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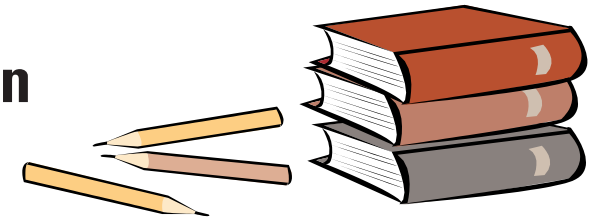
Abstract:
Article briefly discusses an analysis of students' academic and social scores in a Montessori school as compared with other elementary school education programs. Montessori education is characterized by multi-age classrooms, a special set of educational materials, student-chosen work in long time blocks, collaboration, the absence of grades and tests, and individual and small group instruction in both academic and social skills. The effectiveness of some of these elements is noted as being supported by research on human learning.

THE EARLY YEARS

Evaluating Montessori Education



Angeline Lillard[1]* and Nicole Else-Quest[2]

An analysis of students' academic and social scores compares a Montessori school with other elementary school education programs.

Montessori education is a 100-year-old method of schooling that was first used with impoverished preschool children in Rome. The program continues to grow in popularity. Estimates indicate that more than 5000 schools in the United States—including 300 public schools and some high schools—use the Montessori program. Montessori education is characterized by multi-age classrooms, a special set of educational materials, student-chosen work in long time blocks, collaboration, the absence of grades and tests, and individual and small group instruction in both academic and social skills (*1*). The effectiveness of some of these elements is supported by research on human learning (*2*).

We evaluated the social and academic impact of Montessori education. Children were studied near the end of the two most widely implemented levels of Montessori education: primary (3- to 6-year-olds) and elementary (6- to 12-year-olds). The Montessori school we studied [located in Milwaukee, Wisconsin (*3*)], which served mainly urban minority children, was in its ninth year of operation and was recognized by the U.S. branch of the Association Montessori Internationale (AMI/USA) for its good implementation of Montessori principles (*4*).

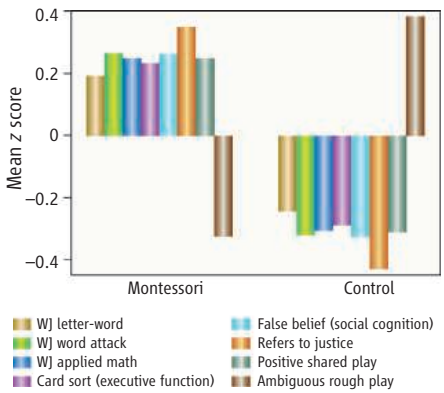
Because it was not feasible to randomly assign children to experimental and control educational groups, we designed our study around the school lottery already in place. Both the experimental and the control group had entered the Montessori school lottery; those who were accepted were assigned to the experimental (Montessori) group, and those who were not accepted were assigned to the control (other education systems) group. This strategy addressed the concern that parents who seek to enroll their child in a Montessori school are different from parents who do not. It is crucial to control for this potential source of bias, because parents are the dominant influence on child outcomes (*5*).

Recruitment

We contacted parents of children who had entered the Montessori school lottery in 1997 and 2003 and invited them to be in the study. All families were offered $100 for participation.

Because the lottery, which was conducted by the school district, was random, the Montessori and control groups should contain similar children. Ninety percent of consenting parents filled out a demographic survey. Parents from the Montessori and control groups had similar average incomes ($20,000 to $50,000 per year) at each student age level. This addressed a concern with a retrospective lottery loser design that the final samples might be different for reasons other than the treatment. Another variable, ethnicity, was not surveyed because parent income contributes more to child outcomes than does ethnicity (*6*). We were also concerned that requesting ethnicity data would reduce participation in this racially divided city.

Overall, 53 control and 59 Montessori students were studied (table S1). The 5-year-old group included 25 control and 30 Montessori children, and the 12-year-old group included 28 control and 29 Montessori children. Gender balance was imperfect, but gender did not contribute significantly to any of the differences reported here. Children at the Montessori school were drawn from all six classrooms at the primary level and all four at the upper elementary level. The control children were at non-Montessori schools: 27 public inner city schools (40 children) and 12 suburban public, private/voucher, or charter schools (13 children). Many of the public schools had enacted special programs, such as gifted and talented curricula, language immersion, arts, and discovery learning.



Results for 5-year-olds. Montessori students achieved higher scores [converted to average *z* scores (*18*)] for both academic and behavioral tests.

Children in both groups were tested for cognitive/academic and social/behavioral skills that were selected for importance in life, not to examine specific expected effects of Montessori education. Our results revealed significant advantages for the Montessori group over the control group for both age groups.

Results: 5-Year-Olds

Cognitive/Academic Measures. Seven scales were administered from the Woodcock-Johnson (WJ III) Test Battery (*7*). Significant differences favoring Montessori 5-year-olds were found on three WJ tests measuring academic skills related to school readiness: Letter-Word Identification, Word Attack (phonological decoding ability), and Applied Problems (math skills) (see chart, left). No difference was expected or found on the Picture Vocabulary test (basic vocabulary) because vocabulary is highly related to family background variables (*8*). Two WJ tests of basic thinking skills—Spatial Reasoning and Concept Formation—also showed no difference.

Five-year-olds were also tested on executive function, thought to be important to success in school. On one such test, children were asked to sort cards by one rule, switch to a new rule, and (if they did well) then switch to a compound rule. Montessori children performed significantly better on this test. A test of children's ability to delay gratification (a treat) did not indicate statistically significant differences.

Social/Behavioral Measures. Children were given five stories about social problems, such as another child hoarding a swing, and were asked how they would solve each problem (*9*).

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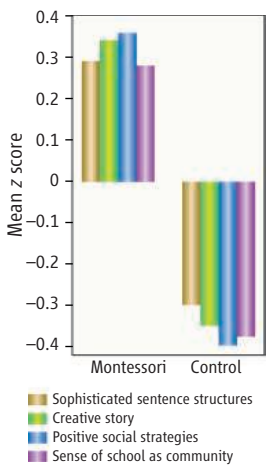
Montessori children were significantly more likely (43% versus 18% of responses) to use a higher level of reasoning by referring to justice or fairness to convince the other child to relinquish the object. Observations at the playground during recess indicated Montessori children were significantly more likely to be involved in positive shared peer play and significantly less likely to be involved in rough play that was ambiguous in intent (such as wrestling without smiling).

The False Belief task was administered to examine children's understanding of the mind (*10*). Recognition that people represent the world in subjective as well as objective ways is a landmark achievement in social cognition (*11*). Social negotiation and discussion about mental states leads to this advance in children (*12*). Whereas 80% (significantly more than chance) of the Montessori 5-year-olds passed, the control children were at chance, with 50% passing.

Results: 12-Year-Olds

Cognitive/Academic Measures. Twelve-year-olds were given 5 minutes to complete a story beginning "____ had the best/worst day at school." The Montessori students' essays were rated as significantly more creative and as using significantly more sophisticated sentence structures (see chart, below). Control and Montessori essays were similar in spelling, punctuation, and grammar. Unlike the 5-year-olds, the 12-year-olds did not perform differently on the WJ tests. This is surprising, because early reading skills normally predict later reading (*13*). Either the control group had "caught up" by age 12 to the Montessori children, or the 12-year-old Montessori children were not more advanced in these early reading skills when they were 5. If the latter, one possible explanation is that the 12-year-olds started at the school when it was in its third year. The Montessori method relies on peer teaching and modeling, so those who are in the early classes of a new school lack some advantages relative to those who begin later.

Social/Behavioral Measures. As a social skills test, 12-year-olds read six stories about social problems (such as not being asked to a party) and were asked to choose among four responses. Montessori 12-year-olds were significantly more likely to choose the positive assertive response (for example, verbally expressing one's hurt feelings to the host). On a questionnaire regarding their feelings about school, Montessori children indicated having a greater sense of community, responding more positively to items such as, "Students in my class really care about each other" and "Students in this class treat each other with respect."



Results for 12-year-olds. Students in the Montessori program wrote more sophisticated and creative stories and showed a more developed sense of community and social skills. Scores were converted to average *z* scores (*18*).

Benefits of Montessori Education

On several dimensions, children at a public inner city Montessori school had superior outcomes relative to a sample of Montessori applicants who, because of a random lottery, attended other schools. By the end of kindergarten, the Montessori children performed better on standardized tests of reading and math, engaged in more positive interaction on the playground, and showed more advanced social cognition and executive control. They also showed more concern for fairness and justice. At the end of elementary school, Montessori children wrote more creative essays with more complex sentence structures, selected more positive responses to social dilemmas, and reported feeling more of a sense of community at their school.

These findings were obtained with a lottery loser design that provides control for parental influence. Normally parental influence (both genetic and environmental) dominates over influences such as current or past school and day-care environments. For example, in the large National Institute of Child Health and Human Development (NICHD) study of early child care, correlations between parenting quality and WJ early academic tests had effect sizes comparable to those seen here, whereas school effects were much smaller (*5*). An evaluation of *Success for All*, considered a highly successful reading intervention, reported a quarter of a standard deviation as its largest effect size (for Word Attack) in a randomized field trial, and stated that it was equal to a 4.69-month advance in reading skills (*14*). Stronger effects are often found in the first years of pilot programs when researchers are involved in implementation of their own programs (*15*), termed the "super-realization effect" (*16*). In our study, the school did not anticipate an evaluation. Especially remarkable outcomes of the Montessori education are the social effects, which are generally dominated by the home environment (*17*).

Future research could improve on the research design here by following lottery participants prospectively and by tracking those who drop out and examining their reasons. It would be useful to replicate these findings in different Montessori schools, which can vary widely. The school involved here was affiliated with AMI/USA, which has a traditional and relatively strict implementation. It would also be useful to know whether certain components of Montessori (e.g., the materials or the opportunities for collaborative work) are associated with particular outcomes.

Montessori education has a fundamentally different structure from traditional education. At least when strictly implemented, Montessori education fosters social and academic skills that are equal or superior to those fostered by a pool of other types of schools.

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18. The *z*-score conversion was used for the graph to give all tests the same metric. A *z* score sets the mean (in this case of the entire sample) at 0, one standard deviation above the mean at 1.68, and one standard deviation below the mean at −1.68.
19. Funding was provided by the Jacobs and Cantus Foundations and sabbatical fellowships from the Cattell Foundation and the University of Virginia to A.L. J. DeLoache, B. Detmer, L. Ma, A. Pinkham, R. Tai, and J. van Reet provided helpful comments, and E. Turkheimer provided valuable statistical advice. We thank the Milwaukee schools that participated; the children and their families; and A. Hart, T. Nishida, A. Pinkham, J. van Reet, and B. Rosen.

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Supporting Online Material for

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Data files as zipped archives: Data file for 5-year-olds
Data file for 12-year-olds

Supplementary On-Line Materials

A. Lillard & N. Else-Quest

Contents

i. Montessori Implementation

The criteria for AMI/USA association include the following (see http://www.montessori-ami.org/ for more information):

- a teacher in each classroom having completed an AMI training course for the level being taught (normally 9 months of lectures interspersed with closely supervised teaching)
- a visit by a trained AMI consultant every 3 years

- a complete set of approved Montessori materials in each classroom
- a class size of 28 to 35 children balanced across the appropriate ages for the level (3 to 6, 6 to 9, and so on)
- an uninterrupted 3-hour work period each morning
- no more than one assistant in a 3- to 6-year-old class

ii. Methods

a. The Lottery. The lottery to get into this Montessori school at age 3 is conducted each February by the district, following a well-advertised 3-week application period. Milwaukee families submit applications naming their school of choice. All the children in the present study listed the Montessori school as their first choice. School principals notify the school district of the number of open slots in their school. A computer assigns each child a rank and admits children randomly in order of rank to fill the slots. Children whose rank is lower than the number of slots are placed on a wait list in order. The Montessori school adheres strictly to children's rankings with this wait list with the exception of admitting siblings of children who have already been admitted by the random lottery. Typically the school leaves 5 – 8 slots open (beyond the number designated as open for the lottery) for incoming siblings each year. Because the older siblings were themselves admitted by random selection, other characteristics of the families with siblings would still be expected to be roughly the same as that of control families, assuming that Montessori school applicants change little from one year to the next. Very few children are admitted to the Montessori school after age 3, and only if they have attended another Montessori school.

b. Initial Recruitment. Letters from the principal of the Montessori school and the Milwaukee Public School District accompanied the initial recruitment letters to all families, to legitimize the study. (Even control families were familiar with the Montessori school principal, as they had typically contacted him years earlier to inquire about admission off the waiting list.) Three mailings were sent to the control families (in September, November, and January), with each subsequent mailing targeting families who had not yet responded. By the third mailing, only 3 new participants were recruited. Two mailings were sent to the Montessori children (September and November).

c. Participation Rates. The participation rates are higher for the Montessori than for the control group. Early in the recruitment phase, the Montessori parents were not offered the financial incentive as it was thought to be unnecessary, and eight parents sent forms back explicitly refusing to participate. The school principal advised us that some had called and expressed that there was no benefit to them. To address this, we offered $100 to the Montessori families as well. In addition, because the numbers of available Montessori children were small enough that very high participation rates at the Montessori school were required in order to have an adequate sample size, the principal also contacted families of all 12-year-olds to remind them of the study, and teachers of 5-year-olds mentioned the study in all of their fall parent-teacher conferences. Following these steps, participation rates from the Montessori increased to required levels. It was not possible to use direct contact with the control group because until parents returned the permission forms, we did not know what schools the children attended, and had no way to contact them except by letters (which we were not certain were received or read). Only 2 control families explicitly declined to participate, and one of those stated that the

reason was a recent change of schools. (This was not a reason to exclude a child from our vantage point, but we did not contact the family again.)

Table S1. Ns In Each Sample at Each Stage of the Recruitment Process.

5-year-olds	*Available (lost/won lottery)*	*Address in MPS database*	*Returned Letter*	*Consented*	*Child Partic-ipated*
Control	112	90	32	31	25*
Montessori	54	54	42	39	30†
12-year-olds					
Control	99	86	33	32	28‡
Montessori	36	36	30	30	29§

* 5 had attended other Montessori schools and 1 was home-schooled

† Thirty was the target *n* for all samples.

‡ 2 had attended other Montessori schools, 1 was severely learning disabled, and 1 refused to participate.

§One child was severely learning disabled.

d. Samples. Although quite a good control sample for a field study in education, the control group is not ideal. The control families who chose to participate in this evaluation might be different in particular ways from the Montessori families who chose to participate. There are several potential sources of difference. For one, the recruitment

methods were somewhat different across samples by virtue of the fact that one group was all at one, known school.

Second, different types of control families might have been willing to participate. Perhaps only control parents with high-achieving children, or only ones who were less watchful of their child (thus did not mind their being tested by a stranger), participated. The Montessori families had "community support" in that many children at their school were being tested.

Another potential problem stems from selective attrition from the Montessori pool. Attrition from the control pool was achieved only by moving out of the area or attending a Montessori or being home schooled, but Montessori students became ineligible when they moved to other schools. Mitigating this concern, an earlier study at a different inner-city public Milwaukee Montessori school showed that attrition from that Montessori was due mainly to families moving out the of area *(S1)*, which would impact the control sample equally. However, if it were the case that children who responded poorly to Montessori left the school, that would be problematic, especially by age 12 since they had more years for poor outcomes to drive schooling decisions.

Another potential problem is that all but one of the Montessori children started school at age 3, whereas 13 of the control children did not attend school until age 4. However, as is shown after the main results (See Table S5), the means of control children who matriculated before age 4 were much more like the means of the whole control sample than they were like the means of the Montessori children.

Although the control group is not ideal, the problems are part of natural experiment research using a retrospective lottery loser design. Given the desirability of doing school

outcome evaluations, and that the design has many positive aspects, the control group used here is a good step forward.

e. Schools. Table S2 shows what types of schools were attended by the control children. Six of the 28 12-year-olds were at public schools described as being for "Gifted and Talented" children.

Table S2. Ns at Each Type of Control School at Each Age.

	Inner-city Public	Suburban Public	Charter	Private Voucher	Private
5-year-olds	18	2	1	3	1
12-year-olds	22	2	2	2	0

f. Table S3. Ages, Age Ranges, and Gender Composition of Samples.

		Mean Age	Age Range	Gender
5-year-olds	Montessori	70 m	64 – 77 m	15 F; 15 M
	Control	70 m	64 – 77 m	10 F; 15 M
12-year-olds	Montessori	12 y 1 m	11 y 5 m – 12 y 7 m	17 F; 12 M
	Control	12 y 0 m	11 y 5 m - 12 y 6 m	10 F; 18 M

g. Procedures. Children were tested in quiet locations at their schools by one of four experimenters, each of whom tested at least 5 children in each group. Two experimenters coded playground behavior.

5-year-olds. Children were administered the False Belief test first, followed by 2 WJ scales (Letter-Word and Word Attack), then the Social Problem Solving task. As a

break they drew a picture for 5 minutes, then received the Dimensional Change Card Sort test of executive function and 2 additional WJ scales (Understanding Directions and Applied Problems). On the next visit, usually 2 days later, they answered 12 questions concerning their feelings about school, received three additional WJ scales (Picture Vocabulary, Spatial Relations, and Concept Formation), and participated in a standard Delay of Gratification test of executive function. The Playground Observation occurred on a separate day. One of two (or two, for reliability samples) coders was present on the playground during recess and coded the child's predominant activity during each 1-minute time block. Recess coding lasted for an average of 12 minutes at both types of schools (with a range of 7 to 20 minutes at both types of school).

12-year-olds. After a questionnaire regarding their feelings about school, 12-year-olds received 3 WJ scales (Letter-Word, Word Attack, and Understanding Directions) followed by the Narrative Composition. Next they read and responded to the six Social Skills Stories, followed by the other 4 WJ scales. Two control 12-year-olds refused to do one or more of the tasks; one more refused to participate at all.

iii. Reliability

All subjective scoring was submitted to commonly-used interrater reliability procedures, with a second blind coder coding at least 20% of the sample. The one place where this was not possible was the playground observation; the second coder had no knowledge of Montessori and no particular interest in the study, but by necessity did know when he was coding at the Montessori school.

Table S4. Reliability of Subjective Measures Across Two Raters.

Age.	Measure	Reliability
5	Social Problem Solving: Appeals to Fairness	*r* = . 98
5	Playground: Positive Peer Play	*r* = .98
5	Playground: Ambiguous Rough & Tumble	*r* = .99
12	Narrative Creativity	*r* = .73
12	Narrative Sentence Sophistication	*r* = .70

iv. Analyses

Most of the data were analyzed using 2-tailed *t*-tests. Effect sizes are increasingly viewed as more important than *p* values in psychology research, in part because they are insensitive to sample size. Large samples can yield impressive *p* values even when mean differences are actually quite small. The widely-used Cohen's *d (2)* gives the proportion of the pooled standard deviation by which two means are different, and is reported here for comparisons where the primary statistical tests were significant at the $p < .05$ level. Effect sizes of .2 to .4 are considered small but meaningful in social sciences research, .4 to .6 is considered medium, and higher than .6 is considered a large effect size.

v. Results

Table S5. Table of Significant Results.

Test	Montessori M and *SD*	Control M and *SD*	Statistic	*p* value	Cohen's *d*
5-Year-Olds					
False Belief	.80 *.41*	.52 *.51*	Binomial (Montessori > chance)	.025	.61
Letter-Word	13.3 *7.00*	10.00 *7.83*	Mann-Whitney *U* *Z* = 2.24	.025	.44
Word Attack	7.30 *4.26*	5.00 *3.19*	$t(53) = 2.23$	.030	.63
Applied Problems	19.00 *3.11*	17.00 *4.19*	$t(53) = 2.03$	.047	.55
Dimensional Card Sort	22.70 *1.58*	21.00 *4.06*	$t(53) = 2.11$	.039	.61
Social Problem Solving: Fairness	3.90 *3.14*	1.60 *2.08*	$t(53) = 3.13$	.002	.89
Positive Peer Play	13.98 *5.27*	10.61 *6.30*	$t(53) = 2.16$	.035	.58
Ambiguous Rough/Tumble	0.36 *0.97*	2.40 *3.83*	$t(53) = -2.81$	.015	.72

12-Year-Olds	Montessori M and *SD*	Control M and *SD*	Statistic	*p* value	Cohen's *d*
Creativity of Narrative	2.72 *1.07*	1.96 *1.09*	$t(54) = 2.64$	.011	.71
Sentence Sophistication: Narrative	2.62 *0.96*	2.06 *0.94*	$t(54) = 2.22$	.031	.59
Social Problem Solving: Positive, Direct Strategy	2.89 *1.47*	1.81 *1.50*	$t(53) = 2.69$	.009	.73
Positive School Feelings	4.72 *5.69*	1.21 *7.32*	$t(55) = 2.03$	.048	.54

vi. Scores Relative to Matriculation Age

Table S5. Means of Whole Control Sample and of Young Matriculators in Control and Montessori Groups.

	Control Whole Sample	Control Matriculated before 4 (n = 10)	Montessori Matriculated before 4 (n = 29)
False Belief	.52	.40	.79
Letter-Word	10.00	10.20	13.52
Word Attack	5.00	5.40	7.45
Applied Problems	17.00	16.80	19.00

DCCS	21.00	20.80	22.72
Appeals to Justice	1.60	2.30	3.86
Positive Peer Play	10.61	9.24	13.77
Ambiguous Rough and Tumble Play	2.40	2.34	0.37

vii. Other Research Using Traditional Montessori Implementations

Other studies of traditional Montessori programs have also recently showed positive effects. Students attending Montessori middle schools, relative to matched controls, were significantly more likely to report 1) feeling energized and engaged while doing schoolwork; 2) spending more time doing schoolwork and less time socializing and watching media during school; 3) that their friends and classmates are one and the same people; and 4) that their classrooms are orderly, that their teachers are supportive, and that they feel emotionally safe at school *(S3, S4*). In another study, children who attended other public Montessoris in Milwaukee from ages 3 to 11 scored significantly higher several years later on standardized tests of math and science, relative to their high school classmates (matched on ethnicity, gender, and free lunch status) (*S5*). Infants who were randomly assigned to a Montessori Early Head Start program had superior language and cognitive skills relative to other infants at 4 time points from 14 to 36 months of age (*S6*). In addition, the parents of these children were significantly more sensitive to their infants while at home. Of 29 school reform movements analyzed in a recent meta-analysis, Montessori obtained one of the largest effects on achievement (d = .27) despite the Montessori schools averaging only 3 years of implementation (*S7*). Because the researcher (Maria Montessori) died over 50 years ago, this would not be considered an

effect of superrealization (where the researcher is overseeing the implementation, see main article), and for reasons also noted in the main article, it might result in less optimal student outcomes.

Two studies of Head Start Programs begun around 1970 included Montessori as one of several programs to which 4-year-olds were randomly assigned (*S8-10*). Unfortunately the implementation of the Montessori program was rather poor in both cases (e.g., only one age group in the class, short duration of program both daily and for the study, first year of classroom), and although the results were intriguing, the sample sizes were miniscule by the long-term follow up.

There are other studies of Montessori education, but either the control group leaves much to be desired, or the Montessori implementation was clearly poor or unspecified, limited to one classroom hence could simply reflect a teacher's influence, and so on. Many but not all show positive Montessori outcomes, yet all have significant scientific weaknesses.

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ix. Data

Several variables were removed from the data file in the interest of protecting participant confidentiality.