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Perfect timing: sensitive periods for Montessori education and long-term wellbeing

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Montessori is the most common alternative education in the world by far, and it exists both in public and private schools and extends from birth to university. A prior study found that Montessori attendance as a child, controlling for demographic factors including SES, was associated with higher adult wellbeing, and that the longer one had attended Montessori school, the higher one's adult wellbeing. Because few people remain in Montessori programs for all their precollege years, here we ask if there are more optimal ages, in terms of an association with long-term wellbeing, to attend Montessori schools (sensitive periods), and more optimal ages to transition from Montessori to conventional schools (sensitive transition points). Using factor scores derived from the responses of $N = 1{,}907$ adults (M_{age} 37, range 18–81 years) on standard measures of wellbeing, we analyzed whether adult wellbeing was higher if one had attended Montessori during specific age spans (3 to 6, 6 to 9, etc.). Although attending Montessori during every period through age 12 predicted higher adult wellbeing (compared to attending conventional schools), the strongest effects were found for attending Montessori rather than conventional programs during preschool (ages 3 to 6), and for attending it for 3 rather than just 2 preschool years. We next examined for optimal points of transition from Montessori to conventional schools, focusing especially on whether one transitioned at the end of one of Montessori's 3-year classroom cycles (ages 6, 9, and 12) or in the middle of those cycles (ages 4, 5, 7, 8, 10, and 11). Controlling for basic demographic variables, the wellbeing factor of Engagement was higher if one had transitioned out of Montessori at the end of one of the 3-year-cycles than if one transitioned in the middle of those cycles, and there was a trend for having higher General Wellbeing. We discuss the implications for parents and for education policy.

KEYWORDS

sensitive periods, childhood education, Montessori, wellbeing, transition points

Introduction

Montessori education was developed by an Italian physician and her collaborators from the late 1800s through the mid-1900s (Montessori, 2012), and its development continues today, with the most innovation occurring in middle and high school programs (Eckert, 2023). Montessori is currently the most common alternative pedagogy in the world, exceeding the next most common (Waldorf/Steiner) in number of schools by 10-fold (Debs et al., 2022). Consistent with its prevalence, the research base on Montessori education is large enough to warrant a Bloomsbury Handbook (Murray et al., 2023), a "Special Interest Group" in the American Education Research Association, and a scientific peer-reviewed journal (the *Journal of Montessori Research*). By comparison, there is little research on the outcomes of other alternative pedagogies like Reggio or Waldorf (Emerson and Linder, 2021; Tyson, 2024).

Montessori is an unusual pedagogy: children in multi-aged classrooms freely choose what to do all day long, their education mainly involves working with a vast set of interconnected hands-on materials, and they have relatively few interactions with a teacher (Montessori, 2012; Preschlack, 2023). In addition, Montessori students tutor and collaborate with peers at will, have no tests or grades, and pursue their own interests, among other distinctions. In these ways it differs sharply from the conventional school model we gleaned from Prussia (Melton, 1988/2002) as well as differing from Steiner, which uses whole-class teaching (hence has much less free choice) and graded classrooms (Steiner, 1995). Although Reggio also emphasizes child interest and self-determination, Montessori has a much more defined available curriculum than the Reggio model (Aljabreen, 2020), and of course Montessori also extends to older ages. It is important to note, however, that because Montessori is not trademarked, its implementation can vary widely (Murray and Daoust, 2023). The most rigorous educational standards are adhered to by the Association Montessori Internationale or AMI, which certifies schools that adhere to those standards (AMI-Montessori schools). The American Montessori Society also certifies schools, using a much broader set of standards that are less specific concerning Montessori pedagogy (AMS-Montessori schools). However, few studies differentiate among the wide array of Montessori implementations (c.f., Courtier et al., 2021; Lillard, 2012; Lillard and Heise, 2016).

Although some fairly recent reviews found equivocal results for Montessori education (Ackerman, 2019; Marshall, 2017), research increasingly suggests that Montessori education has strong outcomes, at least relative to conventional and business-as-usual schools, and this is the case internationally. For example, two recent meta-analyses, one of which accounted for baseline differences, found that both social-emotional and academic child outcomes are better for Montessori as compared to traditional schooling, and this did not differ by country (Demangeon et al., 2023; Randolph et al., 2023). Three randomized controlled trials have also found better outcomes for Montessori. In two of these studies, children applied to a lottery for admission to one or two US-based AMI-Montessori schools at age 3, and at age 5 those who had won a spot and enrolled had higher academic and social skills outcomes, and executive function outcomes were also somewhat better in Montessori as compared to schools attended by children who lost the lottery (Lillard and Else-Quest, 2006; Lillard et al., 2017). A third study randomly assigned children to Montessori or L'école maternelle (the French national preschool curriculum) within a public elementary school; unfortunately the teachers were not Montessori-certified, yet despite this over 3 years the children in Montessori became more advanced in reading (Courtier et al., 2021). A tightly controlled matched-sample study examining year over year growth in South Carolina's dozens of public Montessori schools also found better outcomes on reading, math, and other outcomes (Fleming and Culclasure, 2023). Furthermore, Montessori schooling has been shown to influence facets of wellbeing both concurrently and into adulthood (Denervaud et al., 2019; Dhiksha and Suresh, 2016; Lillard and Else-Quest, 2006; Lillard et al., 2017, 2021; Rathunde and Csikszentmihalyi, 2005a,b; see also Shankland et al., 2010), and dosage effects show longer Montessori school attendance predicts higher adult wellbeing (Lillard et al., 2021). Recent evidence also indicates that Montessori education may influence biology, including brain structure (Denervaud et al., 2020; Duval et al., 2023; Zanchi et al., 2023) and the HPA axis governing stress responses (Dettmer and Lillard, 2023; Schwery et al., 2023).

In sum, Montessori is a relatively popular alternative school model with a growing research base showing good outcomes. Yet few people attend Montessori schools for their entire school career; indeed, there are not many Montessori elementary schools (serving 6- to 12-year-olds), much less Montessori middle and high schools. The question arises as to whether there are age spans when the association between Montessori attendance and later long-term wellbeing is particularly strong. If such an age span exists it be considered a *sensitive period* (discussed more below). Second, most children leave Montessori at some point—their parents may become uncomfortable with it, class sizes may become small at ages when children want to expand their horizons, or Montessori programs may simply not be available anymore as families move or children advance to higher grades. Given that children likely will leave Montessori programs at some point, are there better and worse ages (time points) to do so, in terms of an association with adult wellbeing? We call these hypothesized better times *sensitive [transition] points,* building on sensitive period terminology.

In sum, here we ask if there are in effect sensitive periods in development when attending Montessori school is particularly likely to be associated with higher wellbeing in adulthood, and if one must leave Montessori at some point, when in Montessori's 3-year-cycles is most optimal to do so in terms of a long-term wellbeing association. These findings open a unique window for examining how early educational experiences might be associated with adult flourishing, and also could have important implications for parental decision-making and education policy.

Sensitive periods

All biological organisms adapt to their environments; adaptation is often most marked early in development, during critical or sensitive periods when structural foundations of the nervous system are especially plastic (Blair and Raver, 2015; Merzenich, 2001). For example, when kittens of specific ages are given unusual visual experiences, such as wearing glasses lined with horizontal bars, blocking continuous vertical extents, their vision and corresponding cells in their visual cortex develop abnormally; if such experiences are delivered later in development, vision and cells are unaffected (Wiesel and Hubel, 1963). Similar findings obtain when owls are raised with prism glasses (Knudsen, 2004). As another example, classic ethological studies showed that many species of fowl follow the first large moving object they see in a short period soon after birth, and that later in life they try to mate with similar objects that resemble that "first love" (Lorenz, 1965); corresponding changes are seen in the avian analog of the mammalian association cortex (Horn, 2004). Similarly, humans form attachment relationships with primary caregivers in their 1st year, and often (if there is no intervention) go on to seek similar relationship styles later in life (Van IJzendoorn, 1995); concomitant neural substrates of these patterns have also been identified (Atzil et al., 2011).

Thus, organisms adapt to their environments, and there are sensitive periods when organisms are particularly malleable in

their adaptations. This raises the question of how children adapt to school environments, where they spend significant amounts of time. Among OECD countries, 84% of children ages 3 to 5 attend school (OECD, 2024), and from kindergarten through 8th grade, students spend almost 9,000 h in school, on average (Sparks, 2019). Human childhood is a period of remarkable brain plasticity (Lillard and Erisir, 2011), and research has shown some of the ways students adapt to their school environments. For example, in schools that increase children's sense of agency, children adapt by becoming more engaged in school (Fredricks et al., 2004). Repeated engagement over time is likely to result in lasting biological change (Marshall and Fox, 2006); for example, engagement at work is related to increased heart rate variability (a sign of health) in Finnish women (Seppälä et al., 2012).

Montessori environments have very different parameters for engagement as compared to conditions of conventional[1] schools. Montessori students have much more opportunity for self-determination, for example, including during the periods of rapid neural restructuring in early childhood (Huttenlocher, 2002; Knudsen, 2004; Lillard, 2019; Marzola et al., 2023). It is conceivable that adapting to different school environments as a child creates lasting biological changes that manifest in differences in adult psychology. As alluded to above, in a prior study adults ages 18 to 81 (average age 37) had significantly higher adult wellbeing if they attended a Montessori school for at least 2 years in childhood (Lillard et al., 2021). We cannot know Montessori education was causal or whether the adult outcomes were a byproduct of something associated with attending Montessori, although several likely suspects—childhood SES, attending private schools, age, gender, and race were controlled. Regardless, it is interesting to ask whether attending Montessori school at particular ages might be more or less associated with adult wellbeing—in other words, whether there is a sensitive period during which attending Montessori schools, which vary on a range of features, like self-determination, predicts higher adult wellbeing. Others have shown that several of Montessori's distinguishing features, like self-determination experiences, enhance wellbeing (Deci and Ryan, 2012), and likely do so through effects on physiology (Di Domenico and Ryan, 2017; Ntoumanis et al., 2021). People choose the activities that they do out of intrinsic motivation: They find certain activities rewarding, engaging the dopaminergic system (Di Domenico and Ryan, 2017). We speculate that if self-determination is prevalent early in development, it might be accompanied by physiological changes that lead to higher wellbeing in adulthood, such as lower levels of inflammation or cortisol (de Vries et al., 2022), or possibly changes underlying the dopaminergic system. For example, being able to choose one's activities might reduce stress, and strengthen approach tendencies, along with openness to new experiences. These possibilities could lead to an association between Montessori during sensitive periods and adult wellbeing. For further discussion of why Montessori might enhance wellbeing, see Lillard et al. (2021).

The 3-year cycle

A second question follows, which hinges on the fact that most children leave Montessori for traditional school at some point, either because Montessori is no longer available (e.g., there are fewer Montessori elementary schools than preschools, and fewer Montessori high schools than middle schools), or because family preferences or needs change. Does the age at which one leaves Montessori predict differences in long-term wellbeing? We call this a "sensitive point" in development, namely an age or time point when changing one's school environment from Montessori to conventional is particularly strongly associated with one's long-term outcomes, relative to making this change at other points in development. Here we were concerned in particular with leaving Montessori in the middle or at the end of what is called *the three-year cycle*.

Montessori practitioners argue that it is very important that a child remain in a classroom for 3 years to fully benefit. Classrooms house age ranges corresponding to Montessori's theorized (based on her observations) developmental stages: 3 to 6 years, 6 to 9 years, and so on. Montessori's broader age spans, called the Planes of Development, (0–6, 6–12, and so on) are seen in other developmental theories, such as those of Montessori's admirer Jean Piaget (Flavell, 1963; Piaget, 1970) and the earlier developmental theorist Comenius (Dobinson, 1970), but splitting the broader stages in two as Montessori did is not as common.

Dr. Montessori believed that children in these 3-year age spans have similar developmental needs and benefit from similar classroom structures and materials. Yet these age spans also provide for ample degrees of developmental differences in the classroom—children change a lot in 3 years. With this degree of difference, "The older ones help the smaller ones and the small ones help each other" (Montessori, 2012, p. 233). Children profit from helping one another: "There is nothing that makes you learn more than teaching someone else" (Montessori, 1989, p. 69). Montessori's claim of the benefits of peer tutoring is supported by contemporary research (Bargh and Schul, 1980; Lillard, 2017, Chapter 7; Thurston et al., 2021; Xu et al., 2008).

The 3-year age span is also believed to enhance community, as "children of different ages help one another" (Montessori, 1967/1995, p. 226). Three years is considered close enough to allow for interest and understanding, but not so close as to create competition. "Not only are these children free from envy, but anything done well arouses their enthusiastic praise" (Montessori, 1967/1995, p. 223). By contrast, conventional schools rarely mix more than two ages, but even a 2-year span has been shown to confer social benefits including less loneliness, aggression, and behavioral problems (McClellan and Kinsey, 1997), and more

1 By conventional school, we mean the typical common way of schooling, derived from the 18th century Prussian model (Melton, 1988/2002); see also Tyack and Cuban (1995). In conventional schools, teachers usually face the class, children are organized into age-graded units of approximately 12-month age spans, and are given tests and homework assignments from which grades are derived. Learning stems mainly from reading materials prearranged into a syllabus, and by listening to a teacher who organizes and delivers knowledge based on external standards for what children of different ages should know. Children spend most of class time seated, facing the teacher. There is a schedule with defined start and stop times for each subject each day. And so on.

extended and positive peer interactions (Wu et al., 2022). Although an extensive review (Veenman, 1995) found no *average* overall effect of multi-aged classrooms in conventional settings, findings from conventional settings may not apply because Montessori teaching methods are quite different.

The 3rd year in a Montessori classroom is considered a crucial year of consolidation, allowing children to bring together all they have learned since entering that classroom. The third year provides opportunities for leadership before a child moves up into the next level of classroom to take on new challenges there. The 3rd year also gives opportunity to observe younger children, and realize how far one has come in 3 years. For these reasons, Montessorians maintain that it is very important for children to remain in a classroom for 3 years, to complete the 3-year cycle.

At issue is whether experiencing a full 3-year Montessori classroom cycle is associated with differences in long-term wellbeing: are those who completed the cycles, and therefore experienced being the youngest, middle, and eldest ages in a classroom, better off in terms of long-term wellbeing than those who leave mid-cycle?

The only studies we know addressing this issue in Montessori schools both focused on academic achievement (Fleming and Culclasure, 2023; Hemmen et al., 2023). In the Hemmen study, for example, researchers had noticed a pattern in assessment data from 43 public and private Montessori schools wherein performance on a standardized test, Measures of Academic Progress or MAP, appeared to accelerate near the end of upper elementary or 6th grade (typically ages 12–13). For the study, they examined 5 years (4th through 8th grade) of English Language Arts and Math MAP scores for a single class as it advanced through Upper Elementary and Middle School in a public charter Montessori school. The school ended at 8th grade so one can only observe the first 2 years of that 3-year cycle; therefore those data are not discussed here.

In math, they found students scored below national norms in 4th grade, still slightly below national norms at 5th grade, and then well above national norms at the end of 6th grade. In English Language Arts the pattern was similar except students were already above national norms at 4th grade, and they had greater than expected increases (relative to norms) each year. Looked at another way, the percent of students at the school exceeding their expected growth in math was just 10% in 4th grade, but was 70% in 6th grade. In English Language Arts, the findings were less marked, but still showed that the percentage of students surpassing expected growth was larger at the end of the 3-year-cycle than at its start. The very rigorous (Fleming and Culclasure, 2023) study, discussed previously, had similar results. Thus, there is some limited support for the idea that completing a 3-year cycle in Montessori is associated with better academic outcomes, but no studies have addressed whether it is associated with long-term wellbeing.

Wellbeing

Wellbeing as used here refers to one's subjective assessment of the quality of one's life (see Yiğit and Çakmak, 2024), or the "felt experience of health, happiness, and flourishing" (Lillard et al., 2021, p. 1); measurement of wellbeing for this study is described below. Wellbeing's importance is certainly intrinsic (Diener et al., 2015), but wellbeing also has extrinsic importance, in that it predicts key life outcomes ranging from longevity to social relationships and behaviors (Ryff, 2014). Although genes are partial determinants of wellbeing (Røysamb and Nes, 2019), so are environmental factors. For example, undergoing more residential moves in childhood predicts lower wellbeing in adulthood (Oishi and Schimmack, 2010).

Many features of Montessori education have been associated with concurrent and long-term wellbeing. For example, a Montessori education logic model (Culclasure et al., 2019) highlights features like self-determination, working with one's hands, and collaborating with peers, and notes that a range of positive social and cognitive outcomes would be expected to result from the Montessori model having such features. Montessori program features are also consistent with research in the science of learning (Cantor et al., 2018; Darling-Hammond et al., 2020; National Academies of Sciences Engineering Medicine, 2018). Studies done in conventional schools demonstrate that features like low test anxiety predict higher wellbeing concurrently, while students are still in school (Baker, 2004; Cohen, 2006; Felner et al., 2007; Seligman et al., 2009; Steinmayr et al., 2016, 2018). Furthermore, meta-analyses (Demangeon et al., 2023; Randolph et al., 2023), tightly controlled longitudinal studies (Fleming and Culclasure, 2023), and random lottery studies suggest Montessori education would lead to higher wellbeing due to its association with wellbeing counterparts, like higher academic skills, mastery orientation, creativity, social skills, sense of community, and executive function. We also believe that wellbeing could be enhanced by Montessori education because of its evolutionary match to how children learn; by contrast, conventional school methods are a distinct evolutionary mismatch (Bjorklund, 2022).

Following on this theory, to examine whether Montessori education predicts, and therefore *might* cause, higher adult wellbeing, Lillard et al. (2021) administered 23 validated and commonly used wellbeing surveys to almost 2,000 adults ages 18 to 81, roughly half of whom had experienced Montessori schooling for at least two childhood years and half of whom had not. For example, the 23 surveys included the Satisfaction with Life scale (Diener et al., 1985) and all six subscales of the Psychological Wellbeing Scale (Ryff, 2014). Factor analyses of participant responses to these 23 surveys indicated four factors:

- *General Wellbeing*: derived from scales and subscales tapping satisfaction with one's life, self-acceptance, a sense that one can master one's environment, subjective vitality, finding meaning in one's life, and mindfulness,
- *Engagement*: social contribution, social integration, personal growth, sense of purpose, and positive relations with others,
- *Social Trust*: a sense of optimism about other people and the future of society, and
- *Self-Confidence*: feeling comfortable in the world and one's own skin, and enjoying hard problems.

Lillard et al. (2021) found that people who attended Montessori for at least 2 years as children scored significantly higher on all four factors, even controlling for gender, race, childhood SES, and the proportion of their schooling that was private, which was shown

not to be a factor. In seeking indicators of whether Montessori could have caused the higher wellbeing, the authors reasoned that an association with duration of years in Montessori could support a causal argument. This is because parents who choose Montessori for young children often do not choose to leave it; rather, schools end. In the US, most Montessori schools serve children ages 3 to 6; fewer serve children ages 6 to 9; still fewer serve children 9 to 12; and so on, through high school. Because no clear factors are associated with communities having Montessori schools that extend to higher ages, then if long-term wellbeing was correlated with years in Montessori (duration of attendance), it would support the possibility of a causal relation. Indeed, in a second robustness check, they found that the longer one had been in a Montessori school (range = 2–16 years, mean = 7.88 years), the higher one's General Wellbeing and Engagement in adulthood. Thus, attending Montessori as a child is clearly associated with wellbeing in adulthood, and the robustness checks gave some support for the possibility that the relation is causal.

Based on these findings, the present study examined the data from Lillard et al. (2021) to ask the two new questions stated above: Is there a sensitive period in childhood wherein experiencing Montessori schooling predicts adult wellbeing, relative to the degree of prediction seen in other periods of childhood? And, is there evidence of sensitive points for leaving Montessori schools, such that completing a 3-year cycle might be associated with higher adult wellbeing than leaving in the middle of a cycle?

Method

An overview of the methods used in data collection is provided here; readers are referred to Lillard et al. (2021) for more details. The study was approved by the Internal Review Board for Social Sciences Research at the University of Virginia (Protocol #2657).

Participants

Participants were 1,905 participants in the United States and Canada who had attended Montessori for at least some of their schooling (n = 834), or had spent virtually all their school years at conventional schools (n = 1,071). An additional 194 participants were excluded due to the appearance of inattention or untruthful responses, suggested by: spending <10 min completing the survey (determined in pilot testing to be the minimal time needed to read and respond cogently), n = 154; incorrect answers to attention checks, n = 8; and implausible responses, such as claiming having attended a different type of school three or more years in a row, n = 28, or participants claiming they got the survey link from another source when their actual source was clear (n = 4). Eight participants were excluded because they said they did not attend school for more than 3 years or for 2 years in a row after they were 6 years of age. An additional 39 participants were excluded for more than one of these reasons. Some participants indicated that their gender was other than female or male (n = 31), and because gender was used in the analyses and this group was too small for the models, they were excluded.

This was a purposeful sample in that participants were recruited through Facebook ads in cities known to have many Montessori schools, and through school associations which were asked to send notices to member schools asking that they contact their alumni; additional recruiting methods were posting the study on Amazon's Mechanical Turk, and snowballing, where participants were asked to share the link with others. The mean age of participants was 37.05 years (SD = 13.12, range = 18–81 years), and most of the sample (79.2%) identified as female (79.2%), and White (83.0%); other self-identified races were: 3.4% Black or African American, 4.5% Asian, 3.7% Hispanic or Latino, <1% American Indian or Alaska Native, Native Hawaiian or Pacific Islander, and 3.8% more than one of these categories; an additional 1% self-identified in other categories (e.g., Jewish) or did not specify a race/ethnicity. The subsamples did not differ in mean age or race/ethnicity, but due to subsample sizes those who identified as all categories except White were grouped together.

Procedure

A series of surveys was administered on the Qualtrics and Amazon Mechanical Turk platforms with compensation of $0.50/survey. The stated purpose of the survey was "to better understand the long-term outcomes of alternative and conventional school education on peoples' lives." No specific school system was mentioned until the final page. Two attention check questions were inserted between survey questions.

Survey and factors

The survey included 18 established scales (see below) addressing several aspects of wellbeing. Eleven of these were subscales of the Psychological and Social Wellbeing scales. The scales are described in detail in Lillard et al. (2021) and summarized here with reference to the four wellbeing factors noted earlier. Those factors were derived using exploratory and confirmatory factor analyses from participants' responses and, as noted previously, were General Wellbeing, Engagement, Social Trust, and Self-Confidence (see Lillard et al., 2021 for factor solution including factor loadings). Original scale alphas and our intercorrelations among all scales/subscales are provided in Table 1. The remaining five scales included the 5-factor personality scale and ordinal scales that did not fit the models.

Psychological wellbeing scales

Ryff and Keyes (1995) are six 3-item 7-point subscales. Both the Self-Acceptance (e.g., "When I look at the story of my life, I am pleased with how things have turned out so far"; α = 0.59) and Environmental Mastery ("I am good at managing the responsibilities of daily life"; α = 0.52) subscales contributed to the General Wellbeing factor. Personal Growth ("Life is a continuous process of growth"; α = 0.55), Purpose in Life ("Some people wander aimlessly through life; I am not one of them"; α = 0.36), and Positive Relations ("People would describe me as a giving person"; α = 0.58), contributed to the Engagement factor. Finally,

TABLE 1 Means, SDs, original scale Cronbach's alphas, and correlation matrix for observed variables.

Observed variable	Mean	*SD*	α	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1. Age	37.05	13.11		1.0																	
2. Years in Montessori	3.53	4.66		−0.36	1.0																
3. Life Satisfaction	24.95	7.10	0.90	0.03	0.16	1.0															
4. Self Acceptance	16.82	3.90	0.75	0.05	0.18	0.75	1.0														
5. Meaning in Life	26.64	6.55	0.91	0.19	0.01	0.59	0.60	1.0													
6. Environ. Mastery	15.57	3.86	0.69	0.12	0.16	0.62	0.66	0.48	1.0												
7. Subjective Vitality	4.71	1.26	0.90	0.10	0.12	0.60	0.59	0.55	0.59	1.0											
8. Autonomy	16.87	3.16	0.56	0.24	−0.04	0.20	0.30	0.27	0.33	0.20	1.0										
9. Mindful Awareness	4.08	0.79	0.87	0.24	0.05	0.31	0.39	0.36	0.46	0.41	0.34	1.0									
10. Social Coherence	13.57	3.77	0.54	0.03	0.12	0.30	0.35	0.29	0.40	0.31	0.30	0.29	1.0								
11. Personal Growth	19.05	2.59	0.67	−0.08	0.23	0.39	0.48	0.42	0.44	0.45	0.23	0.25	0.24	1.0							
12. Purpose in Life	17.05	3.24	0.42	−0.04	0.14	0.43	0.51	0.46	0.41	0.36	0.22	0.27	0.27	0.51	1.0						
13. Positive Relations	17.01	3.80	0.65	0.07	0.18	0.51	0.57	0.46	0.48	0.46	0.22	0.35	0.27	0.43	0.41	1.0					
14. Social Integration	16.48	4.49	0.87	0.03	0.23	0.50	0.54	0.45	0.45	0.47	0.13	0.25	0.24	0.45	0.38	0.59	1.0				
15. Social Actualization	13.35	4.24	0.71	−0.13	0.22	0.38	0.38	0.25	0.32	0.36	0.05	0.18	0.35	0.32	0.26	0.32	0.38	1.0			
16. Social Acceptance	14.23	3.55	0.51	0.04	0.20	0.37	0.36	0.27	0.33	0.32	0.12	0.19	0.23	0.33	0.22	0.39	0.45	0.51	1.0		
17. Social Contribution	18.02	3.38	0.76	0.11	0.15	0.48	0.59	0.57	0.48	0.48	0.28	0.29	0.34	0.55	0.49	0.47	0.57	0.35	0.39	1.0	
18. Short Need Cognit.	69.14	12.03	0.90	0.03	0.11	0.26	0.28	0.26	0.27	0.31	0.30	0.20	0.32	0.43	0.32	0.22	0.24	0.20	0.21	0.40	1.0

All rs > 0.04 are significant at the $p < 0.05$ level.

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Autonomy ("I judge myself by what I think is important"; $\alpha = 0.48$) contributed to the Self-Confidence factor.

Social wellbeing scales

The five SWB subscales derived from the 15-item SWB items (Keyes, 1998) use the same basic format as the PWB subscales. Two subscales, Social Contribution ("I have something to give"; $\alpha = 0.66$) and Social Integration ("I feel close to people in my community"; $\alpha = 0.73$), contributed to the Engagement factor. Social Acceptance ("People are kind"; $\alpha = 0.41$) and Social Actualization ("Society is getting better"; $\alpha = 0.64$) contributed to the Social Trust factor. Finally, Social Coherence ("I can predict/make sense of the world"; $\alpha = 0.64$) contributed to the Self-Confidence factor.

Satisfaction with Life Scale

The Satisfaction with Life Scale (Diener et al., 1985), one of the most commonly-used measures of wellbeing (Ackerman et al., 2018), consists of five items (e.g., "In most ways my life is close to my ideal"; $\alpha = 0.87$) which participants rate using the same 7-point scale ranging from *strongly disagree* to *strongly agree*. This scale contributed strongly to the General Wellbeing factor.

Meaning in life questionnaire

This 10-item scale (Steger et al., 2008) measures meaning in life, including its presence and one's search for meaning; the 5-item MILQ-Presence subscale was used here to assess the presence of meaning in life. Using a 7-point scale ranging from *absolutely untrue* to *absolutely true*, participants rated five short statements such as, "My life has a clear sense of purpose"; $\alpha = 0.86$. This scale also contributed strongly to the General Wellbeing factor.

Subjective vitality scale

This 7-item scale (Ryan and Frederick, 1997) measures the extent to which one feels alive and alert. Using a 7-point scale ranging from *not at all true* to *very true*, participants rate seven short statements such as, "I feel alive and vital"; $\alpha = 0.83$. An aggregate score is calculated by adding ratings from each of the items. This scale also contributed strongly to the General Wellbeing factor.

Short need for cognition scale

This 18-item scale (Cacioppo et al., 1984) measures the extent to which individuals engage in and enjoy effortful thinking. Using a 5-point scale ranging from *extremely uncharacteristic of me* to *extremely characteristic of me*, participants rate statements such as, "I really enjoy a task that involves coming up with new solutions and problems"; $\alpha = 0.90$. This scale contributed strongly to the Self-Confidence factor.

Mindful attention awareness scale

This 15-item scale (Brown and Ryan, 2003) measures individuals' dispositional mindfulness, or awareness and attention to the present moment. Participants rate each statement with reference to their day-to-day experiences using a 6-point scale ranging from *almost always* to *almost never*. For example, one item is, "I find it difficult to stay focused on what is happening in the present;" a high score means that is almost never true. An aggregate score is calculated by averaging the 15 responses. Higher scores reflect higher dispositional mindfulness, and contributed to the General Wellbeing factor. Alpha for this scale is $\alpha = 0.81$.

Demographics and school history

After completing the wellbeing measures, participants answered standard demographic questions, reporting factors such as their age, gender, race, and childhood SES, the latter of which is highly related to child outcomes (Duncan and Murnane, 2014; Reardon, 2011). Finally, participants gave a detailed history of their school experience by noting, for each year from ages 2 to 17, what type of school they attended and how the school was funded. Options for school type included Regular/Traditional, Montessori, and a range of other options including Homeschool, Waldorf, Reggio Emilia, and Other Alternative. Options for funding included: Public, Private (non-religious), and Private (religious). "Did not attend school" was an option for both school type and funding questions. People of course often change ages during the 9 months when they are in a given school year. We asked that they respond for where they were most of the year at any given age. This introduces some noise in our data, but that is unavoidable with our design.

Analytic approach

To address the first question regarding a sensitive period for attending Montessori school, we worked with the data file from Lillard et al. (2021), in which participants had stated for each year from when they were 2 to 17, what type of school they attended for the majority of the year. We grouped participants according to the ages at which they attended Montessori, and compared the wellbeing factor scores of those who attended Montessori at given ages or age ranges with those in conventional schools at that time. Children who were not in school or were in other types of schools in any given period were not examined.

To address the second question regarding a sensitive point for leaving Montessori school, we grouped children according to when they made the transition from Montessori to Conventional school. We limited the sample to those who had made just one transition, and we compared ones who completed a cycle (i.e., left Montessori at ages 6, 9, or 12) with those who did not (i.e., left Montessori at ages 4 or 5, 7 or 8, or 10 or 11).

Results

We first present the results regarding possible sensitive periods, then present the results regarding possible sensitive points.

Sensitive periods for attending Montessori schools

Is there a sensitive period when having attended Montessori as a child is particularly likely to be associated with higher adult wellbeing? The first set of analyses used a year-by-year approach with ANCOVAs, using childhood SES, race, and gender as covariates.[2] A larger *F*-value was taken to indicate a larger association. Following this, we grouped data into periods corresponding to those represented in Montessori's mixed-age classrooms: 3 to 6 (thus through age 5), 6 to 9, and so on, and examined the degree to which Montessori schooling at each of these levels is associated with higher wellbeing than is conventional schooling.

Sensitive periods as individual years

For the analyses to come, it is helpful to know the number of children in our sample of 1,907 participants who were enrolled in a Montessori school at any given age. Figure 1 provides this information. As can be seen, 402 participants were enrolled in Montessori programs at age 2, and this increased to 697 at age 4, then began to decline gradually. At age 12, 391 participants were enrolled in Montessori programs; this dropped to 124 at age 14, and then to 50 at age 17.

Furthermore, while the number of control children not attending school at all is miniscule after age 5, at ages 2 and 3, the majority of the control sample stayed home and therefore were not included in the control sample for those years. By age 4, the majority of the control sample not attending Montessori was attending conventional schools. To reiterate, analyses here are limited to those children who are in a Montessori or a conventional school, and do not include those staying home.

We examined, for each age, the difference in adult wellbeing associated with attending Montessori or attending a conventional school at that age. For General Wellbeing, Montessori attendance was associated with significantly higher adult wellbeing factor scores than conventional school attendance every year through age 14, although the associations reduced markedly at age 13. At the oldest ages (15–17), differences still favored Montessori but were no longer significant. Sample sizes in the Montessori group were very small at these older ages, making the results both less reliable and less likely to obtain significance. The largest *F*-values were obtained at 4 and 5 years old: $F_{(1,1,413)} = 43.66$, Cohen's $f^2 = 0.18$, and $F_{(1,1,819)} = 49.87$, Cohen's $f^2 = 0.17$, respectively, both $ps < 0.001$. Cohen (1988) suggests that f^2 of 0.15 represents a medium effect, whereas 0.02 is a small effect and 0.35 is a large effect.

The findings for the Engagement factor were similar to those for General Wellbeing, but with even larger *F*-values. At age 4, $F_{(1,1,413)} = 93.51$, $f^2 = 0.26$, and at age 5, $F_{(1,1,819)} = 120.94$, $f^2 = 0.21$, respectively, both $ps < 0.001$. Values were still quite high across elementary school, suggesting Montessori attendance through Elementary school is particularly strongly associated with Engagement in later life. The differences in Engagement were significant through age 14.

For Social Trust, the largest *F*-value was observed at age 5: $F_{(1,1,819)} = 107.65$, $p < 0.001$, $f^2 = 0.24$, and the next six largest (ranging from 80.87 to 92.73, with all f^2s = 0.21–0.22) were observed from ages 6 to 11, rather than age 4, suggesting that attending Montessori schools across Elementary school is particularly strongly associated with optimism about society and the future. That said, the *F*-values for those who attended Montessori at ages 3 and 4 are still very large: 59.14 and 67.42, respectively both $ps < 0.001$, f^2s = 0.22 and 0.24, respectively. Likewise, the *F*-values for those who attended Montessori at ages 12 and 13 are still quite high, at 56.34 and 48.86, respectively (both $ps < 0.001$, with effect sizes of $f^2 = 0.17$ and 0.16, respectively) and the differences are significant through age 14 when $f^2 = 0.09$.

For Self-Confidence, although *F*-values were much smaller than for the other three factors, they were still significantly different for those who attended Montessori school through age 12; they were largest for those who attended Montessori at ages 4 and 5, at 19.28 and 21.48, respectively, both $ps < 0.001$, and $f^2s = 0.12$ and 0.11.

Sensitive periods as Montessori classroom levels

To examine whether these year-by-year findings translate into potential sensitive periods, children were grouped according to whether they attended Montessori school consistently across each 3-year period from ages 2 to 17. Thus, one analysis focused on children who were enrolled in Montessori from ages 3 through 5 ($n = 563$), or did not attend consistently across those ages and instead attended conventional schools. While ($n = 1,122$) children in the control sample never attended Montessori across ages 3 through 5, a small number ($n = 194$) attended it for 1 or 2 years during that period and were grouped in the control sample for this analysis. Scores were higher for the consistent Montessori attenders (at ages 3 through 5) across all four factors.

Figure 2 shows the factor scores for attending Montessori or not from ages 3 through 5. Using ANCOVAs to examine differences in factor scores for each 3-year grouping (3–6, 4–7, 5–8, and so on), we find the largest *F*-value for General Wellbeing is for those who consistently attended Montessori when they were 3 through 5 years old vs. did not attend during that time, $F_{(1,1,900)} = 56.34$, $p < 0.001$, $f^2 = 0.17$, shown in Table 1. For Engagement as well, a much higher *F*-statistic is obtained when comparing children in Montessori from ages 3 through 5 with those not attending Montessori across that age span, $F_{(1,1,900)} = 141.12$, $p < 0.001$, $f^2 = 0.27$, and the same is true for Social Trust, $F_{(1,1,900)} = 103.89$, $p < 0.001$, $f^2 = 0.23$. Likewise, the value is highest at this age span for Self-Confidence, although the overall difference, while still highly significant, is much smaller for this factor, $F_{(1,1,900)} = 24.34$, $p < 0.001$, Cohen's $f^2 = 0.11$.

Although, as shown in Table 2, the *F*-values are largest when comparing those who attended Montessori from ages 3 through 5, when we examine subsequent 3-year attendance spans through the age period of 11 through 13 years old, although *F*-values for the most part decline each year, they largely remain high through elementary school, with Self-Confidence being least associated with attending Montessori school. *F*-values for General Wellbeing exceed 20 though the 11–13 age span, and are significant ($p < 0.001$) through ages 12–14. This same pattern holds for Engagement and Social Trust. For Self-Confidence, significance

2 Controlling for these demographic variables resulted in higher *F*-values than were obtained when demographic factors were not controlled.

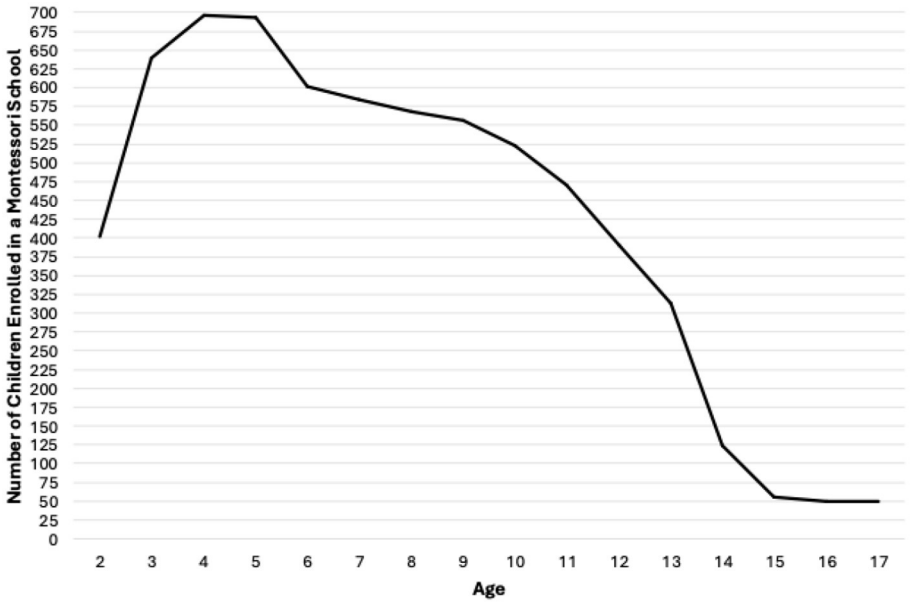


FIGURE 1
Number of sample children attending Montessori at each age.

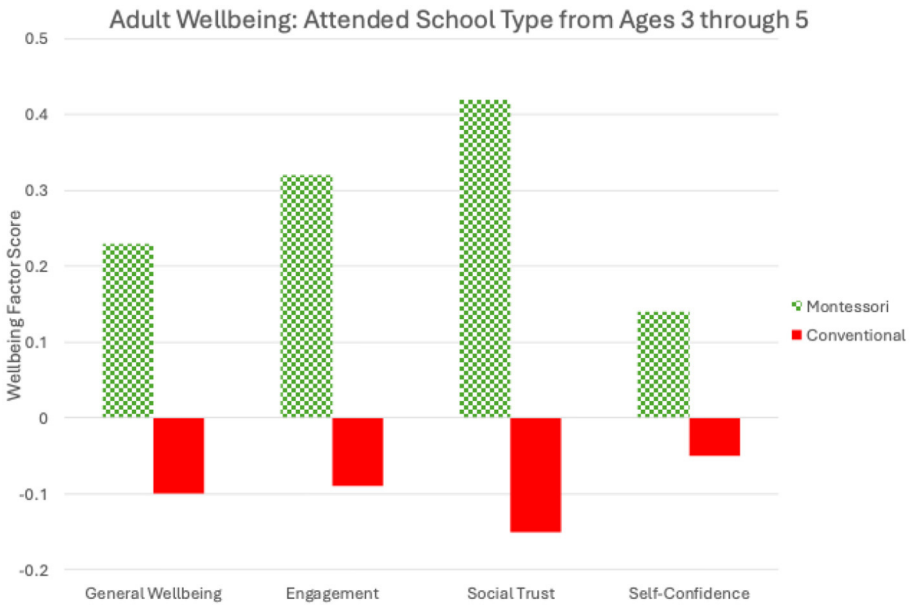


FIGURE 2
Wellbeing factor scores by childhood school from ages 3 though 5.

drops away at 11–13 yet remains high for those who attended Montessori at 10–12 years old.

In sum, earlier attendance at Montessori schools is associated with greater differences in wellbeing (as compared to attending conventional schools) than is later attendance, and attending consistently across preschool has the strongest associations to wellbeing. That said, attending Montessori through middle school (ages 12–14) is still associated with significantly higher wellbeing than was reported by those not attending Montessori across that period. While preschool appears to be a particularly sensitive period, attending Montessori during Elementary and Middle school area also strongly associated with higher adult wellbeing. At high school ages (13–15 and up), the sample size decreased markedly and thus the results may be less reliable.

A further question arose as to whether attending Montessori school for 2 vs. 3 years of preschool is associated with differences in adult wellbeing. People who had attended Montessori preschool only at ages 3 and 4, or only at ages 4 and 5, were combined into a

TABLE 2 *F*-values for differences in adult wellbeing for participants who attended Montessori vs. conventional school during different age spans.

Age span of attendance	*F*-Values			
	GWB	Engagement	Social trust	Self-confidence
2 – 4	35.15	74.15	62.89	17.06
3 – 5	56.34	141.12	103.89	24.34
4 – 6	37.27	91.01	82.54	15.98
5 – 7	35.29	79.62	77.95	13.59
6 – 8	30.28	77.08	76.60	10.78
7 – 9	32.01	85.68	80.05	12.90
8 – 10	24.03	72.11	75.58	9.94
9 – 11	27.20	71.90	75.48	9.12
10 – 12	24.52	48.05	50.55	4.26
11 – 13	22.28	36.56	47.00	3.55
12 – 14	13.47	9.05	15.85	2.52
13 – 15	0.94	0.08	1.46	0.13
14 – 16	0.28	0.04	0.90	0.13
15 – 17	0.68	0.16	1.22	0.59

GWB, General Wellbeing. *F*-Statistics for the difference in adult wellbeing factor scores for those who attended Montessori for the 3 ages shown versus those who did not attend Montessori for those three ages. ANCOVAs controlled for gender, childhood SES, and race. *p*-values are significant at the <0.001 level for all variables for attendance from 2–4 through 12–14 except Self-Confidence, which is insignificant beginning at 12–14. Because these analyses included the whole sample, including children who stayed home, degrees of freedom are 1900.

single group and their adult wellbeing factor scores were compared with those of adults who attended Montessori preschool for all three years: ages 3, 4, and 5. This analysis revealed a significant difference in Engagement, $F_{(1,629)} = 5.20$, $p = 0.02$, $f^2 = 0.14$, and trends toward differences in Social Trust, $F_{(1,629)} = 3.51$, $p = 0.06$, $f^2 = 0.08$, and General Wellbeing, $F_{(1,629)} = 2.87$, $p = 0.09$, $f^2 = 0.11$. There were no differences in adult Self-Confidence among those who attended Montessori preschool for 2 vs. 3 years. Thus, the preschool period appears to be a particularly sensitive one for adult wellbeing, and attending it for all 3 years rather than just two matters for association to adult wellbeing. This leads to the second main question, which is whether there are sensitive ages for making a transition from Montessori to a conventional school.

More favorable transition points: Montessori's 3-year cycle

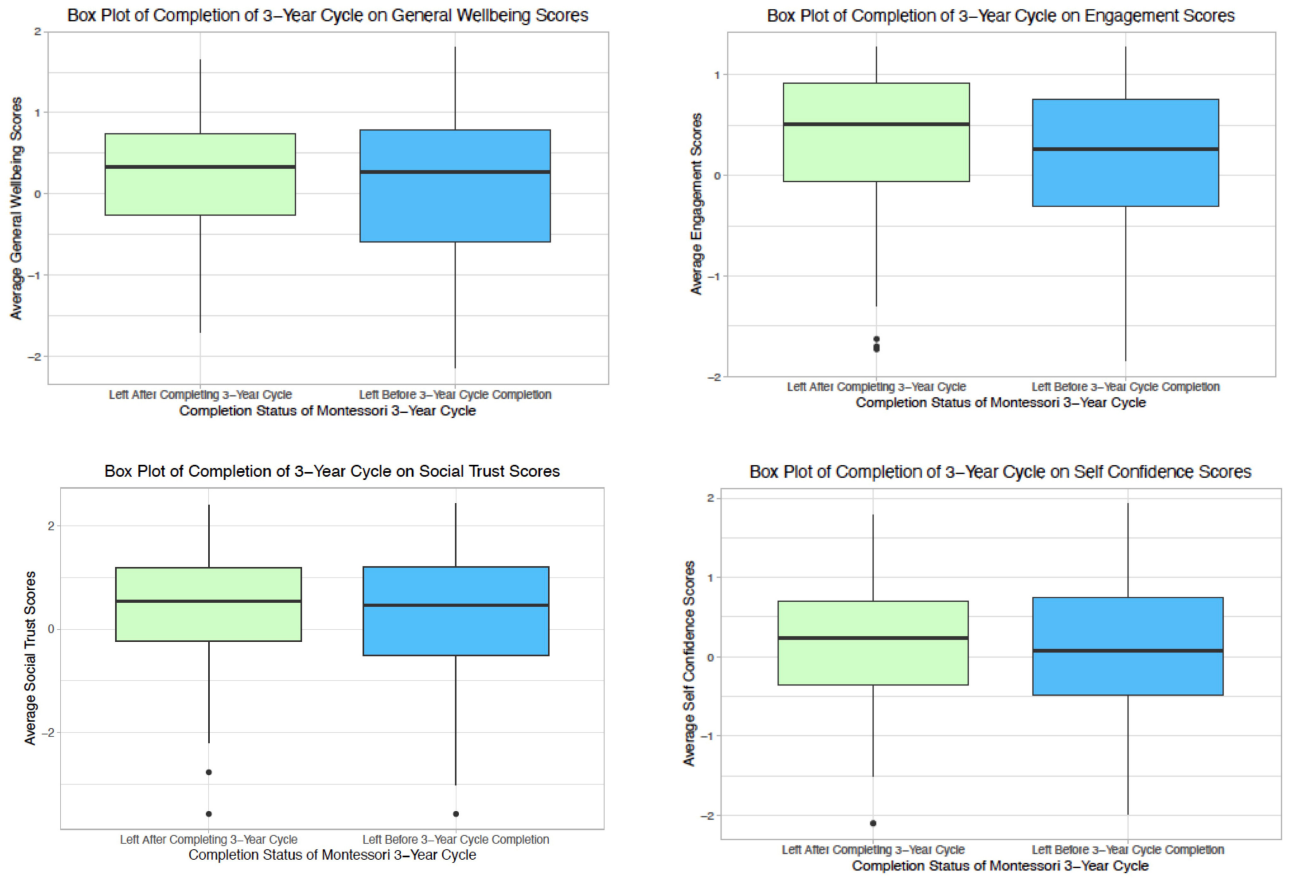
Our second question concerns whether there are more or less optimal times to transition out of Montessori education. This is particularly pertinent in the context of Montessori's 3-year cycle, which refers to the 3-year period during which a child is in a particular classroom. Recall that each classroom is designed for children as they grow through particular 3-year age spans.

To examine this, data were first pared down to those of participants who started in Montessori school and transitioned once to conventional school ($N = 617$). Within this group, we compared adult wellbeing factor scores of those who left Montessori at ages 6, 9, or 12 ($n = 161$) with those who left at any other age ($n = 207$); these numbers sum to <617 because they do not include those who left Montessori after age 12. The reason for excluding the older departers' data is because many Montessori middle schools only have 2 grades (7th and 8th), so the data are not well aligned with 3-year-cycles.

We again controlled in these analyses for childhood SES, race, and gender. Leaving Montessori for conventional school at the end of, rather than during, a 3-year cycle significantly and positively contributed to one's adult level of Engagement, $F_{(1,363)} = 5.49$, $p = 0.02$, $f^2 = 0.02$, and it showed a trend toward association with General Wellbeing, $F_{(1,363)} = 2.81$, $p = 0.09$, $f^2 = 0.01$. Although not significant, wellbeing of those who completed a cycle was still higher than it was for those who did not, with *F*-values of 2.21 and 0.35 for Social Trust and Self-Confidence, respectively. Cohen's (1988) benchmarks for the f^2 statistic classify the effect as small, but completing a Montessori 3-year-cycle is associated with higher adult Engagement. These results are shown in Figure 3.

It is possible that these results are influenced by years in Montessori school; Lillard et al. (2021) showed a positive correlation between years in Montessori school and adult wellbeing. On average, those who left Montessori school after ages 5, 8, and 11 inherently attended longer on average than those who left after the 2 years prior to each of these points. These cumulative additional years might fully account for the differences observed in the sensitive endpoint analyses. An additional analysis was therefore conducted controlling for total years in Montessori as well as the demographic covariates already controlled for. In this analysis, Engagement remained significant ($p = 0.04$), and the General Wellbeing trend went away (*p*-value of 0.14).

In sum, we see some evidence that leaving Montessori at ages 6, 9, and 12—the end of the 3-year cycles in a classroom, is associated with higher wellbeing than leaving Montessori within cycles—at ages 4 or 5, 6 or 7, and 10 or 11. The particular category of adult wellbeing that is associated with completing 3-year cycles is Engagement, characterized by sense of purpose and social closeness.



Note: Green/left hand boxes are Montessori, Blue/right hand boxes are controls.

FIGURE 3
Adult wellbeing as a function of whether one switched from Montessori to conventional schooling following or during a 3-year cycle.

Discussion

A prior survey study had indicated higher adult wellbeing among people who attended Montessori for at least 2 years at some point in their youth, controlling for gender, race, childhood SES, and years in private school (Lillard et al., 2021). Furthermore, in that study the longer one attended Montessori, the higher was one's adult wellbeing, and the effect held even among the subsample that only attended private schools their entire lives.

The present report addressed two questions: Is there a sensitive period during which attending Montessori school is particularly associated with higher adult wellbeing? And, in terms of adult wellbeing, are there more and less optimal times to transition to conventional schools, particularly with reference to Montessori's 3-year cycles?

For the first question, it appears that Montessori schooling is most strongly associated with higher wellbeing during the preschool years. The largest *F*-values and effect sizes were obtained at age 5, and for Engagement. Looking at 3-year-age spans, the period from age 3 through 5, or Montessori Primary, had the highest F-values for all four factors. This makes sense from an adaptation framework. All organisms adapt to their environments, and young mammals are particularly plastic, such that their brain structures and functions adapt to their environments and then retain those structures to a large degree throughout life (Knudsen, 2004; Lillard and Erisir, 2011; Lorenz, 1965; Van IJzendoorn, 1995; Wiesel and Hubel, 1963). Montessori education environments include features that are associated with concurrent wellbeing, like low test anxiety and a good deal of self-determination (Baker, 2004; Cohen, 2006; Deci and Ryan, 2012; Felner et al., 2007; Seligman et al., 2009; Steinmayr et al., 2016, 2018). This could lead to neural structures and patterns that create a stronger sense of wellbeing throughout life (Atzil et al., 2011; Denervaud et al., 2020; Dettmer and Lillard, 2023; Di Domenico and Ryan, 2017; Duval et al., 2023; Horn, 2004; Ntoumanis et al., 2021; Schwery et al., 2023; Zanchi et al., 2023).

Although it was strongest for those who attended Montessori at ages 3 though 5, significantly higher adult wellbeing was observed throughout childhood for all four factors. Specifically, it was observed through ages 11–13 for Self-Confidence, and 12–14 for General Wellbeing, Engagement, and Social Trust. This makes sense, because even though plasticity is highest in early childhood, brains are malleable throughout childhood (and beyond, see Lillard and Erisir, 2011). In addition, many of the participants who were in Montessori programs at older ages were also there at younger

ages; the sample size changes shown in Figure 1 reflect mainly loss at each age, and little gain (indicated new attenders) after age 5.

We do not know why the differences in wellbeing are much smaller after age 13. It might be that attending Montessori school vs. conventional school at younger ages truly is associated with greater differences in adult wellbeing, compared to attending Montessori at older ages. This could be because conformity to the peer group is particularly important at older ages, and most teenagers attend conventional schools. However, the association to wellbeing is still positive at older ages. Corroborating this, one focused study using experience sampling methods found that Montessori middle school attenders were clearly higher in moment-to-moment wellbeing while in the classroom than were matched conventional middle school attenders (Rathunde and Csikszentmihalyi, 2005a). Another possibility is that the 50 or so people in the sample in these older ages were slightly less happy as adults than were those who attended Montessori at earlier ages only, by chance. Further research on long-term wellbeing of people who attended Montessori middle and high schools is needed to shed light on these findings. We note however that although the wellbeing differences are smaller than those observed in the larger samples attending Montessori at earlier ages, adult wellbeing is still higher for Montessori high school alumni than for people who attended conventional high schools.

Finally, the last analysis examining sensitive periods checked whether remaining in Montessori for all 3 preschool years, rather than attending for just 2 years, was associated with higher adult wellbeing. We found that it was. This was particularly the case for Engagement as an adult, with trends for General Wellbeing and Social Trust. Self-Confidence was not significantly associated with spending 3 rather than 2 years in Montessori preschool. One potential explanation for this is the 3-year-cycle, discussed next.

After controlling for other associates like social class, leaving Montessori at the end of a cycle is associated with higher levels of Engagement than leaving Montessori in the middle of a cycle. Across all these findings—sensitive periods and sensitive points for transition—Engagement as an adult is most strongly associated with attending Montessori. Engagement tapped into one's sense that one has something to give the world, positive relations or believing others see one as a giving person, and social integration or feeling close to others, as well as one's sense of purpose and sense that life is a process of continual growth. Attending Montessori rather than conventional schools early in life was particularly strongly related to Engagement, perhaps because of the community bonds forged by the 3-year cycle, where children have the opportunity to experience being led and then growing into being a leader. Having these experiences when the brain is especially malleable might be particularly impactful. Yet this finding is also very interesting, given that children in Montessori 3 to 6 programs are often seen working alone (Baines and Snortum, 1973; Hojnoski et al., 2008; Lillard et al., 2025), and anecdotally some express concern about this; people expect preschool-aged children to be interacting in groups. The fact that adult Engagement is particularly strongly associated with Montessori attendance demands further inquiry.

Social Trust was also strongly associated with Montessori attendance, through age 14. This factor derived from just two variables: Social Acceptance and Social Actualization on the Social Wellbeing Scales. These items referred to a sense that one can trust people and society, a sense that people are kind and that the world is becoming a better place. Here, it seems the close community children experience in Montessori, remaining with the same peers and teachers for several years, without grades or marking, might be pertinent. Again, ages 3 to 5 seem particularly relevant; Figure 2 shows that the differences in Social Trust for Montessori and conventional school alumni are more marked for alumni who attended at those ages. And yet, as with Engagement, the differences remained strong through ages 12 to 14. The same is true of General Wellbeing, although its associations to Montessori schooling are weaker than for Engagement and Social Trust. This may be because its sub-constructs, like self-acceptance and subjective vitality, can also be well-nurtured in home environments or other later self-selected environments.

Although still positively (but not always significantly) associated with Montessori schooling at all ages, the factor we named Self-Confidence showed the least strong adulthood associations with childhood Montessori schooling. This variable referred to enjoying taking on hard problems (the Short Need for Cognition scale), confidence that one can making sense of the world, and judging oneself by one's own standards. One might expect that more time in Montessori environments in childhood would be more strongly associated with this factor in adulthood, and it was significantly associated through ages 10–12, but with smaller *F*-values and effect sizes than were observed for the other three factors, suggesting its association is mitigated. This seems puzzling, in that many aspects of Montessori education would seem to be associated with liking to take on challenging cognitive problems; conversely, this tendency should be low in "individuals who are subjected to high levels of what they perceive to be continuing and controlling surveillance, time pressure, and external reward" (Cacioppo et al., 1996, p. 246)—statements that describe conventional and *not* Montessori school. Perhaps, as Cacioppo et al. (1996) speculated, the tendency to take on cognitive problems stems somewhat more from an internal need to control one's world than from early school conditions, thus a personality factor that school is less likely to influence. It is well-known in Psychology that personality tends to become stronger with age, and the environment's influence weakens (Bouchard and McGue, 1990; Haworth et al., 2010). Perhaps relative to the other latent constructs explored here, the one we named Self-Confidence is more attributable to biology and less to environment. But this still does not explain why its association is weaker among students who attended Montessori during later rather than earlier years. The older sample was much smaller, and thus less reliable, and in additional Montessori adolescent programs are less established. Further research is needed to explore this variable further.

Finally, it is interesting to consider whether other alternative educational approaches, like Reggio and Steiner/Waldorf might influence long term wellbeing outcomes similarly. Some research does suggest that people who attended alternative schools (including Waldorf, Montessori, and New School all together) as children adjust better to and do better in university (Shankland et al., 2010). Further, adolescents currently attending Waldorf schools have higher current student life, but not general life, satisfaction (Besançon et al., 2015). Regarding Reggio, one study examined long term adult wellbeing correlates like employment

and social-emotional skills, and found no difference between those who had attended Reggio as young children and those attending other preschools (Biroli et al., 2018). It would be interesting to apply the methods used in the current study to these alternative programs, which have some similarities to Montessori (student-led learning with teachers being guides in Reggio and Montessori; looping with the same teacher for up to six Elementary school years for Waldorf and Montessori; hands-on learning and an emphasis on stories in all three alternatives) that could be associated with higher adult wellbeing. However, the Reggio approach (as developed in Reggio Emilia, Italy) does not extend beyond age 6, nor does it have the full set of hands-on and interconnected materials that Montessori has; and Waldorf employs whole-class teaching in single-age classrooms, with tests and evaluative grading commonly employed by third or fourth grade. Neither pedagogy explicitly discusses important cycles, like Montessori's 3-year cycles.

Limitations

One clear limitation of this study is that we cannot know if Montessori attendance is causally related to adult wellbeing. It may be that a third variable that is associated with attending Montessori rather than a conventional preschool, or attending Montessori for three preschool years rather than two, drives adult wellbeing. An obvious possible third variable would be childhood SES—children who grow up in wealthier families might well have higher adult wellbeing. However, these analyses controlled for childhood SES—and in fact the group differences were larger in the analyses that controlled for it and other demographic variables than they were in analyses that did not control for such variables. Some other factor, like parental involvement, extracurricular activities, or early life health indicators might be driving the results. An experimental study in which people were randomly assigned to Montessori or conventional school, and were randomly assigned to leave Montessori at particular ages, would allow causal inference, but is not practical. However, one could do a natural experiment, following people admitted by lottery to Montessori schools at early ages through to adulthood, and examine their wellbeing. This would provide some basis for causal inference, particularly if one could determine whether reasons for leaving Montessori at different ages were random (like a parent's job forcing them to move) or endemic (like being unhappy at the school). Further research should examine possible associates and attempt to systematically investigate their potential role in this study and adult wellbeing generally.

A second limitation is that the adjusted R-squared values in all the linear models here are low, which is likely because our models are trying to predict variables related to human behaviors and affect. Subjective variables such as these are inherently less predictable than objective variables (Achen, 1982). Low R-squared values are not inherently bad; they may simply reflect random variation in the world that is also being reflected in the model.

A third limitation concerns the age ranges that were used, which may not exactly correspond to particular levels of Montessori schooling for any given person. Someone with a May birthday might attend Montessori preschool for ages 3 to 5, whereas one with a November birthday might attend Montessori preschool for ages 4 to 6. Ideally we would have captured these children as belonging to the same group. This introduces noise into our data, making the results we did obtain more impressive. In other words, if several of the children who were included in the group that was not considered to have completed a 3-year-cycle because they transitioned at 7 in fact did complete the cycle but were simply old for their class (hence were 4, 5, and 6 years old in Montessori Primary), their higher wellbeing scores (which the study data suggest accompany completing the cycles) would be represented in the wrong group. One might also be concerned that our operationalization of sensitive periods is biologically inaccurate, given that it was determined by parallel with Montessori classroom structures. There might be more subtle associations with Montessori in slightly different sensitive periods that are not picked up by our method of stratification; with a theoretical basis to demarcate different periods, one might examine this possibility.

A fourth limitation derives from the fact that people self-selected to take the survey. Perhaps people who felt more positively about their Montessori school experience, and are more positive as adults, were more likely to respond to the invitation. However, if that is the case, one would assume similar bias in all survey-takers, including those who attended conventional schools. It is also possible that people who felt more negatively about their school experience were more inclined to take the survey. In either case, adding a question about general feeling about their school experiences and, were the outcomes not normally distributed, weighting the responses, could be used to assess this self-selection concern.

Another issue related to self-selection is that most survey respondents were white and female. Unfortunately, this is a byproduct of who fills out online surveys (Boulianne, 2013; Peytchev, 2011; Smith, 2008). Although race and gender were controlled in the analyses, and this correction actually increased group differences, the concern that the results may not apply to all demographic groups is valid. Although studies of Montessori education have shown no gender or race difference in its concurrent relation to wellbeing and related factors, ideally future research would recruit more representative samples, weight responses, or stratify recruitment in order to balance participant characteristics. As is, the generalizability of the findings beyond this population is at issue is not certain.

A fifth limitation concerns the operationalization of Montessori. At the beginning of the article we noted that Montessori is not a trademarked term, and its implementation can vary drastically from the original model (Lillard and McHugh, 2019a,b). When participants noted they attended a Montessori school, we have no idea whether it was true Montessori or some variation on the pedagogy. If the pedagogy truly enhances long-term wellbeing, low fidelity of implementation would be expected to weaken results. If one could limit analyses to the wellbeing of people who attended authentic Montessori programs as children, results might be strengthened. Further research might address this by getting the names of the Montessori schools attended and years, and attempting to research and score the fidelity of implementation at the time participants attended those schools.

Related to this, if Montessori is causing wellbeing, we do not know what aspects of Montessori do so. Further research might

explore what aspects of Montessori education are most strongly associated with longterm wellbeing, and whether those aspects, once discovered, could be inserted into the Prussian-derived system we conventionally use (Paglayan, 2024). Montessori is a full system (Lillard, 2019) and its benefits might be strongest when retained as such, but several of its aspects (free choice, peer learning, intrinsic rewards, and so on) have been associated with higher concurrent wellbeing even in conventional school settings (Lillard, 2017).

Conclusion

This study set out to examine whether there are sensitive periods and sensitive points of transition for an association between Montessori education and adult wellbeing. This represents is an important and novel question in education research. While most people attend conventional schools for most of their childhood years, a meaningful number attend alternative schools like Montessori for at least some years. Furthermore, alternative school models are growing in popularity; enrollments at conventional schools are down markedly since the pandemic (Dee, 2023; Scafidi et al., 2023). Better understanding the impact of alternative school attendance, as some studies have done (Demangeon et al., 2023; Denervaud et al., 2019; Dhiksha and Suresh, 2016; Lillard and Else-Quest, 2006; Lillard et al., 2017, 2021; Randolph et al., 2023; Rathunde and Csikszentmihalyi, 2005a,b; see also Shankland et al., 2010), and the association of an impact with timing of attendance and departure, is crucially important. Indeed, studying the concept of sensitive periods and points in relation to the prevailing environment of a child's school is an exciting new frontier in the study of child development.

These findings also have important practical implications. One is for education policy. Publicly-funded Montessori schools are increasingly common, numbering around 600 in the United States today (National Center for Montessori in the Public Sector, n.d.). Yet some of these schools do not respect the 3-year-cyle—the school might begin at age 4, or end at fifth grade (typically ages 11–12). Others begin at age 6, missing the first cycle altogether. Likewise, parents must decide when to begin enrollment and if and when to move their child to conventional school. These results suggest that beginning Montessori by age 3, and completing the 3-year-cycle to age 6, is most impactful for long term wellbeing. If a school or child continues Montessori past age 6 or the kindergarten year, the results indicate it is best to do this in 3-year increments, through age 9 (third grade) or age 12 (sixth grade). The results also suggest that the benefits, while still there in middle school, diminish. This might be because our sample was smaller (because fewer people attend Montessori school at those ages), or it might be because Montessori education is itself less developed at those ages, or it might be because Montessori is less impactful at those ages. Further research is needed to disentangle those possibilities.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: it can be shared on request. Requests to access these datasets should be directed to asl2h@virginia.edu.

Ethics statement

The studies involving humans were approved by the Institutional Review Board, Social and Behavioral Sciences, University of Virginia. The studies were conducted in accordance with the local legislation and institutional requirements. The participants provided their written informed consent to participate in this study.

Author contributions

AL: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Visualization, Writing – original draft, Writing – review & editing. RJ: Data curation, Formal analysis, Conceptualization, Methodology, Software, Visualization, Writing – review & editing. XT: Conceptualization, Data curation, Formal analysis, Methodology, Software, Supervision, Visualization, Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The author(s) declare that no Gen AI was used in the creation of this manuscript.

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