Twin Classroom Dilemma: To Study Together or Separately?

Elaine K. White
University of London and Tomsk State University

Gabrielle Garon-Carrier
Université Laval

Maria G. Tosto and Sergey B. Malykh
Tomsk State University

Xinying Li
Chinese Academy of Science

Beatrix Kiddle
University of Cambridge

Lucy Riglin
Cardiff University

Brian Byrne
University of New England

Ginette Dionne
Université Laval

Mara Brendgen
Université du Québec à Montréal

Frank Vitaro
Université de Montréal

Richard E. Tremblay
Tomsk State University and Université de Montréal

Michel Boivin
Tomsk State University and Université Laval

Yulia Kovas
University of London; Tomsk State University; and King's College London

There is little research to date on the academic implications of teaching twins in the same or different classroom. Consequently, it is not clear whether twin classroom separation is associated with positive or negative educational outcomes. As a result, parents and teachers have insufficient evidence to make a well-informed decision when twins start school. This study addresses two research questions: Are there average positive or negative effects of classroom separation? Are twins taught in different classes more different from each other than twins taught in the same class? Twin pairs from two large representative samples from Quebec (Canada) and the United Kingdom were evaluated across a large age range (7 to 16 years) on academic achievement, several cognitive abilities and motivational measures. Our results show almost no sizable positive or negative average effect of classroom separation on twins' achievement, cognitive ability and motivation. Twin pairs at age 12 (Quebec, Canada) and at age 16 (United Kingdom) were slightly more similar on achievement if placed in the same classroom, with slightly

greater similarity among monozygotic twins than dizygotic twins. However, the few effects found were weak, and it remains unclear whether they result from classroom separation or other factors. These results suggest that in terms of educational outcomes, policymakers should not impose rigid guidelines to separate twin pairs during their education. The choice of whether to educate twin pairs together or separately should be up to parents, twins and teachers, in response to twins' individual needs.

The Twin and Multiple Birth Association (TAMBA) in the United Kingdom recommend that the decision of whether to educate twin pairs separately or together should be one made by parents and teachers (TAMBA, 2009, 2010). Separation might have positive consequences, such as aiding development of individual identities; reducing intertwin competition (Segal & Russell, 1992); and decreasing dependency, especially where dominant-dominated relationships occur (Lalonde & Moisan, 2003). Separating twins also helps teachers and other class members to distinguish between the pair.

Conversely, the arguments against separation are also strong. A recent study found that twinship may have a positive effect on longevity, similar to a documented positive effect of marriage on longevity (Sharrow & Anderson, 2016). It is possible that the protective effect of twinship results from the unique bond held between twin pairs. Indeed, separation from their cotwin at the beginning of school may have adverse emotional consequences, considering the proximity that twins have shared all their lives up to this point (e.g., Tully, Moffitt, Caspi, Taylor, Kiernan, & Andreou, 2004; Van Leeuwen, Van Den Berg, van Beijsterveldt, & Boomsma, 2005). Early classroom separation might increase separation anxiety, cotwin preoccupation, and desire to be with their cotwin, which may reduce school enjoyment (Lalonde & Moisan, 2003). Twins attending different schools could also contribute to family stress as getting both twins to school on time might cause logistical problems for parents.

On the other hand, choice for separation may reflect twins' interests/suitability for a specialized school or program (e.g., specialized music school or schools with enhanced mathematics curricula). It may also reflect imposed selection processes of setting or streaming to different schools/classes by ability. Indeed, children may be placed in the same class/program when they are equally matched on skill, drive, or talent, and separated (e.g., into advanced vs. remedial classes) when they differ markedly on these phenotypes. For twins, this may result in a higher number of separated nonidentical twins (i.e., dizygotic [DZ]) compared with identical twins (i.e., monozygotic [MZ]), as MZ twins are more similar in ability (Petrill, Kovas, Hart, Thompson, & Plomin, 2009) and motivation (Spinath, Spinath, & Plomin, 2008). Consequently, this could increase the likelihood of MZ twins to enroll in the same program as a matter of choice and/or selection processes.

Average Classroom Separation Effect on Twins' Abilities

A summary of previous studies investigating whether, on average, educating twins in the same versus separate classrooms was associated with twins' abilities is given in Table 1. One study of Australian and American twins found no significant differences in literacy across kindergarten and first grade after preexisting differences in disruptive behavior and preliteracy ability were taken into account (Coventry et al., 2009). Similarly, another study investigating the effect of separation on twins' achievement by using the Netherlands Twin Registry found no difference between separated and nonseparated twin pairs at age 12 (Polderman et al., 2010). Twins taught together or separately did not differ on an independent national academic achievement test taken at the end of elementary school (controlling for zygosity, familial socioeconomic status [SES], externalizing problems at age 3, and urbanization).

However, a study from a large Netherland's educational survey collected longitudinally across Grade 2 (aged 6 years) to Grade 8 (aged 12 years) reported significantly lower language ($d = 0.02$) and arithmetic ($d = 0.23$) scores for separated twins in early school years, especially for same-sex pairs. These effects were found even after controlling for peers' test scores, school and familial SES, which are potential indicators of nonrandom class placement (Webbink, Hay, & Visscher, 2007). However, no significant effect was found at age 12, suggesting no long-lasting effect of early separation. Similarly, a longitudinal study investigated the effects of classroom separation in U.K. twins at ages 5 and 7 years. Twins were divided into three groups: (1) pairs who were taught together at both ages, (2) pairs who were taught together at age 5 and separately at age 7, and (3) pairs who were separated at both ages (Tully et al., 2004). The results showed significant but small effect sizes of classroom separation at age 7 only (see Table 1). Both MZ and DZ twins separated at age 7 had lower reading scores.

Do Separated Twins Perform More Differently Than Twins Educated Together?

Previous studies have also tested whether twins educated separately perform more differently than twins educated together. One U.K. study compared mean differences between twins educated together versus separately and found that twins educated separately were marginally more different than twins educated together. This was found for school achievement and cognitive abilities, such as verbal and nonverbal reasoning at ages 7, 9, and 10 years (Kovas, Haworth, Dale, & Plomin, 2007). However, this pattern was not observed for academic motivation. U.K. twins in different classrooms were no more dissimilar in their academic motivation than were twins in the same classrooms at age 9 (Kovas et al., 2015). A similar study of Australian and American twin pairs from kindergarten to second grade showed slightly larger mean differences for twin pairs taught separately compared with

Table 1
Summary of Previous Research Investigating Separation and Non-Separation of Twin Pairs in the Classroom

Authors (year)	Sample size	Age of sample	Significant difference of same same (S)/different (D) classrooms	Effect size	Analyses by zygosity
Asbury, Almeida, Hibel, Harlaar, and Plomin (2008)	122 twins (61 MZ pairs)	10 years	Effect for twin pairs within same classroom in school achievement	8% to 15% science and mathematics achievement	MZ only
Byrne et al., (2010)	1,422 twins (355 MZ; 356 DZ pairs)	54–71 months	S > D literacy	Literacy: 8% of variance explained by classroom separation status	MZ vs DZ
Coventry et al., (2009)	1,505 individual twins/triplets (752 MZ; 752 DZ)	59–77 months	No significant difference for literacy	None	MZ vs. DZ
Kovas, Haworth, Dale, and Plomin (2007)	11,482 twins (~1910 MZ; ~3,830 DZ pairs)	7, 9, and 10 years	No significant difference for school achievement or cognitive ability	None	MZ vs. DZ
Kovas et al., (2015)	2,294 twins (~382 MZ; ~764 DZ pairs)	9 years	Non significant difference for motivation	None	MZ vs. DZ
Polderman et al., (2010)	4,006 twins (839 MZ; 1164 DZ pairs)	12 years	No significant difference for school achievement	None	Zygosity; sex; classroom separation by zygosity.
Tully et al., (2004)	1,756 twins (484 MZ; 394 DZ pairs)	5 &7 years	S > D reading D > S internalizing problems	Internalizing problems: Separated early: age 5: MZ (d = .4); DZ (d = .2) age 7: MZ (d = .3); DZ (d = .1) Separated late: age 5: MZ (d = .4); DZ (d = .3) age 7: MZ (d = .4); DZ (d = .2) Reading at age 7: Separated early: MZ (d = .1); DZ (d = .1) Separated late: MZ (d = .2); DZ (d = .1)	MZ vs. DZ
Webbink, Hay, and Visscher (2007)	5,756 twins (2878 pairs)	6–12 years	S > D language and arithmetic at age 6	Language: d = .02 Arithmetic: d = .23	None

those taught together across time, with larger differences shown for DZ compared with MZ twins.

Additionally, lower correlations were found for both MZ and DZ twins taught separately (Byrne et al., 2010). Classroom separation status explained a modest percentage (8%) of the variance in literacy and this was not due to initial differences in literacy between the pairs. The slightly smaller similarity for separated twins (than for twins educated together) may result from differences in teacher–student relationships, quality of instruction and emotional support, or peer relations (Hamre & Pianta, 2005). However, research investigating mean differences between twin pairs has shown that these factors may also lead to dissimilarity in achievement for twins taught together as they each perceive the same classroom differently (Asbury, Almeida, Hibel, Harlaar, & Plomin, 2008).

To sum up, previous studies suggest inconsistent and very modest average effects of twins' classroom separation in elementary school years (see Table 1). As a result, parents and educational policymakers are left without clear evidence for educating twins separately or together. Consequently, more research into the implications of twin separation is needed.

The inconsistencies of previous research may mean that effects of classroom separation differ across different measures, samples and year/stage of education. Previous research has also suffered from a number of limitations. First, most studies assessed three data points or less. Some time points were quite close in age, covering a short developmental period. Second, few studies investigated the effect of classroom separation by twin's sex and zygosity which precluded an investigation of whether the effects of separation are stronger as a function of genetic similarity (e.g., MZ vs. DZ twins) and sex differences between twins (e.g., male vs. female twins). Third, most previous studies investigated classroom separation in one country only, limiting their interpretations to one educational policy/system and culture.

Here, we extend the results from previous research by investigating the average effect of classroom separation on three educational outcomes: school achievement, motivation and cognitive ability. We also investigate whether separated twins perform more differently to each other than those in the same classroom. Achievement, motivation and cognitive ability are associated with each other, including through partially shared etiology and reciprocal developmental links (e.g., Spinath, Spinath, Harlaar, & Plomin, 2006; Malanchini et al., 2016). Therefore, it can be expected that similar effects of separation will be observed for all three traits.

We also extend results of previous research by investigating in two large representative twin samples from the United Kingdom and Quebec (Canada). These samples represent two different education systems with differences in policy for twin separation. In Quebec (Canada), separation of twin pairs is widespread. Canada's policy for classroom placement of multiple births is to leave the decision to parents, although separating twins is sometimes strongly encouraged by the School Commission Boards (Lalonde & Moisan, 2003). In the United Kingdom, parents can mostly choose whether or not to send twins to the same class. A recent survey of 514 U.K. parents of twin pairs aged up to 3 years showed that 60% of MZ and 55% of DZ twins' parents wanted to keep the twins together when they started school (Cherkas, 2015). However, in around 20% of cases, schools have a stringent policy to

separate twins and/or triplets without consultation or supporting evidence that this would be in the children's best interests (Cherkas, 2015).

In the present study, twins were followed longitudinally from ages 7 to 16 years, which span the elementary and high school education in the United Kingdom and Quebec, Canada. The study addresses two main research questions: (1) Are there average positive or negative effects on school achievement, cognitive ability, and academic motivation of twins associated with being in the same versus different classroom, and do the effects vary as a function of twins' sex and/or zygosity and the timing of separation? (2) Are twins taught in different classes more different than each other in achievement, cognitive ability, and academic motivation than are twins taught in the same class? In addition, are these differences greater for DZ twins than MZ twins, reflecting greater initial genetic and/or environmental differences for DZ twins?

Method

Participants

The two representative samples taking part in the study are as follows: the U.K. Twins Early Development Study (Haworth, Davis, & Plomin, 2013), which provided data between ages 7 and 16 years from 8,705 twin pairs (3,039 MZ and 5,666 DZ pairs), following exclusion of data from participants with medical issues and English spoken as a second-language and the Canadian French and/or English speaking Quebec Newborn Twin Study (QNTS; Boivin et al., 2013), which provided data from 426 twin pairs (182 MZ and 244 DZ pairs) between ages 7 and 12 years. In both samples, participant numbers vary across measures and time of data collection. Further information about the samples is provided in supplemental online material sample description section. Ethical approval was obtained from the U.K. Medical Research Council since 1995; from the Twins Early Development Study (TEDS); from the Sainte-Justine Hospital Research Centre (2009-202, 2764); and from QNTS.

Educational system. The U.K. and Quebec education systems are mostly similar with some differences in teacher/classroom allocation across the school years. In both Quebec and the United Kingdom, the same teacher teaches all subjects for students during elementary education, with the teacher changing on a yearly basis. In Quebec, elementary education starts at age 5 to 6 and continues to age 12 (Grade 6), whereas in the United Kingdom, elementary education starts at age 4 to 5 and continues to age 11 (Year 6). In high school, the majority of the U.K. schools' mathematics and English classes are selected based on students' ability in these subjects, whereas there is no such selection in Quebec, except for optional advanced classes for English.

Measures and Procedure

A broad range of achievement, cognitive and motivational measures were used across all samples. These measures are briefly summarized here, with details and the overall sample size for the U.K. twin study in Tables S1 in the online supplemental material.

Taught together or taught separately. To determine whether twin pairs were taught together or separately, teacher contact details

for each twin were used from the studies' admin data for ages 7 to 12 years (QNTS) and ages 7 to 14 years (TEDS). U.K. twins also self-reported retrospectively if they were in the same class as their cotwin at age 16 for English and mathematics, generating two different classroom separation variables at this age (one per school subject). These teacher reports and twins' self-report gave a reliable indication of whether or not twins had the same or different teacher.

Achievement. Academic achievement data were collected by teacher report across both samples. In QNTS, teachers assessed the twins' achievement at ages 7, 9, 10, and 12 years by answering the following question: "How would you rate this child's current academic achievement (in reading, writing, mathematics, and in general)?" Rating was given on a 5-point Likert's scale ranging from 1 (*near the bottom of the class*) to 5 (*near the top of the class*). According to their strong correlations (mean correlations ranging between .78 and .82), average scores of academic achievement were then computed across school subjects at each age. In TEDS (United Kingdom), teachers reported children's level of achievement in mathematics, and English at ages 7, 9, 10, 12, and 14 from tests that are set and marked by the teacher according to National Curriculum guidelines. The test scores contribute toward an overall level for each subject which ranges from 1 to 4, 1 to 5, and 1 to 7, depending on guidelines at the time of the study (with 1 being the lowest level). Again, composite scores of achievement were derived by averaging scores across school subjects, that is, mathematics and English (average correlations ranging between .73 and .82), at each measurement time.

At age 16, U.K. participants reported their own grades for internationally recognized exams, General Certificate of Secondary Education (GCSE). These exams are taken for each specific subject at age 16 (here mathematics and English), which at the time of data collection was the end of compulsory education in the United Kingdom. The exams are graded A^* to G with A^* being the highest. Obtaining at least Grade C is necessary for many further study/career options. (Assessment guidelines can be accessed at https://www.gov.uk/government/consultations/gcse-subject-content-and-assessment-objectives).

Cognitive ability. Cognitive ability was assessed in the U.K. sample at ages 7, 9, 10, 12, and 14 years using a composite measure of general cognitive ability. This was comprised of averaging across scores from verbal and nonverbal ability assessments at each age. Verbal ability was evaluated using a combination of age appropriate tasks from Wechsler Intelligence Scale for Children (WISC–III; Wechsler, 1992). Additional verbal tests were included at ages 9, 10 and 12 from WISC–III as a Process Instrument (Kaplan, Fein, Kramer, Delis, & Morris, 1999; see Table S2 in the supplemental online material).

Nonverbal ability was also evaluated using WISC–III tasks at ages 7, 10, and 12 years. Additional tests were included at age 7 from McCarthy Scales of Children's Abilities (McCarthy, 1972), and at age 12 from Raven's Standard Progressive Matrices (Raven, Court, & Raven, 1996). Nonverbal ability was assessed at age 9 using Cognitive Abilities Test 3 (Smith, Fernandes, & Strand, 2001). At age 14, an expanded version of the age 12 Raven's Standard Progressive Matrices task was used (Raven et al., 1996). A full description of the tasks can be found in Kovas et al., (2007).

Motivational constructs. Academic motivation was self-reported by the children in both samples. In the QNTS, children self-reported their enjoyment, and how they perceived their ability in

mathematics and reading at ages 10 and 12 with six items from the Elementary School Motivation Scale (Guay et al., 2010). Items for enjoyment included the following: "I like mathematics/reading; mathematics/reading interest me a lot" and "I do mathematics/reading even when I am not obliged to do so." Items for self-perceived ability included the following: "Mathematics/reading is easy for me," "I have always done well in mathematics/reading," and "I learn things quickly in mathematics/reading." Children answered each item using a 4-point Likert scale ranging from 1 (*never*) to 4 (*always*). We averaged the enjoyment and self-perceived ability scores for each school subject separately at age 10 and 12.

In TEDS, children completed the motivational tasks by a combination of booklet completion at age 9, and by web-based testing at age 12. Children self-reported their enjoyment (How much do you like?) and self-perceptions of ability (How good do you think you are at . . .?) with a six-item measure (Spinath et al., 2006). Participants were asked to rate their enjoyment and perceptions of ability on a 5-point scale (1 = *like very much/very good*, and 5 = *do not like at all/not good at all*) for three aspects of mathematics (solving number and money problems, doing mathematics in your head, and multiplying and dividing) and three aspects of English (reading, writing, and spelling). Again, the enjoyment and self-perceived ability scores were averaged for mathematics and for English at each time point.

Although the measures were not identical across the samples, they tap into achievement and motivational constructs. As a consequence, similarity of results across the samples increases confidence in their generalizability.

Analyses

Average effect of classroom separation. Analyses were conducted using one twin selected randomly from each pair, and within each sample on variables corrected for age, with outliers ($\pm 3SD$) removed. Descriptive analyses assessed frequency of twins in the same versus different classes. Chi-square analysis assessed frequency differences of groups as a function of same/different class and zygosity. Analyses of variance (ANOVA) were conducted to assess potential differences in means for three dependent variables: achievement, cognitive ability, and motivation, as a function of three independent variables; same versus different classes; zygosity; and sex by zygosity.

Similarity among twin pairs. Further ANOVAs were conducted on absolute mean difference scores between twins of a pair to assess whether twins taught together were more similar in achievement, cognitive ability, and motivation than those taught separately. Smaller absolute mean difference scores indicate greater similarity between twins of a pair, whereas greater absolute mean difference scores indicate less similarity, that is, greater differences between twins of a pair. We also tested within-pair similarity using intraclass correlations.

Results

Frequency of Separation

Most Quebec twins were in different classes between ages 7 and 12, with only 24% to 39% taught in the same class, whereas most U.K. twin pairs (65.9%) were taught together at age 7, but only 28% were in the same class by age 16 (see Table 2). In both

Table 2

Quebec and U.K. Twin Pairs Taught by the Same or Different (S/D) Teachers by Sex and Zygosity and by Zygosity

Age	S/D teacher	MZm	DZm	MZf	DZf	DZos	MZ	DZ	Total
				Quebec twin pairs ages 7 to 12 years					
Age 7	Different	74.7%	79.1%	70.5%	74.6%	78.8%	72.5%	77.9%	75.6%
		n = 65	n = 53	n = 67	n = 44	n = 93	n = 132	n = 190	n = 322
	Same	25.3%	20.9%	29.5%	25.4%	21.2%	24.5%	22.1%	24.4%
		n = 22	n = 14	n = 28	n = 15	n = 25	n = 50	n = 54	n = 104
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 87	n = 67	n = 95	n = 59	n = 118	n = 182	n = 244	n = 426
Age 9	Different	71.6%	72.9%	63.5%	72.1%	72.4%	77.2%	76.3%	70.3%
		n = 59	n = 43	n = 54	n = 44	n = 76	n = 125	n = 167	n = 275
	Same	28.4%	27.1%	36.5%	27.9%	27.6%	22.8%	23.7%	29.7%
		n = 23	n = 16	n = 31	n = 17	n = 29	n = 37	n = 52	n = 116
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 81	n = 59	n = 85	n = 61	n = 105	n = 162	n = 219	n = 391
Age 10	Different	71.6%	72.9%	63.5%	72.1%	72.4%	67.5%	72.4%	70.3%
		n = 58	n = 43	n = 54	n = 44	n = 76	n = 122	n = 167	n = 275
	Same	28.4%	27.1%	36.5%	27.9%	27.6%	32.5%	27.6%	29.7%
		n = 23	n = 16	n = 31	n = 17	n = 29	n = 54	n = 62	n = 116
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 81	n = 59	n = 85	n = 61	n = 105	n = 166	n = 255	n = 391
Age 12	Different	57.6%	57.4%	59.1%	64.9%	62.2%	58.4%	61.4%	60.3%
		n = 38	n = 35	n = 52	n = 37	n = 69	n = 90	n = 140	n = 231
	Same	42.4%	42.6%	40.9%	35.1%	37.8%	41.6%	38.6%	39.7%
		n = 28	n = 26	n = 36	n = 20	n = 42	n = 64	n = 88	n = 152
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 66	n = 61	n = 88	n = 57	n = 111	n = 154	n = 228	n = 383
				U.K. twin pairs ages 7 to 12 years					
Age 7	Different	36.5%	37.3%	32.7%	31.7%	33.4%	34.4%	33.9%	34.1%
		n = 404	n = 393	n = 420	n = 361	n = 702	n = 824	n = 1,456	n = 2,280
	Same	63.5%	62.7%	67.3%	68.3%	66.6%	65.6%	66.1%	65.9%
		n = 702	n = 662	n = 866	n = 778	n = 1,398	n = 1,568	n = 2,838	n = 4,406
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 1,106	n = 1,055	n = 1,286	n = 1,139	n = 2,100	n = 2,392	n = 4,294	n = 6,686
Age 9	Different	42.0%	42.8%	39.4%	40.1%	42.4%	40.6%	41.9%	41.4%
		n = 238	n = 229	n = 273	n = 234	n = 452	n = 511	n = 915	n = 1,426
	Same	58.0%	57.2%	60.6%	59.9%	57.6%	59.4%	58.1%	58.6%
		n = 328	n = 306	n = 420	n = 350	n = 613	n = 748	n = 1,269	n = 2,017
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 566	n = 535	n = 693	n = 584	n = 1,065	n = 1,259	n = 2,184	n = 3,443
Age 10	Different	45.6%	49.3%	43.2%	47.1%	46.8%	44.2%	47.5%	46.3%
		n = 241	n = 252	n = 293	n = 269	n = 504	n = 534	n = 1025	n = 1,559
	Same	54.4%	50.7%	56.8%	52.9%	53.2%	55.8%	52.5%	53.7%
		n = 288	n = 259	n = 386	n = 302	n = 574	n = 674	n = 1,135	n = 1,809
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 529	n = 511	n = 679	n = 571	n = 1,078	n = 1,208	n = 2,160	n = 3,368
Age 12	Different	66.4%	67.7%	61.6%	61.5%	71.6%	**63.8%**	**68.0%**	66.5%
		n = 725	n = 710	n = 792	n = 715	n = 1,535	**n = 1,517**	**n = 2,960**	n = 4,477
	Same	33.6%	32.3%	38.4%	38.5%	28.4%	**36.2%**	**32.0%**	33.5%
		n = 367	n = 339	n = 493	n = 447	n = 608	**n = 860**	**n = 1,394**	n = 2,254
	Total	100%	100%	100%	100%	100%	**100%**	**100%**	100%
		n = 1,092	n = 1,049	n = 1,285	n = 1,162	n = 2,143	**n = 2,377**	**n = 4,354**	n = 6,731
				UK twin pairs ages 14 to 16 years					
Age 14	Different	79.4%	73.9%	70.3%	71.8%	78.9%	74.1%	75.7%	75.1%
		n = 108	n = 88	n = 130	n = 112	n = 195	n = 238	n = 395	n = 633
	Same	20.6%	26.1%	29.7%	28.2%	21.1%	25.9%	24.3%	24.9%
		n = 28	n = 31	n = 55	n = 44	n = 52	n = 83	n = 127	n = 210
	Total	100%	100%	100%	100%	100%	100%	100%	100%
		n = 136	n = 119	n = 185	n = 156	n = 247	n = 321	n = 522	n = 843
Age 16 English	Different	67.8%	80.7%	63.5%	72.5%	84.8%	**65.5%**	**80.6%**	75.5%
		n = 202	n = 230	n = 216	n = 240	n = 530	**n = 418**	**n = 1,000**	n = 1,418
	Same	32.2%	19.3%	36.5%	27.5%	15.2%	**34.5%**	**19.4%**	24.5%
		n = 96	n = 55	n = 124	n = 91	n = 95	**n = 220**	**n = 241**	n = 461
	Total	100%	100%	100%	100%	100%	**100%**	**100%**	100%

(*table continues*)

Table 2 (*continued*)

Age	S/D teacher	MZm	DZm	MZf	DZf	DZos	MZ	DZ	Total
Age 16 Math	Different	*n* = 298	*n* = 285	*n* = 340	*n* = 331	*n* = 625	**n = 638**	**n = 1,241**	*n* = 1,879
		63.5%	76.3%	55.3%	76.5%	81.5%	**59.2%**	**79.0%**	72.2%
	Same	*n* = 190	*n* = 219	*n* = 188	*n* = 254	*n* = 507	**n = 378**	**n = 980**	*n* = 1,358
		36.5%	23.7%	44.7%	23.5%	18.5%	**40.8%**	**21.0%**	27.8%
	Total	*n* = 109	*n* = 68	*n* = 152	*n* = 78	*n* = 115	**n = 261**	**n = 261**	*n* = 522
		100%	100%	100%	100%	100%	**100%**	**100%**	100%
		n = 299	*n* = 287	*n* = 340	*n* = 332	*n* = 622	**n = 639**	**n = 1,241**	*n* = 1,880

Note. MZm = monozygotic male; MZf = monozygotic female; DZm = dizygotic male; DZf = dizygotic female; DZos = dizygotic opposite sex; MZ = all monozygotic; DZ = all dizygotic. Significant results in bold at *p* ≤ .05.

samples, the proportion of twin pairs taught together was slightly higher for MZ than DZ twins at all ages. Chi-square tests of separation by zygosity showed no differences in the Quebec sample across all ages. In the U.K. sample, differences were not present at ages 7, 9, 10, and 14, but at age 12 and 16 more DZ twins than MZ twins were in different classes (age 12: χ^2 = 11.967, $p < .001$; age 16: English, χ^2 = 82.564, and mathematics, χ^2 = 51.637). All effect sizes were small, with the greatest effect of 4.4%.

Average Effects of Classroom Separation

Means and standard deviations for achievement, motivationm and cognitive ability at ages 7, 9, 10, 12, 14, and 16 by same or different teacher can be found in Tables S2 to S5 in the online supplemental material for the whole sample, the five sex by zygosity groups, and zygosity.

The patterns of results were very similar for twins taught separately and together across zygosity groups. ANOVAs (presented in Table 3 for achievement, Table 4 for cognitive ability, and Table 5 for motivation) showed no differences for most measures between same versus different class groups. A few differences were found, although with very weak effect sizes (ranging from 0.2% to 2.8%). The biggest effect of 2.8% was observed for mathematics GCSE (U.K.), with twins taught in the same class performing better than those in different classes. Results of ANOVA for sex and zygosity are presented in Tables 3, 4, and 5. Although some

significant differences between the sex by zygosity groups were found, effect sizes were weak (ranging from 0.5% to 4.5%).

Additional analyses were performed to test whether there was a cumulative effect of classroom separation on twins' achievement and motivation across their years of education from age 7. Tables S6 and S7 in the online supplemental material present the percentage of twins who were educated in the same classrooms most of their school years versus twins in different classes most of their school years. We conducted ANOVAs on achievement and motivational constructs at age 12 (Quebec) and on mathematics and English at age 16 (United Kingdom) by twins taught together or separately for most of the time (up to age 14 in the United Kingdom). See Tables S6 and S7 in the online supplemental material for group partitioning. For both samples, the results revealed no significant differences between these two groups: This was the case for both MZ and DZ twins (see Table S8 in in the online supplemental material), suggesting no cumulative average effect of classroom separation.

Similarity (or Difference) Among Twin Pairs Taught Together Versus Separately

Because some weak average effects of separation were suggested at age 12 (Quebec), and 16 (United Kingdom), additional ANOVAs were conducted at these ages to test whether twin pairs taught together were more similar to each other than those taught separately. We computed the absolute difference in scores between

Table 3

Achievement: Analysis of Variance Results by Zygosity, Sex, and Being Taught by the Same or Different (S/D) Teachers

Age	Country	Construct	S/D teacher		Zygosity × S/D		Zygosity × Sex		Sex, Zygosity × S/D	
			p	η²	*p*	η²	*p*	η²	*p*	η²
7	Quebec, Canada	Achievement	.363	.003	.146	.007	.166	.021	.488	.011
	U.K.	Achievement	.043	.001	.774	.000	**.000**	**.005**	.159	.001
9	Quebec, Canada	Achievement	.866	.000	.399	.002	.407	.011	.726	.006
	U.K.	Achievement	.184	.001	.969	.000	.044	.004	.943	.000
10	Quebec, Canada	Achievement	.382	.002	.691	.000	**.002**	**.045**	.392	.011
	U.K.	Achievement	.267	.000	.832	.000	.260	.002	.432	.001
12	Quebec, Canada	Achievement	**.016**	**.019**	.106	.009	**.045**	**.032**	.128	.023
	U.K.	Achievement	.442	.000	.763	.000	.139	.002	.158	.002
14	U.K.	Achievement	.680	.000	.353	.002	.520	.008	.173	.016
16	U.K.	Math	**.000**	**.028**	.104	.002	.207	.001	.469	.002
		English	**.000**	**.008**	.303	.001	**.000**	**.019**	.180	.004

Note. One twin selected randomly. Composite scores at all ages apart from age 16 (U.K.). Bold indicates significance at *p* < .05.

Table 4

Cognitive Ability Composite: Analysis of Variance Results for the U.K. Twins From Ages 7 to 14 by Zygosity, Sex, and Being Taught by the Same or Different (S/D) Teachers

Age	S/D teacher		Zygosity × S/D		Zygosity × Sex		Sex, Zygosity × S/D	
	p	η^2	p	η^2	p	η^2	p	η^2
Age 7	.897	.000	.091	.001	**.000**	**.005**	.322	.001
Age 9	.018	.012	.874	.000	.026	.004	.171	.002
Age 10	.301	.000	.890	.000	**.000**	**.013**	.800	.001
Age 12	.033	.001	.482	.000	**.000**	**.009**	.094	.002
Age 14	.355	.000	.547	.000	.413	.002	.272	.002

Note. One twin selected randomly. Results are from multiple tests. Bold indicates significance at $p \leq .05$.

twin and cotwin in each pair for all constructs of the Quebec sample at age 12 and for mathematics and English GCSE grades of the U.K. sample at age 16. We applied a log-10 transformation on the absolute difference scores to correct for non-normality. The transformed variables were also corrected for age and outliers ($\pm 3SD$) removed (see Figure S1 through S5 in the supplemental online material). Using the transformed within-pair difference scores, we next conducted ANOVAs on the absolute mean difference scores by same versus different classrooms and zygosity and by same versus different classrooms and sex by zygosity (see Table 6). Within-pair differences (or similarity) by zygosity and same versus different classrooms are illustrated in Figures 1, 2, and 3.

Overall, we found smaller absolute mean difference scores (i.e., greater twin similarity) for those taught together than separately (see Figures 1, 2, and 3). Greater similarity was found for MZs than DZs, with the greatest difference shown for DZs taught separately. However, the effects were weak: 2.7% for achievement at age 12 (Quebec, Canada) and 3.4% for GCSE at age 16 (United Kingdom). Although small significant differences were found between sex and zygosity groups, (3.2% to 11%), these did not differ as a function of same versus different classroom (see Table 6). In general, similarity was greater for twins taught together than apart. This conclusion was also supported by MZ and DZ intraclass correlations (ICCs), showing slightly greater ICCs for twins taught

together than separately (see Table S9 in the online supplemental material).

Discussion

The aim of this study was to examine the average effect of classroom separation on school achievement, cognitive ability, and academic motivation; and if average effects were found, to further test whether twins taught separately perform more differently from each other than those taught together. Our results showed almost no average effect of classroom separation, or cumulative effect of separation across years of education. These results were consistent across ages and countries, and across sex and zygosity. The only significant differences found between twins taught together and separately were at age 12 (Quebec, Canada) and at 16 (United Kingdom), which showed a weak average effect in favor of educating twins together. Moreover, twin pairs at age 12 (Quebec, Canada) and at age 16 (United Kingdom) were slightly more similar on achievement if placed in the same classroom, with slightly greater similarity among MZ twins than DZ twins.

Beyond the separation per se, the small but significant effect of being taught in different classes at age 16 (United Kingdom) may result from setting and streaming by ability processes. However, this is unlikely to explain the weak classroom separation effect in Quebec-Canada at age 12, as the Quebec education system does not apply streaming/selection processes. In the United Kingdom, students are streamed for ability at age 16, and therefore, are more likely to be taught separately as a result of different subject choices and differences in ability. This is particularly true of DZ twins as they are usually less similar phenotypically than MZ twins (Petrill et al., 2009; Spinath, Spinath, et al., 2006) and for this reason might end up in separate classrooms more often than MZ twins.

Indeed, we found larger numbers of DZ than MZ twin pairs taught separately at age 16 in the United Kingdom, whereas the numbers were similar across zygosity groups for prior years in Quebec and the United Kingdom. The proportion of DZ twins taught separately compared to MZ twins was slightly larger for mathematics (DZ 79% vs. MZ 59.2%) than for English (DZ 80.6% vs. MZ 65.5%), and the effect of classroom separation was greater for mathematics than for English. This might reflect the greater genetic overlap found between intelligence and mathematics performance, than between intelligence and other academic subjects

Table 5

Motivation: Analysis of Variance Results of Composite Scores by Zygosity, Sex, and Being Taught by the Same or Different (S/D) Teachers

Age	Country	Motivation	S/D teacher		Zygosity × S/D		Zygosity × Sex		Sex, Zygosity × S/D	
			p	η^2	p	η^2	p	η^2	p	η^2
9	U.K.	English	.161	.001	.879	.000	**.000**	**.016**	.433	.002
		Mathematics	.387	.000	.740	.000	**.000**	**.022**	.842	.001
10	Quebec, Canada	Reading	.524	.001	.819	.000	.591	.008	.271	.014
		Mathematics	.235	.004	.242	.004	.404	.011	.795	.005
12	Quebec, Canada	Reading	.096	.008	.582	.001	.438	.011	.229	.016
		Mathematics	**.007**	**.020**	.458	.002	.363	.012	.465	.010
	U.K.	English	**.003**	**.002**	.830	.000	**.000**	**.023**	.437	.001
		Mathematics	**.008**	**.002**	.478	.000	**.000**	**.007**	.452	.001

Note. One twin selected randomly. Bold indicates significance at $p < .05$.

Table 6

Absolute Mean Difference Scores in Achievement and Motivation: Analysis of Variance Results Between Twin Pairs by Zygosity, Sex, and Being Taught by the Same or Different (S/D) Teachers

Age	Country	Construct	School subject	S/D teacher		Zygosity × S/D		Zygosity × Sex		Sex, Zygosity × S/D	
				p	η^2	p	η^2	p	η^2	p	η^2
12	Quebec, Canada	Achievement	Composite	**.008**	**.027**	.403	.003	**.000**	**.111**	.540	.012
		Motivation	Reading	.097	.008	.785	.000	**.001**	**.054**	.967	.002
			Math	.114	.006	.506	.001	**.000**	**.064**	.715	.006
16	U.K.	Achievement	Math GCSE	**.000**	**.036**	**.005**	**.005**	**.000**	**.042**	.058	.006
			English GCSE	**.000**	**.027**	.464	.000	**.000**	**.032**	.726	.001

Note. One twin selected randomly. Results are from multiple tests. Bold indicates significance at $p \leq .05$. GCSE = General Certificate of Secondary Education.

(Rimfeld, Kovas, Dale, & Plomin, 2015). Therefore, ability streaming/selection related separation effects may be particularly evident in mathematics.

The present investigation also highlights both similarities and differences in classroom separation between Quebec (Canada) and the United Kingdom. In Quebec, a greater proportion of twins were taught separately at the beginning of elementary school, whereas in the United Kingdom at this stage of education, a greater proportion of twins were taught together. By age 12, the proportions of twins taught separately were similar across the two countries. This likely reflects differences in educational policies for the two countries. In Quebec, the School Commission Boards strongly encourage separation of twins when they begin education (Lalonde & Moisan, 2003), whereas separation in the United Kingdom occurs later on in secondary education/high school, potentially as a result of ability selection.

Nevertheless, despite the weak effects of classroom separation at age 12 (Quebec, Canada) and at age 16 (United Kingdom), our findings mostly corroborate previous research that found no significant average differences between twin pairs taught together or separately for school achievement (Coventry et al., 2009; Kovas et al., 2007; Polderman et al., 2010), cognitive abilities (Kovas et al., 2007), and academic motivation (Kovas et al., 2015), as well as no cumulative effect of separation (Kovas et al., 2015; Webbink et al., 2007).

Overall, although previous research found significant average effects of classroom separation—especially in the early years, at ages 5 and 6 (Tully et al., 2004; Webbink et al., 2007), well-powered studies found negligible or small effects of classroom separation at age 7. Inconsistencies in previous studies could be due to differences in samples (e.g., spurious effects in unrepresentative samples). It is also possible that other aspects of the classroom environment, such as quality of instruction or peer relations, may buffer any effect of separation on achievement (e.g., Hamre & Pianta, 2005). Finally, as twins' classroom allocation is usually a result of discussion between parents, teachers and the twins themselves, any potential ill effects of assignment may be attenuated, or potentially be present only if decisions were determined by high-level school policy beyond family and teacher control.
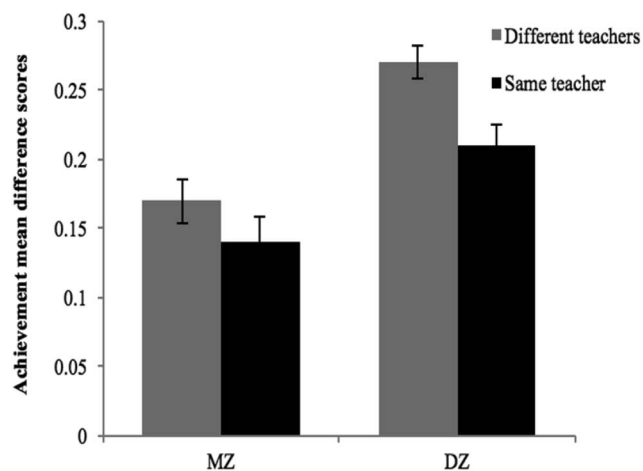

Figure 1. Absolute mean difference scores in academic achievement at age 12 for Quebec monozygotic (MZ) and dizygotic (DZ) twin pairs taught by the same or different teachers. * Significant differences found at $p \leq .05$.
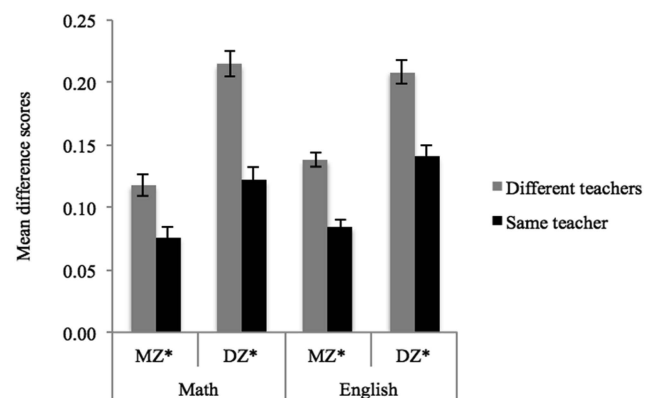

Figure 2. Absolute mean difference scores for GCSE grades in mathematics and English at age 16 for U.K. monozygotic (MZ) and dizygotic (DZ) twin pairs taught by the same or different teachers. Although larger within-pair differences found in math General Certificate of Secondary Education (GCSE) for separated DZ twin pairs, compared to separated MZ twins suggest the presence of a Gene × Environment interaction. However, we are unable to formally test this as the subsample of twin pairs with available same/different teacher data is too small for the analyses (less than 1,000 twin pairs of each type). * Significant differences found at $p \leq .05$.
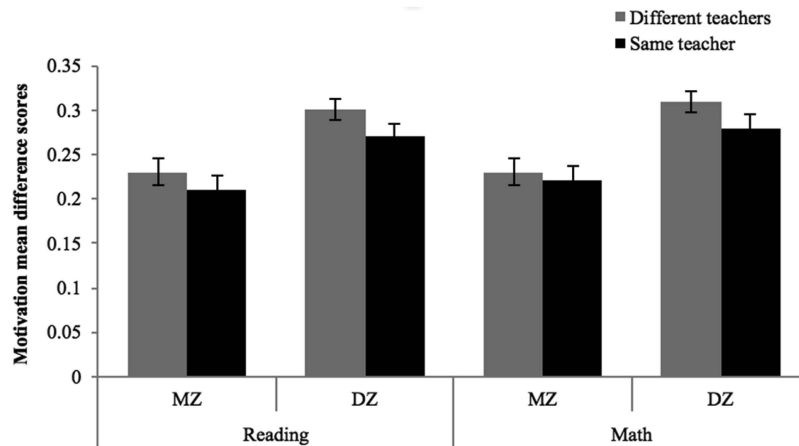
Figure 3. Absolute mean difference scores for motivation in reading and mathematics at age 12 for Quebec monozygotic (MZ) and dizygotic (DZ) twin pairs taught by the same or different teachers. * Significant differences found at $p \leq .05$.

Although we found no substantial average classroom separation effect, this does not mean an absence of effect for the individual. Effects of classroom separation are likely to depend on individual characteristics and different perceptions of classroom experience (e.g., Asbury et al., 2008). Other factors such as socioemotional difficulties (e.g., Van Leeuwen et al., 2005; Tully et al., 2004), ability streaming, or school transition might also play a role beyond classroom separation.

Limitations and Future Research

The study is not without limitations. First, it is important to mention that the study is not a randomized controlled trial of twins' classroom placement. Instead, it is a naturalistic study of twins' classroom allocation, where allocation is likely to be the result of discussion between parents, teachers and the twins themselves. Second, we were not able to fully test the patterns of results across both samples up to age 16, as data were not available at age 16 in the Quebec sample. Similarly, we only had available data for GCSE at age 16 in the U.K. subsample that provided same/different teacher data. Therefore, we were unable to assess any effect of same/different teacher on cognitive ability or motivation at this age. Third, attrition for both samples also resulted in some nonoverlapping data across the years of the study and so prevented further longitudinal analyses to show potential effects for consecutive years of being in the same versus different classes. Fourth, other traits, such as emotional or behavioral outcomes may show a different pattern of results and therefore need to be explored in future research. Fifth, the results of this study should not be generalized to other countries/systems. Despite some differences between the two educational systems, the cultures investigated here are very similar. Future studies would benefit from investigating across more diverse cultures and education systems.

Finally, in both countries, teachers reported twins' school achievement. It is possible that teachers of twins in the same classroom rated twins more similarly than teachers of twins in separate classrooms. Teacher rater-bias could especially be a limitation in the United Kingdom where the national curriculum tests

on which these assessments were based were set and marked by the teachers. However, the small effects of classroom separation and within-pair similarity found at age 16 (United Kingdom) are unlikely to be the result of teacher rating reliability, as at this age, achievement was measured by externally assessed exams.

Conclusion

Our results show no sizable positive or negative average effect of separation on twins' achievement, cognitive ability and motivation. The few effects found were weak and could stem from other factors rather than a real effect of classroom separation. These results suggest that in terms of academic achievement, cognitive ability and motivation, policymakers should not impose rigid guidelines for schools and parents to separate twin pairs during their education. The choice of whether to educate twin pairs together or separately should be up to parents, twins and teachers, in response to twins' individual needs.

References

Asbury, K., Almeida, D., Hibel, J., Harlaar, N., & Plomin, R. (2008). Clones in the classroom: A daily diary study of the nonshared environmental relationship between monozygotic twin differences in school experience and achievement. *Twin Research and Human Genetics, 11,* 586–595. http://dx.doi.org/10.1375/twin.11.6.586

Boivin, M., Brendgen, M., Dionne, G., Dubois, L., Pérusse, D., Robaey, P., . . . Vitaro, F. (2013). The Quebec Newborn Twin Study into adolescence: 15 years later. *Twin Research and Human Genetics, 16,* 64–69. http://dx.doi.org/10.1017/thg.2012.129

Byrne, B., Coventry, W. L., Olson, R. K., Wadsworth, S. J., Samuelsson, S., Petrill, S. A., . . . Corley, R. (2010). "Teacher effects" in early literacy development: Evidence from a study of twins. *Journal of Educational Psychology, 102,* 32–42. http://dx.doi.org/10.1037/a0017288

Cherkas, L. (2015). *Results of questionnaire survey of parents of young twins regarding placement of twins in primary school.* Retrieved from https://www.tamba.org.uk/Reports1/3/15

Coventry, W. L., Byrne, B., Coleman, M., Olson, R. K., Corley, R., Willcutt, E., & Samuelsson, S. (2009). Does classroom separation affect

twins' reading ability in the early years of school? *Twin Research and Human Genetics, 12,* 455–461. http://dx.doi.org/10.1375/twin.12.5.455

Guay, F., Chanal, J., Ratelle, C. F., Marsh, H. W., Lar-ose, S., & Boivin, M. (2010). Intrinsic, identified, and controlled types of motivation for school subjects in young elementary school children. *British Journal of Educational Psychology, 80,* 711–735. http://dx.doi.org/10.1348/000709910X499084

Hamre, B. K., & Pianta, R. C. (2005). Can instructional and emotional support in the first-grade classroom make a difference for children at risk of school failure? *Child Development, 76,* 949–967. http://dx.doi.org/10.1111/j.1467-8624.2005.00889.x

Haworth, C. M., Davis, O. S., & Plomin, R. (2013). Twins Early Development Study (TEDS): A genetically sensitive investigation of cognitive and behavioral development from childhood to young adulthood. *Twin Research and Human Genetics, 16,* 117–125. http://dx.doi.org/10.1017/thg.2012.91

Kaplan, E., Fein, D., Kramer, J., Delis, D., & Morris, R. (1999). *WISC-III as a Process Instrument (WISC–III–PI).* New York, NY: The Psychological Corporation.

Kovas, Y., Garon-Carrier, G., Boivin, M., Petrill, S. A., Plomin, R., Malykh, S. B., . . . Vitaro, F. (2015). Why children differ in motivation to learn: Insights from over 13,000 twins from 6 countries. *Personality and Individual Differences, 80,* 51–63. http://dx.doi.org/10.1016/j.paid.2015.02.006

Kovas, Y., Haworth, C. M., Dale, P. S., & Plomin, R. (2007). The genetic and environmental origins of learning abilities and disabilities in the early school years. *Monographs of the Society for Research in Child Development, 72,* 1–144.

Lalonde, N., & Moisan, D. (2003). Les jumeaux à l'école: Dans la même classe ou dans des classes séparées . . . qui doit décider? [Twins at school: Being in the same or separate classrooms . . . who should decide?] *Résolution des Commissaires,* 1–11. Retrieved from http://apjtm.com/wp-content/uploads/2014/11/les_jumeaux_a_ecole.pdf

Malanchini, M., Tosto, M. G., Garfield, V., Dirik, A., Czerwik, A., Arden, R., . . . Kovas, Y. (2016). Preschool drawing and school mathematics: The nature of the association. *Child Development, 87,* 929–943.

McCarthy, D. (1972). *McCarthy Scales of Children's Abilities.* New York, NY: The Psychological Corporation.

Petrill, S. A., Kovas, Y., Hart, S. A., Thompson, L. A., & Plomin, R. (2009). The genetic and environmental etiology of high math performance in 10-year-old twins. *Behavior Genetics, 39,* 371–379. http://dx.doi.org/10.1007/s10519-009-9258-z

Polderman, T. J., Bartels, M., Verhulst, F. C., Huizink, A. C., van Beijsterveldt, C. E., & Boomsma, D. I. (2010). No effect of classroom sharing on educational achievement in twins: A prospective, longitudinal cohort study. *Journal of Epidemiology and Community Health, 64,* 36–40. http://dx.doi.org/10.1136/jech.2009.091629

Raven, J. C., Court, J. H., & Raven, J. (1996). *Manual for Raven's Progressive Matrices and Vocabulary Scales.* New York, NY: Oxford University Press.

Rimfeld, K., Kovas, Y., Dale, P. S., & Plomin, R. (2015). Pleiotropy across academic subjects at the end of compulsory education. *Scientific Reports.* Advance online publication. http://dx.doi.org/10.1038/srep11713

Segal, N. L., & Russell, J. M. (1992). Twins in the classroom: School policy issues and recommendations. *Journal of Educational & Psychological Consultation, 3,* 69–84. http://dx.doi.org/10.1207/s1532768xjepc0301_5

Sharrow, D. J., & Anderson, J. J. (2016). A twin protection effect? Explaining twin survival advantages with a two-process mortality model. *PLoS ONE, 11,* e0154774. http://dx.doi.org/10.1371/journal.pone.0154774

Smith, P., Fernandes, C., & Strand, S. (2001). *Cognitive Abilities Test 3 (CAT3).* Windsor, England: NferNelson.

Spinath, B., Spinath, F. M., Harlaar, N., & Plomin, R. (2006). Predicting school achievement from general cognitive ability, self-perceived ability, and intrinsic value. *Intelligence, 34,* 363–374. http://dx.doi.org/10.1016/j.intell.2005.11.004

Spinath, F. M., Spinath, B., & Plomin, R. (2008). The nature and nurture of intelligence and motivation in the origins of sex differences in elementary school achievement. *European Journal of Personality, 22,* 211–229. http://dx.doi.org/10.1002/per.677

TAMBA. (2009). *Multiple choice: The educational needs and experiences of multiple birth children.* Retrieved from https://www.tamba.org.uk/parenting

TAMBA. (2010). *Part III. Primary and secondary school admissions and appeals pack: Information guide for parents and professionals in England.* Retrieved from http://www.nhs.uk/Conditions/pregnancy-and-baby/Pages/twins-at-school.aspx

Tully, L. A., Moffitt, T. E., Caspi, A., Taylor, A., Kiernan, H., & Andreou, P. (2004). What effect does classroom separation have on twins' behavior, progress at school, and reading abilities? *Twin Research, 7,* 115–124. http://dx.doi.org/10.1375/136905204323016087

van Leeuwen, M., van den Berg, S. M., van Beijsterveldt, T. C., & Boomsma, D. I. (2005). Effects of twin separation in primary school. *Twin Research and Human Genetics, 8,* 384–391. http://dx.doi.org/10.1375/twin.8.4.384

Webbink, D., Hay, D., & Visscher, P. M. (2007). Does sharing the same class in school improve cognitive abilities of twins? *Twin Research and Human Genetics, 10,* 573–580. http://dx.doi.org/10.1375/twin.10.4.573

Wechsler, D. (1992). *Wechsler Intelligence Scale for Children* (3rd ed.) *U. K. (WISC-III-U. K.) manual.* London, UK: The Psychological Corporation.