p = 0.04$, V = 0.09).

We have also noticed considerable changes in the balance of sexes in our samples of biology students. While in Study 1 (1990–1995), males represented 51% of the students, in Study 2 (2011–2017) they accounted for just 26.6% of the sample. We have therefore performed also a separate comparison of proportions of firstborn (including single children) in men and women. These differences were not statistically significant. In men, firstborns (including single children) accounted for 64.5% individuals in Study 1and for 67.1% of individuals in Study 2 ($\chi^2 = 0.34$, df = 1, $p = 0.56$, and V = 0.02). In women, the proportion of firstborns was 61.7% in Study 1 versus 62.8% in Study 2 ($\chi^2 = 0.07$, df = 1, $p = 0.78$, and V = 0.01).

3.2. Birth-order proportions by family size

3.2.1. Study 1

The average number of children in the families of study participants was 2.13 (i.e., they had on average 1.13 siblings). Overall, 12.9% of the participants were single children: 10.9% men and 15% women, whereby the difference between the sexes was not statistically significant ($\chi^2 = 1.05$, df = 1, $p = 0.31$, V = 0.06).

In total, 66.1% of the participants were from the two-child families. If no birth-order effect were present, the expected proportion of the first- versus secondborn children within this subgroup would be equal. We did, however, find a significant overrepresentation of the firstborns. They formed 60.3% of the group ($\chi^2 = 7.65$, df = 1, $p = 0.01$, V = 0.57), whereby male firstborns represented 64.1% of males in this group and female firstborns constituted 56.3% of females in this group (the overrepresentation is statistically significant for both sexes).

In total, 21.0% of participants were from families with 3 and more children. In absence of a birth-order effect, the expected proportion of firstborns within this group would be 33%. Once again, however, we found a significant overrepresentation of firstborns. In total, they formed 49.1% ($\chi^2 = 6.39$, df = 1, $p = 0.01$, V = 0.85), whereby for men the proportion was 48.4% and for women 50.0%. Once the sexes were tested separately, however, differences between the firstborn representation were not significant. Overrepresentation of firstborns is visualised in Fig. 3.

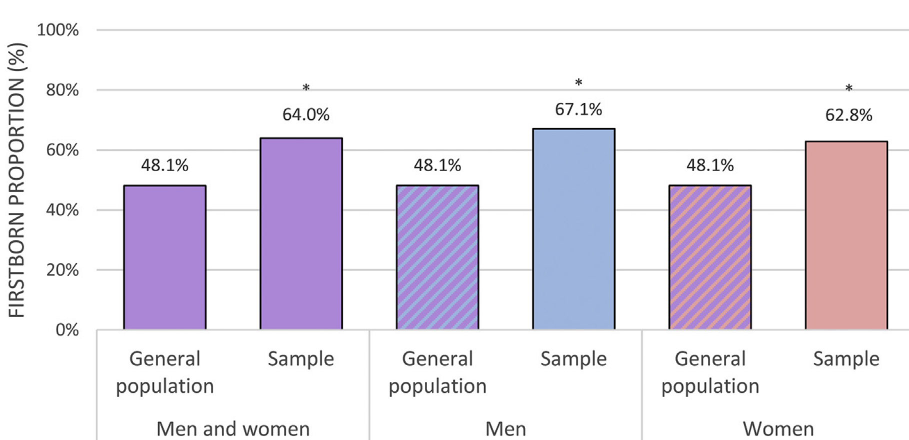

Fig. 2. Participants 2011–2017: Comparison between the proportion of firstborns in the sample and in the general population by participants' gender. Note: Asterisks denote a statistically significant overrepresentation in comparison to data pertaining to the general population. (probably a 1.5 or 2-column fitting image; preference for colour – online only)

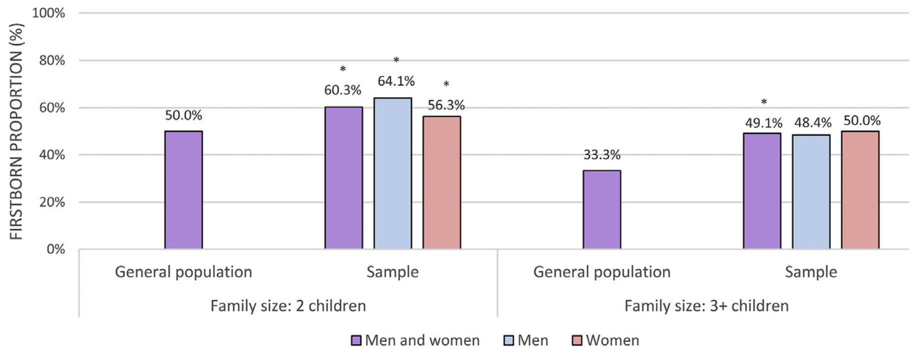

Fig. 3. Participants 1990–1995: Proportion of firstborns according to family size and gender. Note: Asterisks denote a statistically significant overrepresentation in comparison to general population data. (probably a 2-column fitting image; preference for colour – online only)

Complete data for all the tested family sizes and the testing of overrepresentation are presented in the Appendix in Table A3.

3.2.2. *Study 2*

The average number of children in the participants' families was 1.93 (i.e., they had on average 0.93 siblings).

Overall, 29.1% of the participants were single children (29.3% for men and 29.0% for women), whereby the difference between the sexes was not significant ($\chi^2 = 0.02$, df = 1, p-value = 0.90, V = 0.00).

In total, 53.7% of the participants were from the two-child families, which means that in absence of a birth-order effect, the expected representation of first- and secondborn children within this subgroup would be equal. We found a statistically significant overrepresentation of firstborns only in males (59.4% of firstborns). In females, the proportion of firstborns was 49.8%, and for both sexes taken together, the proportion was 52.3% ($\chi^2 = 10.00$, df = 1, p-value < 0.001, V = 0.60).

In total, 17.2% of the participants were from families with 3 and more children, i.e., families where in absence of the birth-order effect the expected representation of the firstborns would be 33% and less. In total, we found that firstborns formed 39.3% of this subgroup, which significantly differed from the expected frequency ($\chi^2 = 5.55$, df = 1, p-value = 0.01, V = 0.3). Firstborn males in this subgroup accounted for 36.1%, females for 40.6% of the sample. In contrast to analysis of two-child families, overrepresentation of firstborns was statistically significant only in women. Overrepresentation of firstborns is visualised in Fig. 4.

Complete data for all types of family sizes as well as tests for overrepresentation are presented in the Appendix in Table A4.

3.2.3. *A comparison between the samples*

The average number of children in respondents' families in Study 1 was slightly higher than in Study 2 (2.13 vs. 1.96 child per family). We also found considerable differences in the frequency of particular family sizes (the following results are for both sexes jointly). The proportion of single children increased significantly, from 12.9% to 29.2%. Correspondingly, the proportion of firstborns (i.e. individuals with younger siblings) significantly decreased, from 50.2% to 34.8%. The proportion of two-child families declined by 12.4% (from 66.1% to 53.7%), and this was accompanied by a significant reduction – from 60.3% to 52.3% – in the representation of firstborns from this subgroup in our sample. The proportion of families with three and more children decreased from 21.0% to 17.2%, and overrepresentation of firstborns in our sample decreased from 49.1% to 39.3% (in this case, however, the difference is not significant).

A complete comparison for both sexes jointly and separately as well as testing of overrepresentation is presented in Table 1.

4. Discussion

As expected, in both studies we found that representation of firstborns among university students of biology is significantly higher than their proportion in the general population. Moreover, firstborns were also overrepresented when analyses were carried out separately for different family sizes. A comparison between the samples in Study 1 and 2 had shown that in the more recent cohort (in Study 2), firstborns were overrepresented somewhat less.

4.1. *Overrepresentation of firstborns in our samples*

Based on data about the general population, the expected proportion of firstborns including single children was 44.8% and 48.1% in Study 1 and 2, respectively. What we found, however, was that firstborns constituted 63.1% and 64.0% of university students. The observed overrepresentation of firstborns in both cohorts of biology students corresponds to findings from other countries (Bayer, 1966; Bernstein & Grambs, 1976; Farley et al., 1976; Harkonen, 2014; Powell & Steelman, 1993). Schachter (1963), for instance, reported that the

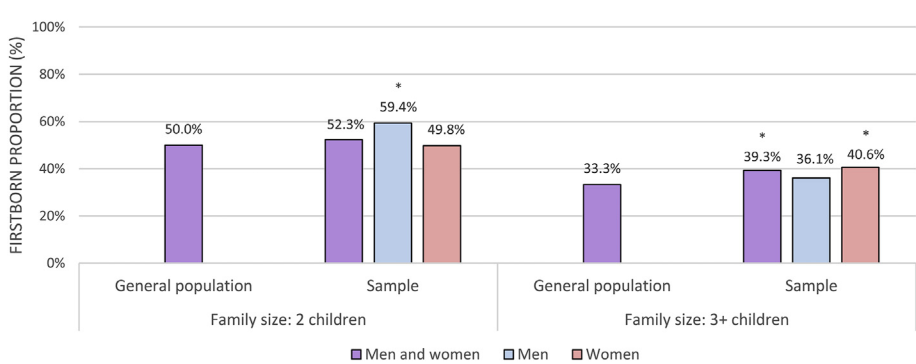

Fig. 4. Participants 2011–2017: proportion of firstborns according to family size and gender. Note: Asterisks denote a statistically significant overrepresentation in comparison to general population data. (probably a 2-column fitting image; preference for colour – online only)

Table 1
Comparison between Sample 1 and Sample 2 by birth order and family size.

Family size	Birth order	Sample 1 (1990–1995)		Sample 2 (2011–2017)				
		Observed	Observed	Observed	Observed	χ2	p-value	sV
(N of children)		(N)	(%)	(N)	(%)			
Men and women								
All	Single children	35	12.9	588	29.2	31.83	**0.00**	0.12
	Others	236	87.1	1428	70.8			
	Firstborns 1	136	50.2	701	34.8	24.33	**0.00**	0.10
	Others	135	49.8	1313	65.2			
	Firstborns 2	171	63.1	1290	64.0	0.08	0.77	0.01
	Others	100	36.9	726	36.0			
2	1.0	108	60.3	565.0	52.3	3.97	**0.05**	0.06
	2+	71	39.7	515.0	47.7			
3+	1.0	28	49.1	136.0	39.3	1.95	0.16	0.07
	2+	29	50.9	210.0	60.7			
Men								
All	Single children	15	10.9	157	29.3	19.68	**0.00**	0.17
	Others	123	89.1	378	70.7			
	Firstborns 1	74	53.6	202.0	37.8	11.42	**0.00**	0.13
	Others	64	46.4	333.0	62.2			
	Firstborns 2	89	64.5	359	67.1	0.34	0.56	0.02
	Others	49	35.5	176	32.9			
2	1.0	59	64.1	167.0	59.4	0.64	0.42	0.04
	2+	33	35.9	114.0	40.6			
3+	1.0	15	48.4	35.0	36.1	1.49	0.22	0.11
	2+	16	51.6	62.0	63.9			
Women								
All	Single children	20	15.0	429	29.0	11.90	**0.00**	0.09
	Others	113	85.0	1048	71.0			
	Firstborns 1	62	46.6	499.0	33.8	8.85	**0.00**	0.07
	Others	71	53.4	978.0	66.2			
	Firstborns 2	82	61.7	928	62.8	0.07	0.79	0.01
	Others	51	38.3	549	37.2			
2	1.0	49	56.3	398.0	49.8	1.33	0.25	0.04
	2+	38	43.7	401.0	50.2			
3+	1.0	13	50.0	101.0	40.6	0.86	0.35	0.06
	2+	13	50.0	148.0	59.4			

The χ2 test indicates the difference between Sample 1 and Sample 2.
Firstborns 1 = firstborns excluding single children; Firstborns 2 = firstborns including single children.
The number of degrees of freedom (df) is for all test equal to 1.
Significant values are marked bold and 0.00 denote $p < 0.001$.

proportion of firstborns was 12% higher than expected in college and 21% higher than expected among graduate school students (regardless of the family size). Comparison between the sexes shows that in both of our samples, the firstborn effect was stronger in men than in women (Study 1: 64.5% of men, and 61.7% of women; Study 2: 67.2% of men, and 62.8% of women). On the other hand, several previous studies had reported a more pronounced birth order effect on educational achievement in women (Black et al., 2005; Kristensen & Bjerkedal, 2010). At the moment, we have no reasonable explanation that would account for the discrepancy between our results and those that had previously been reported, which is also why future studies should confirm the robustness of this phenomenon.

4.2. The effect of family size

It has been argued (Powell & Steelman, 1993; Rodgers et al., 2000) that overrepresentation of firstborns at universities is due to the fact that education-oriented parents (or wealthier families in general) tend to have less children. To test the possibility that the birth-order effect may be an epiphenomenon of family size, we have also performed analyses separately for various family sizes. In general, we concluded that the effect of birth order on educational achievement is noticeable in both studies irrespective of family size. Our data also suggests, however, that the effect is stronger in larger families. For instance, in Study 1 we found in our sample 60.3% of firstborns from two-child families (the expected proportion was 50%; effect size – Cramer's V = 0.57), but in families with 3 and more children, the observed proportion of firstborns was 49.1% (the expected proportion was < 33%; V = 0.85). In Study 2, analogous results were 52.3% (V = 0.07) of firstborns from two-child families and 39.4% (V = 0.30) of firstborns from families with 3 and more children. Especially in Study 1, our results thus show a similar trend as in the Altus study (Altus, 1966), which found that among university students, the proportion of firstborns from two-child families was 63%, 50% from three-child families, and 50.5% from four-child families.

Some studies, however, indicate that if the family size is controlled for, the birth-order effect is no longer significant (e. g., Kanazawa, 2012). Similarly, Cho (2011) found a birth-order effect on educational achievement only in larger families. A possible explanation of this pattern might perhaps be found in a study by Hester, Osborne, and Nguyen (1992), which had shown that children from larger families had higher expectations of good grades. They hypothesised that in larger families, there are more opportunities for mutual comparisons among siblings and that may lead to a stronger birth-order effect.

Irrespective of the birth order, numerous studies report that a higher number of siblings has a negative effect on various factors which are directly and indirectly related to educational achievements (Black et al., 2005; Booth & Kee, 2009; Kuo & Hauser, 1997; Page & Grandon, 1979; Park & Chung, 2012), such as intelligence (Bjerkedal et al., 2007; Holmgren et al., 2003; Rodgers et al., 2000). Similar results were also found in the Czech Republic, where Hirschova and Kreidl (Hirschova & Kreidl, 2012) in their study found a negative effect of larger family size on mathematical skills and knowledge of natural sciences.

4.3. A comparison between the two cohorts

Over the past three decades, the demography of university students in the Czech Republic had undergone various important changes. A comparison between the two cohorts allowed us to test the dynamics of the birth-order effect. We expected a decrease in the overrepresentation of firstborns due to changes in the Czech (and European) educational system which took place since 1999 (in connection with the 'Bologna Process'). As mentioned in the Introduction section, the gross enrolment ratio shows an increase of university students from about 16% of Czech population aged 18–23 in 1990 to 68% in 2010 (source: UNESCO; http://data.uis.unesco.org/).

Such a rapid increase in student numbers was necessarily accompanied by a relaxation of demands on the applicants. While in the years when data were being collected for Study 1 (1990–1995), only about 70 students enrolled in the biology programme each year, during the period investigated by Study 2 (2011–2017), the biology programme annually accepted approximately 350 students. We have therefore expected that in Study 2, overrepresentation of firstborns would be less prominent. What we found is that both cohorts show a similar proportion of firstborns (63% and 64%, including single children), but a direct comparison between these values could be misleading since due to a smaller number of children per family, the proportion of firstborns in the population had in the meantime increased by 3.3% (44.8% in Study 1 vs. 48.1% in Study 2). Once this is taken into account, we see that in Study 2, overrepresentation of the firstborns among biology students is significantly smaller than in Study 1. Our results therefore confirm our initial hypothesis regarding a decrease of firstborn children in the student population over time.

Also in line with our expectation is a shift in the category of single children which we had observed. In Study 1, single children accounted for 12.9% of the cohort, whereas in Study 2, their number increased to 27.1%. Proportion of single children in the population has been rising due to a lower natality in general (in our samples, the average number of children per family decreased from 2.13 to 1.96). The proportion of two-child families declined from 66.1% to 53.7% (the proportion of firstborns from such families correspondingly went down from 60.3% to 52.3%), but – somewhat surprisingly – the number of students from families with three and more children dropped only from 21.0% to 17.2% (and the proportion of firstborns from such families decreased from 49.1% to 39.3%). It seems that the demographic shift had affected families with two children the most: the proportion of firstborns from such families declined substantially and it seems that such families may have to some extent 'transformed' into single-child families encountered in Study 2. In other words, the proportion of firstborns with younger siblings decreased between Study 1 and Study 2 from 50.2% to 34.9%.

This shift may well be due to significant improvements in the standard of living in the Czech Republic, which was connected with the profound socioeconomic changes the country had experienced in the aftermath of the fall of the Communist regime in 1989 and a subsequent transition to market economy. It has been repeatedly observed abroad that wealthier families tend to have less children (Perusse, 1993; Vining, 1986). Single children born to such families can draw on more resources, which in turn leads to better educational achievements. Some existing studies and models suggest, however, that when it comes to intellectual achievements, firstborn children with younger siblings actually have an advantage over single children and tend to achieve higher education more frequently (e. g., Kristensen & Bjerkedal, 2010). This is often explained by the basic principles of Zajonc's 'confluence model', which shows that firstborn children with younger siblings profit from a 'teaching effect' (Zajonc, 1976; Zajonc & Bargh, 1980) in the sense that the older sibling is often in a position of a teacher with respect to a younger sibling or siblings. This process leads to repetition and better comprehension of the learned subject matter, resulting in the older sibling's eventual better educational outcome.

4.4. Possible mechanisms of the birth-order effect on educational achievements

Despite intensive research of various birth-order effects in recent years, concrete mechanisms responsible for these phenomena are yet to be convincingly argued for and described.

In the context of the effect of birth order on educational achievements, two theoretical models are particularly relevant: i) The confluence model, which explains this effect by reference to the intellectual environment in which a child is being reared (Hester et al., 1992; E. V. Nuttall & Nuttall, 1979; Zajonc et al., 1979), and ii) resource dilution model, which emphasises the dilution of the resources among children and includes not only financial means, but also for instance time which parents spend with each child (Blake, 1985; Downey, 1995). According to both models, firstborns (including single children) have an advantage over laterborn children. Several studies have confirmed that firstborns receive from their parents a higher proportion of available resources (including financial ones) than their younger siblings (Bradley, 1982; de Haan, 2010). It should be noted, however, that neither of the two models briefly outlined here can be seen as a generally accepted explanation of the birth-order effect.

Differences in educational outcomes are often attributed to various personality traits related to performance in the educational process. Educational achievement is a complex issue, affected by various sociological determinants, such as socioeconomic status, but also psychological factors, such as personality and intellectual potential. And since the birth order seems to have an effect on various personality dimensions, it is possible that overrepresentation of firstborns among university students is due to characteristic differences in personality traits that provide an advantage in educational processes (Altus, 1966; Belmont & Marolla, 1973; Palmer, 1966). Such personality traits include higher scores in orientation to adults' attitudes (McArthur, 1956), tendency to identify with parents' expectations (Belmont & Marolla, 1973), higher obedience, self-control and discipline (Palmer, 1966), a more serious and methodical attitude to life (Price, 1969), success-orientation (Lampi & Nordblom, 2010), responsibility (Adams, 1972; Steelman & Powell, 1985), and need of external validation and appreciation (Hornbostel & McCall, 1980). In all these characteristics, firstborns score higher than laterborn individuals and it could lead to their higher educational achievements. On the other hand, several recent studies report no effect of birth order on personality, which indicates that the link between educational achievement and birth order may be due to other mechanisms (Damian & Roberts, 2015a, 2015b; Rohrer et al., 2015).

Overrepresentation of firstborns among university students could also be due to their higher intellectual or cognitive abilities. Firstborn children tend to be better problem-solvers (Carette et al., 2011), they perform better in tests oriented on quantitative aptitude (Altus, 1966), in exercises that require planning, mental flexibility, and working memory (Holmgren et al., 2003). As mentioned above, a number of studies had directly tested a possible relationship between the birth order and the IQ, and while most reported a higher IQ in the firstborns (Black et al., 2011; Glass et al., 1974; Kanazawa, 2012; Nuttall et al., 1976; Rohrer et al., 2015; Schachter, 1963), the actual effect size is usually relatively small (1–3 IQ points per one birth order level). Some studies, on the other hand, did not find any such effect (Holmgren et al., 2003;Retherford & Sewell, 1991; Rodgers et al., 2000).

Regarding a possible relation between birth order and intellectual abilities, some researchers point out that differences in the IQ in relation to birth order may be due to a random distribution of the IQ within the population and possible birth-order effect in this area should be studied within individual families rather than across families (Retherford & Sewell, 1991; Rodgers et al., 2000). Other studies, however, seem to show that the effect is present even when an 'across families' design is used (Black et al., 2011). For more information about various methodological issues in birth-order research, see other works (e. g., Black et al., 2005; Downey, 1995; Hester et al., 1992; Rodgers, 2001; Rodgers, Cleveland, van den Oord, & Rowe, 2001; Travis & Kohli, 1995).

Chittenden et al. (1968) suggested an alternative explanation for the overrepresentation of firstborns among university students. His account is based on a simple observation that majority of existing research has been based on recruiting volunteers and since firstborns tend to display a higher level of conscientiousness, they may also volunteer to participate in research more frequently. In our studies, the questionnaires were administrated during an examination and most students completed the surveys (in average about 98%). It is thus unlikely that attendance bias can explain the pattern observed here.

Based on our data, we cannot tell apart all the factors which contributed to the observed effect. Moreover, differences in personality characteristics and in intellectual abilities are not mutually exclusive. They may in fact work in concert. Their relative contribution is thus an issue that could be taken up by future studies.

4.5. Limitations

It has been argued that the birth-order effect may be an epiphenomenon of some other factor, such as family size or parental age (so-called 'admixture hypothesis') (de Haan, 2010; Guo & VanWey, 1999; Kristensen & Bjerkedal, 2007; Page & Grandon, 1979; Rodgers, 2001; Rodgers et al., 2000). Our study had tested for the possible effect of family size, but data regarding parental age were not available and it is a variable that could be further investigated in future studies.

Moreover, while single children are frequently subsumed into the firstborn category, there is no clear consensus in the literature regarding this approach and previous research has reported differences between single children and firstborns with siblings (e. g., Belmont & Marolla, 1973). It would be thus of interest to investigate whether or how the observed patterns change when single children are excluded from the analyses. Unfortunately, data on the proportion of single children in the population is not available, because some of their mothers are still in reproductive age and may have therefore bear more children. Nevertheless, we clearly indicate the proportion of single children in our samples, which would allow researchers to perform additional comparison at some point in the future when the relevant population data are available.

Furthermore, most existing research had investigated simple birth order without considering the difference in age among siblings (i.e., the age-gaps) or the presence of stepsiblings in the family. Most authors either do not mention stepsiblings or simply include them in their samples. We believe, however, that it is an important and possibly confounding variable which may well influence the difference between the results of the previous studies. We have used a conservative approach and excluded stepsiblings from our data analysis. Taking this additional factor into account was beyond the scope of the present study and such an investigation would require a higher number of participants. In our research, the number of participants in some categories, such as families with a high number of children, was relatively low, which may have resulted in imprecise estimates. Our results do, however, show trends that have been observed in previous studies, which suggests that the effect is robust.

In our study, we have not been able to test for a possible effect of the socioeconomic status. Nevertheless, there are several reasons why we think that this effect is likely to be a weak predictor in the studied population. First of all, income and wealth dispersion (as measured by Gini index) in the Czech Republic is about 0.26, which is relatively low value in comparison to other countries (source: OECD; http://www.oecd.org/social/income-distribution-database.htm). Secondly, education at state universities such as the Charles University is free, which is why the effect of economic background of the family can be expected to be limited. And finally, we found the birth-order effect in families of various sizes, including larger families, whereby a larger family size negatively correlates with the family's socioeconomic status (Bayer, 1966; Perusse, 1993; Vining, 1986).

5. Conclusions

Majority of existing research on the birth-order effect investigated the phenomenon at one particular time, which did not enable researchers to assess possible fluctuations related to sociodemographic changes. Our study compared two groups 20 years apart, which offers a unique opportunity for evaluation of the birth-order effect in relation to significant sociodemographic changes. Our results show that the firstborn advantage in university enrolment is robust even in the face of dramatic changes in university attendance which took place in the Czech Republic in the last 20 years. Moreover, our results indicate that the birth-order effect is not just an epiphenomenon of the family size. Finally, majority of existing research on the birth-order effect was carried out in just handful of societies (mostly in the US). Our analyses thus demonstrate that the effect of birth-order on educational achievements can be observed also in different cultural settings, namely Central European ones.

Acknowledgements

The authors would like to thank Julie Nekola Nováková, Martin Hůla, and Robin Kopecký for their help with data collection, Petr Tureček for his help with the statistical analysis, Anna Pilátová for extremely helpful language editing, and two anonymous reviewers for a constructive feedback. The authors' work was supported by the Charles University of Prague (GAUK 269215) and by the project 'Sustainability for the National Institute of Mental Health', grant number LO1611, with a financial support from the Ministry of Education, Youth, and Sports of the Czech Republic under the NPU I program. The funders had no role in the study design, data collection and analysis, decision to publish, or the preparation of the manuscript.

Declaration of interest

None.

Appendix A. Appendix

Table A1
Participants 1990–1995 by gender and birth order.

Birth order	Observed (N)	Observed (%)	Observed 2 (N)	Observed 2 (%)	Expected (%)	χ2	*p*-value	V
Men and women								
Single children	35	12.9	171	63.1	44.8	36.70	**0.00**	2.23
Firstborns	136	50.2						
Laterborns	100	36.9	100	36.9	55.2			
Total	271							
Men								
Single children	15	10.9	89	64.5	45.4	20.29	**0.00**	1.73
Firstborns	74	53.6						
Laterborns	49	35.5	49	35.5	54.6			
Total	138							
Women								
Single children	20	15.0	82	61.7	44.3	16.23	**0.00**	1.41
Firstborns	62	46.6						
Laterborns	51	38.3	51	38.3	56			
Total	133							

The firstborn group contains only firstborns with younger siblings (single children are not included).
Values for 'observed 2' are for a joint category of firstborns including single children.
The χ2 test column indicates the observed proportion in the sample against the expected proportion based on data obtained from the Czech Statistical Office.
The number of degrees of freedom (df) is for all test equal to 1.
Significant values are marked bold and 0.00 denote $p < 0.001$.

Table A2
Participants 2011–2017 by gender and Birth order.

Birth order	Observed (N)	Observed (%)	Observed 2 (N)	Observed 2 (%)	Expected (%)	χ2	*p*-value	V
Men and women								
Single children	588	29.2	1290	64.0	48.1	203.86	**0.00**	4.54
Firstborns	702	34.8						
Secondborns	614	30.5	726	36.0	36.9	35.95	**0.00**	0.80
Third and higher	112	5.6			15.0	141.04	**0.00**	3.14
Total	2016							
Men								
Single children	157	29.3	359	67.1	48.1	77.39	**0.00**	3.35
Firstborns	202	37.8						
Secondborns	143	26.7	176	32.9	36.9	23.77	**0.00**	1.03
Third and higher	33	6.2			15.0	32.73	**0.00**	1.42
Total	535							
Women								
Single children	429	29.0	928	62.8	48.1	128.37	**0.00**	3.34
Firstborns	499	33.8						
Secondborns	471	31.9	549	37.2	36.9	15.93	**0.00**	0.41
Third and higher	78	5.3			15.0	109.42	**0.00**	2.85
Total	1477							

The firstborn group contains firstborn children with younger siblings (single children not included).
Expected data for men and women separately is not available; we have therefore used the general proportion for the genders.
Values for 'observed 2' relate to a joint category of firstborns including single children.
The χ2 test indicates the observed proportion in the sample against the expected proportion based on data obtained from the Czech Statistical Office.
The number of degrees of freedom (df) is for all test equal to 1.
Significant values are marked bold and 0.00 denote $p < 0.001$.

Table A3
Participants 1990–1995 by family size, gender, and birth order.

Family size	Observed	Observed	Birth order	Observed 2	Observed 2	Observed in total	Expected	χ2	*p*-value	V
(N of children)	(N)	(%)		(N)	(%)	(%)	(%)			
Men and women										
1	35	12.9	1.0	35	100.0	12.9				
2	179	66.1	1.0	108	60.3	39.9	50.0	7.65	**0.01**	0.57
			2+	71	39.7	26.2	50.0			
3+	57	21.0	1.0	28	49.1	10.3	< 33.3	6.39	**0.01**	0.85
			2+	29	50.9	10.7	> 66.6			
Total	271									
Men										
1	15	10.9	1.0	15	100.0	10.9				
2	92	66.7	1.0	59	64.1	42.8	50.0	7.35	**0.01**	0.77
			2+	33	35.9	23.9	50.0			
3+	31	22.5	1.0	15	48.4	10.9	< 33.3	3.16	0.08	0.57
			2+	16	51.6	11.6	> 66.6			
Total	138									
Women										
1	20	15.0	1.0	20	100.0	15.0				
2	87	65.4	1.0	49	56.3	36.8	50.0	1.39	**0.01**	0.15
			2+	38	43.7	28.6	50.0			
3+	26	19.5	1.0	13	50.0	9.8	< 33.3	3.25	0.07	0.64
			2+	13	50.0	9.8	> 66.6			
Total	133									

The expected value expresses the proportion of each birth order separately for each family size.
The 'observed 2' values express birth-order proportions for each family size separately.
The χ2 test indicates the observed proportion in the group compared to the expected proportion.
The number of degrees of freedom (df) is for all test equal to 1.
Significant values are marked bold and 0.00 denote $p < 0.001$.

Table A4
Participants 2011–2017 by family size, gender, and birth order.

Family size	Observed	Pbserved	Birth order	Observed 2	Observed 2	Observed	Expected	χ2	*p*-value	V
(N of children)	(N)	(%)		(N)	(%)	in total (%)	(%)			
Men and women										
1	586	29.1	1.0	586	100.0	29.1				
2	1080	53.7	1.0	565	52.3	28.1	50.0	2.31	0.13	0.07
			2+	515	47.7	25.6	50.0			
3+	346	17.2	1.0	136	39.3	6.8	< 33.3	5.55	**0.01**	0.30
			2.0	99	28.6	4.9	> 33.3			
			3+	111	32.1	5.5	> 33.3			
Total	2012									
Men										
1	157	29.3	1.0	157	100.0	29.3				
2	281	52.5	1.0	167	59.4	31.2	50.0	10.00	**0.00**	0.60
			2+	114	40.6	21.3	50.0			
3+	97	18.1	1.0	35	36.1	6.5	< 33.3	0.33	0.57	0.03
			2.0	29	29.9	5.4	> 33.3			
			3+	33	34.0	6.2	> 33.3			
Total	535									
Women										
1	429	29.0	1.0	429	100.0	29.0				
2	799	54.1	1.0	398	49.8	26.9	50.0	0.01	0.92	0.00
			2+	401	50.2	27.1	50.0			

(*continued on next page*)

Table A4 (*continued*)

Family size (N of children)	Observed (N)	Pbserved (%)	Birth order	Observed 2 (N)	Observed 2 (%)	Observed in total (%)	Expected (%)	χ2	*p*-value	V
3+	249	16.9	1.0	101	40.6	6.8	< 33.3	5.86	**0.02**	0.37
			2.0	70	28.1	4.7	> 33.3			
			3+	78	31.3	5.3	> 33.3			
Total	1477									

The expected value represents the expected proportion of each birth order separately for each family size.
The 'observed 2' values indicate the birth-order proportions for each family size separately.
The χ2 test presents testing of the observed proportion in the group against the expected proportion.
The number of degrees of freedom (df) is for all test equal to 1.
Significant values are marked bold and 0.00 denote $p < 0.001$.

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