Physical activity and depressive symptoms

Stavrakakis, Nikolaos

CHAPTER VI

Relative-Age Effects in Adolescents: The TRAILS Study

"I can honestly say that insecurity was something formerly unknown to me. I was always the best of my grade. The tallest, the fastest – I thought I was Superman. It turned out this was mainly because I was born in January, thus older than my peers".

Gert Verhulst, in *De Volkskrant* interview, 2013

Jeronimus BF, Stavrakakis N, Veenstra R & Oldehinkel AJ

Submitted

ABSTRACT

Purpose: This study examined intra-classroom age position (or relative-age) effects on adolescents' school progress and performance (as rated by teachers), physical development, temperament, and depressive symptoms, all adjusted for age at the time of measurement.

Methods: Data were derived from three waves of Tracking Adolescents' Individuals Lives Survey (TRAILS) of 2230 Dutch adolescents (51% girls, baseline mean age = 11.1, SD = 0.6).

Results: Relative-age predicted school progress (grade retention ORs = 0.83, skipped grade OR = 1.47, both $p<0.001$), but substantial effects in adolescents with a normative school trajectory were absent, in contrast to most literature.

Conclusion: Adolescents who had repeated a grade showed inverse relative-age effects on physical development and school performance, as well as on depressive symptoms, favoring the relative young.

INTRODUCTION

Relative-Age

In most countries, children at school are assorted in same-age groups based on the month and year of birth (Gledhill, Ford, & Goodman, 2002; Verachtert, De Fraine, Onghena, & Ghesquiere, 2010). Consequently, within a single classroom children may differ in age by up to 11 months. Relatively older children have a slightly more developed physique and mind than their younger classmates (Martin, Foels, Clanton, & Moon, 2004; Verachtert et al., 2010). These physical and psychological advantages may become catalyzed into different developmental trajectories through favorable peer-contrast effects (Bedard & Dhuey, 2006; Gladwell, 2008). We define developmental differences due to the age position driven peer contrast effects as relative-age effects.

Taller and more mature children tend to have more prestige (Harris, 2009; Henrich & Gil-White, 2001), which in turn affects friendship formation (Dijkstra, Cillessen, & Borch, 2013; Newcomb, Bukowski, & Pattee, 1993), and enhances learning opportunities (Carruthers, Laurence, & Stich, 2006). Relative-age has been associated with higher intelligence (Lawlor, Clark, Ronalds, & Leon, 2006), school success (Cobley, McKenna, Baker, & Wattie, 2009), identity formation (Allen, 2008), peer-perceived competence and leadership (Dhuey & Lipscomb, 2008), success in sports (Musch & Grondin, 2001), and positive self-perception and self-esteem (Fenzel, 1992; Thompson, Barnsley, & Battle, 2004). Children's internal working models are based on self- and other representations ("looking glass self"), which emerge and crystallize relatively early in development (Fraley, 2002; Harris, 1995): five-year olds have already stable and clearly established classroom hierarchies (Boyce et al., 2012).

Self-Fulfilling Prophecy

Children's relative-age position can become a self-fulfilling prophecy ("learning by being"), catalyzed by reciprocal feedback loops between the developing phenotypes and their environments (Allen, 2008; Pierson, Addona, & Yates, 2014), analogous to the corresponsive principle (Caspi & Shiner, 2006) and Dick-Flynn model (Beam & Turkheimer, 2013; Flynn, 2009). Part of this effect may be driven by external adult evaluations, based on unfavorable intra-cohort contrast effects (Verachtert et al., 2010). Relatively old children are granted special opportunities for success, such as extra coaching in sports (Gladwell, 2008; Musch & Grondin, 2001; Persico, Postlewaite, & Silverman, 2004), whereas relatively young children meet lower expectations and have an increased risk to repeat a grade (Cobley et al., 2009; Doornbos, 1971; Martin et al., 2004).

Though classroom hierarchies are established in childhood, their consequences may be particularly salient in adolescence. Adolescents become increasingly able to influence their environment (while parental socialization wanes), and select a rapidly expanding peer network and a first romantic partner (Collins, Welsh, & Furman, 2009; Cyranowski, Frank, Young, & Shear, 2000). Furthermore, earlier work associated being relatively young with victimization (Muhlenweg, 2010), psychiatric problems (Goodman, Gledhill, & Ford, 2003; Morrow et al., 2012), and suicide before age 20 (Thompson, Barnsley, & Dyck, 1999). Because unfavorable relative-age contrast effects modulate children's self-perception and self-esteem (Thompson et al., 2004), which are known risk factors for affective disorders (Abela, Fishman, Cohen, & Young, 2012), being relatively young may increase risk of depression, which has a high incidence in adolescence (Hankin et al., 1998; Oldehinkel, Wittchen, & Schuster, 1999). Because low self-perception and self-esteem can have a persistent impact on affect, the effect of relative-age might also be discernible in temperamental negative affect.

Finally, relatively older children tend to play more sports – partly driven by selection effects (Gladwell, 2008; Pierson et al., 2014), which may explain observed relative-age effects on multiple indices of physical growth in adolescence (Sandercock et al., 2013). Timing of puberty onset seems also influenced by environmental factors (up to 12% variance), including experiences unshared by twins (Eaves et al., 2004) and neighborhood characteristics (Deardorff et al., 2012). Hence, small relative-age effects on body mass and rate of maturation seem speculative, but not impossible.

Ability Streaming

Though relative-age effects have been observed in multiple countries (Bedard & Dhuey, 2006), most literature is based on samples from the United States of America (USA) or United Kingdom (UK) (Musch & Grondin, 2001; Verachtert et al., 2010). One of the challenges in isolating relative-age effects is that their manifestation is contingent on mechanisms to group children in classes, which differ over time and place (Dalton, 2012; Cascio and Schanzenbach, 2007). For example, the Dutch cohort under study was allocated over classes based upon an annual birthdate cutoff (pre/post October), and all children in each grade attended all courses together. In other systems children attend courses (e.g., language, math, or sports) subdivided on base of ability, called 'setting' or 'banding', which may alleviate relative-age effects (Pierson et al., 2014).

The influence of apparently innocuous institutional differences becomes manifest in international comparisons, e.g., in the 2006 Program for International Student Assessment (PISA) up to half of the Dutch (or Belgian, Austrian, or Czech) 15-year olds were in a different grade than expected in a normative trajectory, compared to 12% in the USA, 1% in the UK, and none in Japan or Finland (Dalton, 2012). Relative-age effects may thus manifest themselves via grade progression, that is, the possibility to allocate children to a higher or lower grade than the normative one, based on their abilities (Doornbos, 1971; Dalton, 2012). We expect that especially the (less qualified) relative young are retained, whereas the (highly qualified) relative old are accelerated, which we call ability streaming.

The Present Study

A demonstration of persistent relative-age effects in adolescence, bestowed upon children by an adult-imposed structuring of their worlds, could lead to renewed awareness and prevention strategies of teachers, parents, and psychiatrists. We therefore aimed to quantify associations between relative-age position and multiple outcome domains in early and middle adolescence. Relative-age effects were defined as the effects of intra-cohort age position adjusted for the actual age at the time of measurement. Only after adjustment for the additional developmental time granted to the relatively old (a methodological artifact) the alleged accumulating benefits and disadvantages driven by adolescents' relative-age position can be observed.

We hypothesized unfavorable outcomes, in multiple domains, for the relatively young compared to the relatively old adolescents. More specifically, we expected to replicate relative-age effects on school progress (H1), and tested whether relative-age predicted whether adolescents had repeated or skipped a grade. For both the adolescents with a normative progress and the group who repeated a grade we tested whether relative-age predicted weight (H2a), pubertal status (H2b), school performance (H3), sport competence (H4), and peer status in terms of peer rejection (H5a) and popularity (H5b). Innovatively, we tested whether relative-age effects predicted depressive symptoms (H6a) and temperamental fear and frustration (negative affect, H7a); as well as change in depressive symptoms (H6b) and fear and frustration (H7b) between age 11 and 16. Because earlier work suggested associations between maternal socioeconomic status (SES) and month of birth (Bobak & Gjonca, 2001; Buckles & Hungerman, 2013; Martin, 2013), we ran all analyses without and with adjustment for family SES.

METHODS

Design and Participants

Data were collected as part of the TRacking Adolescents' Individual Lives Survey (TRAILS), a large ongoing prospective cohort of Dutch adolescents followed to study the psychological, social and physical development of children towards adulthood (Ormel et al., 2012). The core aim was to unravel developmental pathways to psychological (ill) health. The study was approved by the Dutch Central Committee on Research Involving Human Subjects. The first measurement wave (T1) started in 2001, whereas data collection for the remaining waves (T2 to T3) took place at intervals of approximately 2.5 years. Informed consent was collected from the parents at T1, whereas for T2 and T3 informed consent was obtained from both parents and adolescents. The TRAILS design, sample selection, and data collection are described extensively elsewhere (de Winter et al., 2005; Huisman et al., 2008; Ormel et al., 2012). Briefly, participants were selected from five municipalities in the North of the Netherlands. From a total of 2935 children, 2230 agreed to take part at T1 (response rate 76%; 51% girls, mean age 11.1, SD = 0.6). The response rates were 96% at T2 (N = 2149; 51% girls, mean age 13.7, SD = 0.5) and 81% at T3 (N = 1816; 52% girls, mean age 16.3, SD = 0.7). Non-response associated slightly with low socioeconomic background, male gender, low IQ and school performance, non-western ethnicity, and externalizing problems, but not with other emotional and behavioral problems (de Winter et al., 2005). At T1, the parents or guardians were interviewed at their homes, and handed in a previously sent questionnaire at that occasion. At T2 and T3, the questionnaire was sent to the parents or guardians by mail. At all three waves, the adolescents and their teachers completed the questionnaires at school.

Measures

Relative-Age

As outlined, when the TRAILS children entered school, children born between the first of October and the 30th of September of the next year were allocated in the same age group in the Netherlands. Consequently, in a normative situation, children born in September were the youngest in a given grade (month 1), while children born in October were the oldest (month 12). This relative-age measure (1-12) was used as a continuous measure in our analysis.

School Progress

Information on school progress was collected from the schools before sample selection. Four categories were distinguished: (1) normal progression, (2) children who repeated a grade, (3) children who skipped a grade, and (4) children in special education. The groups of adolescents who had repeated one or two grades were merged because only nine adolescents had repeated a grade twice.

Physical Development

At T2, the length in centimeters (cm) and the weight in kilograms (kg, without shoes and heavy clothing) were measured. Body Mass Index (BMI) was calculated by dividing the weight (kg) by the square of the height (m^2).

Pubertal Status

At T2, pubertal status was measured with the Pubertal Development Scale (PDS), previously shown to be reliable, with a Chronbach's alpha of 0.77 for boys and 0.81 for girls (Shirtcliff, Dahl, & Pollak, 2009). The PDS assesses development on five (Tanner) characteristics, including growth spurt in height, skin changes, body hair in both boys and girls, breast development and menarche in girls, and voice change and facial hair growth in boys (Janssens et al., 2011). Each item was rated on a four-point scale (0 = not yet started, 1 = just started, 2 = going on for a while, 3 = passed that). In our analyses we used the mean of the four item scores.

School Performance

At T2, teachers provided school ratings on history, geography, math, and natural sciences. Adolescent's school performance was operationalized as the composite of these marks rated on a five point scale, ranging from 1 = inadequate to 5 = outstanding. Cronbach's alpha was 0.86.

Sport Competence

At T2, teachers were asked to rate the sport competence of each adolescent on a five-point scale (1 = inadequate, 2 = hardly adequate, 3 = adequate, 4 = good, and 5 = outstanding).

Peer Status (being popular or rejected)

At T2, social status was assessed using a sociometric nomination procedure in classrooms with at least three TRAILS respondents (Oldehinkel, Rosmalen, Veenstra, Dijkstra, & Ormel, 2007). Adolescents could nominate an unlimited number of classmates on a total of 18 questions, covering a wide range of issues and behaviors. For the purpose of this study, we used the proportions of the peer nominations for rejection ("being disliked") and popularity ("being someone others want to be associated with"), and contrasted these nominations against the adolescents without this specific peer nomination (i.e., rejected/popular status adolescents *vs.* all adolescents without this peer nomination).

Depressive Symptoms

Depressive symptoms were assessed at T1 and T3 with the Affective Problem scales of the Youth Self Report (YSR; Achenbach, 1991b) and parent-reported Child Behavior Checklist (CBCL; Achenbach, 1991a), which cover depressive symptoms according to DSM-IV criteria with 13 items, including information on sadness, loss of pleasure, crying, self-harm, suicidal ideation, feelings of worthlessness, guilt, loss of energy, overtiredness, eating problems and sleeping problems (Achenbach, Dumenci, & Rescorla, 2003; Ferdinand, 2008). Both scales are rated on a three-point scale ranging from 0 = never or not at all true to 2 = very often or very true. Cronbach's alpha for the YSR was 0.72 at T1 and 0.78 at T3 and for the CBCL 0.68 at T1 and 0.76 at T3. In the analyses we used the combined mean scores of the CBCL and YSR scales.

Temperamental Fear and Frustration

Temperamental negative affectivity was assessed at T1 and T3 with the Dutch parent version (Hartman, 2000) of the revised Early Adolescent Temperament Questionnaire (EATQ-R; Putnam, Ellis, & Rothbart, 2001), which is based on the temperamental model by Rothbart et al. (2011; 2000). Earlier work in TRAILS showed the EATQ factor structure of the parent version to be superior to the child version (Oldehinkel, Hartman, de Winter, Veenstra, & Ormel, 2004). Fear and frustration were measured with five questions rated on a five-point scale (ranging from 1 = almost never to 5 = almost always true). Cronbach's alpha was 0.63 (T1) and 0.66 (T3) for Fear and 0.74 (T1) and 0.75 (T3) for Frustration.

Socioeconomic Status

SES of the family of origin was the composite of five standardized variables measured at T1, i.e., professional occupation and educational attainment of both parents/guardians, and household income.

Plan of Analyses

Data cleaning, calculation of descriptives, and all analyses were performed in SPSS (version 20, SPSS Inc., Chicago, Illinois). To test whether relatively young or relatively old adolescents were more likely to repeat or skip a grade (H1), we performed bootstrapped multinomial regressions with school progress as outcome (1 = normal progression, 2 = repeated grade, 3 = skipped grade, and 4 = special education). Normal school progress was used as reference category, and relative-age effects on school progress were expressed in odds ratios (ORs).

Hypotheses H2 to H7 were tested with partial Pearson's correlations (r_p) adjusted for age at testing. In addition, we performed a series of linear regression analyses in which relative-age predicted, respectively, length and weight (H2a), pubertal status (H2b), school performance (H3), sport competence (H4), depressive symptoms (H6a), fear and frustration (H7a), and change in depressive symptoms (H6b) or temperament (H7b), adjusted for age at testing. To obtain change scores for depressive symptoms and temperamental fear and frustration we subtracted T1 from T3 scores. To test relative-age effects on being rejected (H5a) and popular (H5b), we applied binary logistic regression analyses adjusted for age at testing.

All hypotheses were tested in adolescents with a normal school progress and in those who had repeated a grade (with the exception of H5 because of insufficient peer nomination data). We lacked power to test effects in the group that skipped a grade (see appendix for calculations). To ensure the robustness of our results, and because height, weight and BMI were non-normally distributed, we bootstrapped all regression analyses (k = 10000 with bias corrected confidence intervals), see (Li, Wong, Lamoureux, & Wong, 2012). We calculated the power for our regression analyses, and to enable comparison with other literature, we converted some results to Cohen's d (standardized effect sizes), based on formulas derived from Borenstein et al. (2009), and Peterson and Brown (2005). To reduce family-wise alpha inflation, we only interpreted correlations that were significant at p<0.01.

Finally, we performed two robustness checks. First, we repeated all analyses adjusted for family SES. Second, to circumvent the strong positive association between relative-age and biological age, we applied an alternative approach to adjust for relative-age, and combined the relative old children from grade 7 (month 7-12) and relative young from grade 8 (month 1-6). In this control sample of 794 children with a normative school progress relative-age showed an inverse association with biological age, and was used to repeat our analyses (H2-7).

RESULTS

Descriptive Statistics

Descriptive statistics of all variables used in this study are reported in table 1. The correlations shown in table 2 indicate that relative old adolescents were still somewhat larger, heavier, and in a more advanced pubertal development stage than the relative young adolescents.

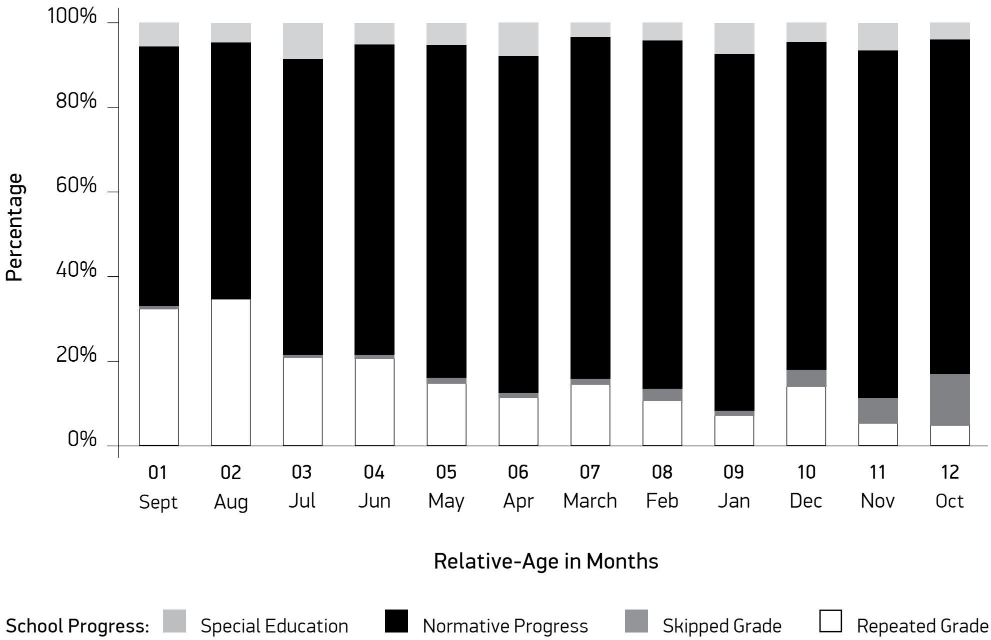
School Progress

Relative-age effects on school progress are reported in table 3. For each additional month, relative-age was associated with 17% lower odds of grade repetition and a 47% increased odds of skipping a grade, see also figure 1. The relatively young quartile (July to Sept) was almost four times more likely to repeat a grade (29.6% *vs.* 8.2%) and over twenty times less likely to skip a grade (0.3% *vs.* 7%) than the relatively old quartile (Oct to Dec); all details can be found in the appendix (table A1). Compared to adolescents with a normative school progress adolescents who repeated a grade were on average 8 weeks younger and those who skipped a grade were on average 14 weeks older (75% of the latter were relatively old). As shown in table 3, no association was found for special education (d≈0.03; 95% CI = -0.06 to 0.01). Notably, after adjustment for SES, the effects became slightly stronger, and the effect on special education significant (see appendix, table A3).

Adolescents with a Normative School Progress (75.4%, n = 1681)

Recall that all results in the following section were adjusted for age at testing. Partial correlations and linear regression models (table 4) showed that relative-age effects predicted

Figure 1. School Progress stratified over Relative-Age Positioning.



temperamental frustration (d≈0.22); but this effect disappeared after adjustment for SES (see appendix, table A2). We further observed that relative-age predicted social rejection (OR = 1.12, p<0.001), but was unrelated to popularity (OR = 0.99, see appendix, table A4). This rather small relative-age effect on rejection followed a u-shape, favoring the middle quartiles (9.3%, 6.1%, 6.5%, 9.8%, respectively; all details are given in the appendix, table A5). All other associations were absent. Because relative-age correlated (r = 0.53) with biological age (see table 2), we calculated a control relative-age sample (see method section), which correlated (r = -0.28) with biological age (see table 2), but led to similar results (see table 4). In sum, there were no substantial relative-age effects in the adolescents with a normative school progress.

Adolescents who had Repeated a Grade (16.9%, n = 377)

Though adolescents who had repeated a grade were inherently relative old compared to their new peers (with a normative school progress), relative-age effects might still play a role for adolescents who repeated a grade. Partial correlations, presented in table 4, showed slightly lower intellectual ability and more depressive symptoms for the relatively old adolescents who repeated a grade; a reversed relative-age effect. As shown in table 4, linear regression models showed that relative older adolescents were heavier (d≈0.39), had a higher BMI (d≈0.42), lower intellectual ability (d≈0.35), and reported more depressive symptoms (d≈0.50). These results persisted after adjustment for SES (see appendix, table A2).

Table 1. Descriptive Statistics of the Variables.

Variable	Wave	N	Range			Mean	SD
Relative-Age		2230	1	to	12	6.20	3.44
Relative-Age (control)		794	1	to	12	8.02	2.99
Age	1	2230	10.01	to	12.58	11.11	0.55
Fear	1	1982	1	to	5	2.42	0.73
Frustration	1	1983	1	to	4.80	2.79	0.66
Depressive Symptoms	1	2024	0	to	2.31	0.48	0.36
SES	1	2188	-1.94	to	1.73	-0.05	0.80
Age in Years	2	2149	12.15	to	15.15	13.65	0.53
Length (cm)	2	2041	131	to	195	164.85	8.24
Weight (kg)	2	2030	29	to	134	52.84	11.08
BMI	2	2028	12.23	to	40.20	19.00	3.21
Physical Development	2	2087	1	to	20	9.34	3.38
Intellectual Development	2	1534	1	to	20	11.64	3.71
Social Status	2	1007	1	to	5	3.40	1.31
Sport Competence	2	1455	1	to	5	3.48	0.64
Age	3	1819	14.69	to	18.69	16.27	0.73
Δ Fear	1 to 3	1396	-3.57	to	4.12	0.05	1.04
Δ Frustration	1 to 3	1397	-4.07	to	3.11	0.02	0.99
Δ Depressive Symptoms	1 to 3	1343	-3.63	to	4.94	0.00	1.06

N = 2230 (50.8% women), T1 = baseline wave, T3 = third measurement wave, Δ = change score between T1 and T3, BMI = body mass index, cm = centimeter, k = number of categories, kg = kilogram, N = number of participants, SD = standard deviation.

Table 2. Pearson Correlations among all Study Variables.

	Wave	1.	2.	3.	4.	5.	6.	7.
1. Relative-Age		—						
2. Length	2	0.15***	—					
3. Weight	2	0.13***	0.62***	—				
4. BMI	2	0.08***	0.19***	0.88***	—			
5. Physical Dev.	2	0.15***	0.46***	0.43***	0.29***	—		
6. Intellectual Dev.	2	-0.01	0.02	-0.01	-0.03	0.03	—	
7. Popular Status	2	0.00	-0.04	-0.08	-0.08	0.08	0.10*	—
8. Rejected Status	2	0.06	0.04	0.08	0.10	0.06	0.02	—
9. Sport Competence	2	-0.02	-0.05	-0.16***	-0.17***	-0.02	0.28***	0.12*
10. Fear	1	-0.02	-0.03	0.03	0.06*	0.03	-0.04	0.10*
11. Frustration	1	0.01	0.04	0.07**	0.07**	0.02	-0.05	-0.06
12. Depressive Sx	1	-0.01	-0.03	0.03	0.04	0.01	-0.02	-0.10*
13. ΔFear	1-3	-0.01	-0.02	-0.02	0.01	0.03	-0.06*	-0.02
14. ΔFrustration	1-3	0.03	-0.02	-0.02	-0.02	0.02	-0.07*	0.04
15. Δ Depressive Sx	1-3	0.03	0.00	0.05	0.07**	0.11***	0.00	0.06
16. Rel. Age (control)		1.00***	0.02	0.07	0.08*	0.02	0.01	0.03
17. Biological Age		0.53***	0.15***	0.14***	0.09***	0.16***	-0.04	-0.02

N = 2230 (50.8% women).
Rel. Age = Relative-Age, T1 = baseline wave, T3 = third measurement wave, Δ = change score between T1 and T3.
Table 1 gives details (e.g., ages). For popular and rejected social status we report biserial correlations (e.g., being popular or rejected or not), because the scale was artificially dichotomous. Partial correlations adjusted for real age at testing, which show the relative-age effects, are presented in table 4.
Significance ***p<0.001, **p<0.01, *p<0.05, two-tailed.

8.	9.	10.	11.	12.	13.	14.	15.	16.
—								
-0.06	—							
0.02	-0.03	—						
0.11**	-0.05	0.31***	—					
0.17***	-0.12***	0.29***	0.32***	—				
-0.02	-0.03	-0.51***	-0.08**	-0.07*	—			
-0.06	-0.05	-0.11***	-0.49***	-0.08**	0.26***	—		
-0.08	-0.04	-0.08**	-0.08**	-0.52***	0.19***	0.18***		
-0.07***	0.01	-0.01	0.05	0.03	-0.04	0.04	0.01	
-0.02	-0.03	-0.07**	-0.04	-0.05*	0.08**	0.06*	0.07*	-0.28***

Table 3. Relative-Age Effects on School Progress (Normative Development is reference).

Binary Outcome	OR	CI (95%)
Repeated Grade	0.83***	(0.80 to 0.86)
Skipped Grade	1.47***	(1.30 to 1.67)
Special Education	0.96	(0.91 to 1.01)

N = 2230 (50.8% women). Regression estimates are based on bootstrapping (k = 10000).
CI = Bias Corrected and Accelerated confidence intervals, OR = Ratio of the probability (odds) of an event occurring in one group to the odds of it occurring in another group.
***p<0.001, **p<0.01, *p<0.05, two-tailed.

DISCUSSION

In this study we tested effects of intra-classroom relative-age position on multiple domains of functioning and well-being in adolescence. Three key observations merit further discussion. First, we observed substantial relative-age effects on school progress; relative young adolescents repeated a grade about four times more often than the relatively old, who in turn were over 20 times more likely to skip a grade. These observations align with our first hypothesis (H1), and replicate earlier studies (Cobley et al., 2009; Doornbos, 1971; Verachtert et al., 2010).

Second, in adolescents with a normative school progress (75.4%), no substantive relative-age effects were observed. Although we observed a small effect on peer rejection (H5a; which might be a chance finding), we could not replicate previously reported relative-age effects on weight (H2a), pubertal status (H2b), school performance (H3), sport-competence (H4), or peer status in terms of popularity (H5b). Neither did we observe substantial effects on depressive symptoms (H6a), temperamental negative affectivity (H7a), and changes in depressive symptoms (H6b) or negative affectivity (H7b) between age 11 and 16. Third, in the subgroup of adolescents who had repeated a grade (16.9%), inverse relative-age effects were observed; the relatively young were thinner (weight and BMI), had higher school marks, and reported less depressive symptoms than their relatively older peers.

Relative-Age Effects

The absence of substantial relative-age effects in adolescents with a normative school progress is surprising, given the existing literature (Doornbos, 1971; Goodman et al., 2003; Martin et al., 2004; Verachtert et al., 2010), which also covers adolescents between age 11 and 17 (Allen, 2008; Bell & Daniels, 1990; Musch & Grondin, 2001). Some studies reported that

Table 4. Relative-Age Effects, adjusted for Actual Age, as predictor of Multiple Domains, for Adolescents with a Normative School Progress (n= 1681) and Adolescents who had Repeated a Grade (n=377). Finally, the Control Sample (n=794) comprised Relative Old Children from Grade 7 and Relative Young from Grade 8 with a Normative School Progress.

		Normative School Progress			Repeated Class			Control Sample (robustness check)		
Variable	**Wave**	r_p	**B**	**CI (95%)**	r_p	**B**	**CI (95%)**	r_p	**B**	**CI (95%)**
Weight (kg)	2	-.03	-0.10	-0.28 to 0.08	.09	0.57*	0.07 to 1.09	.01	0.05	-0.21 to 0.30
BMI	2	-.01	-0.01	-0.06 to 0.04	.11	0.19*	0.04 to 0.36	.00	0.04	-0.03 to 0.11
Pubertal Status	2	-.01	-0.04	-0.10 to 0.02	.09	0.07	-0.07 to 0.19	-.02	-0.03	-0.11 to 0.05
Intellectual Development	2	.04	0.02	-0.00 to 0.04	-.14*	-0.05*	-0.10 to -0.01	.05	0.04	-0.07 to 0.15
Sport Competence	2	.01	0.00	-0.02 to 0.02	-.02	-0.01	-0.05 to 0.04	.02	0.00	-0.00 to 0.00
Fear	1	-.02	0.01	-0.01 to 0.02	.10	0.04	0.00 to 0.08	-.03	-0.01***	-0.01 to -0.01
Frustration	1	.05*	0.01*	0.01 to 0.02	.05	0.02	-0.03 to 0.06	.03	0.01	-0.01 to 0.02
Depressive Symptoms	1	.02	0.00	-0.01 to 0.01	.18***	0.07**	0.02 to 0.11	.03	0.00	-0.01 to 0.01
Δ Fear	1-3	-.05	-0.02	-0.04 to 0.00	-.11	-0.06	-0.13 to 0.02	-.06	-0.02***	-0.02 to -0.02
Δ Frustration	1-3	-.01	-0.00	-0.23 to 0.02	-.04	-0.03	-0.09 to 0.04	.02	0.01*	0.01 to 0.01
Δ Depressive Symptoms	1-3	.01	0.00	-0.02 to 0.02	-.08	-0.03	-0.09 to 0.00	-.01	-0.01***	-0.01 to -0.01

T1 = baseline wave, T3 = third measurement wave, Δ = change between T1 (age 11) and T3 (Age 16), BMI = body mass index, CI = Bias Corrected and Accelerated confidence intervals, r_p = partial correlations between relative-age and outcome, adjusted for real age at time of testing. Regression estimates were bootstrapped (k = 10000, bias corrected intervals), and indicate change in outcome per month in relative-age, after adjustment for age at testing. Note that for change variables we also adjusted for change in age between T1 and T3. Details on all measures and procedures can be found in the method section. All correlations between all variables are given in table 2, and SES-adjusted regression estimates in the appendix (table A2).
Significance ***p<0.001, **p<0.01, *p<0.05, two-tailed.

relative-age effects reverse for relatively young adolescents who managed to stay in their initial cohort (Dalton, 2012; McDonald, 2001), called the extended Akerlof/Kranton model (Allen, 2008), but we neither replicated this. It has been commonly argued that relative-age advantages erode when full maturity in the specific system has been reached, in contrast to advantages conferred by genes (Allen, 2008). Some studies indeed reported this dissipation of differences (Hutchison & Sharp, 1999; Verachtert et al., 2010).

Many studies reported relative-age effects on health, educational attainment, earnings, and mortality that persisted into adulthood (Bedard & Dhuey, 2006; Cobley et al., 2009; Persico et al., 2004). This suggests that relative-age advantages modulate personal and social development such that perpetuating mechanisms "get under the skin", e.g., via identity-formation (Fenzel, 1992; Thompson et al., 2004), opportunity costs (Bedard & Dhuey, 2006; Flynn, 2009; Gladwell, 2008; Persico et al., 2004), and/or development of (soft) skills (Dhuey & Lipscomb, 2008; Musch & Grondin, 2001). We may interpret the substantial relative-age effects on school progress along similar lines, an amplification of small differences.

Ability Streaming

The absence of substantive relative-age effects in adolescents with a normative school progress may be a Dutch cultural artifact. In our sample 20% of the adolescents at age 11 had repeated or skipped a grade (another 6% went to special education), which is already more than the 1% in the UK and 12% in the USA at age 15 (Dalton, 2012). Ability streaming might have diluted the relative-age effects in the adolescents with a normative school progress. Alternative (and convergent) explanations are that the Dutch environment is less competitive, which is a known moderator of relative-age effects (Musch & Grondin, 2001), or that combined classrooms (with multiple grades) dilute effects. Finally, it may be that positive spillover from relative older peers result in a net zero effect for the relative young.

This ability streaming hypothesis aligns in a slightly unexpected way with the hypothesized reciprocal feedback loops in which individuals shape (select/evoke) their environments to their propensities, in analogy to the corresponsive principle (Caspi & Shiner, 2006) and Dick-Flynn model (Beam & Turkheimer, 2013; Flynn, 2009). The corresponsive principle predicts that small intrinsic differences can become amplified by intra-classroom relative-age position effects, and this process may become catalyzed by strong ability streaming (via its outcome, that is, a change of grade) which results in a qualitative different classroom environment.

We may understand the reversed relative-age effects in adolescents who repeated a grade (lower school performance and more depressive symptoms for the relative old than the relative young) also in terms of the ability-streaming hypothesis; with increasing relative-age low innate potential (or maturity) rather than chronological age (the cultural relative-age artifact) becomes the preeminent reason for grade retention. In addition, relatively young retenders also lost their undesirable intra-cohort position (they became relatively old), whereas the relatively old became conspicuously old (Doornbos, 1971). Negative long-term effects of grade retention have been reported before (Wu, West, & Hughes, 2010).

Strengths and Limitations

Our results should be interpreted in light of the following strengths and limitations. A notable strength of this study is the large sample of adolescents from the general Dutch population. We are quite confident that substantial relative-age effects are absent in our sample, because our power calculations (in the appendix) for our specific regression analyses indicated that we would observe effects that explained 1% of the variance in each outcome variable in adolescents with normative school progress ($\geq d=0.18$) and 3% in the group who repeated a grade ($\geq d=0.34$). Moreover, we repeated analyses with a control relative-age sample, which, despite a negative association with biological age ($r=-0.28$ versus $r=0.53$), showed similar results. Nevertheless, our adjusted regression analyses lack the rigor of an experimental design.

The biggest limitation is our lack of knowledge about *why* children repeated a grade. For example, some studies reported that some high SES parents deliberately delay their relative young child's entry into school ("academic redshirting") to create a favorable relative old age position (Bedard & Dhuey, 2006; Graue & DiPerna, 2000; Musch & Grondin, 2001). This suggests cumulative disadvantages for relatively young children from a low SES background (Dhuey & Lipscomb, 2008). However, we did not observe more relatively young adolescents from families in the low SES quartile (see appendix table A1), and our results remained unchanged after adjustment for family SES. Notably, alternative explanations like season-of-birth effects have been refuted in earlier work, because relative-age effects were observed in both hemispheres (Bedard & Dhuey, 2006; Musch & Grondin, 2001) and remained after statistical adjustment for seasonal effects (Lawlor et al., 2006). However, future studies might explore gender effects, because most studies suggest that relative-age effects are stronger in males (Musch & Grondin, 2001; Cascio & Schanzenbach, 2007; Sandercock et al., 2013).

CONCLUSION

We studied the relative-age effect bestowed upon children by an adult-imposed structuring of their worlds, a cultural artifact that may modulate the development of their innate abilities. Our preeminent observation is that intra-classroom position influenced school progress, and rendered relatively young adolescents more likely to repeat a grade. Second, we could not replicate substantial relative-age effects on physical and psychosocial development and well-being in adolescents with a normative progress. We argued that this absence of relative-age effects in adolescents with a normative school progress may reflect a "wash-out effect" due to ability streaming. This ability streaming (grade retention) may distinguish the Dutch sample from earlier studies in Britain and the USA. Third, in the subgroup of adolescents who repeated a grade, reverse relative-age effects were observed; the relative old adolescents performed worse in school and reported more depressive symptoms than their relatively younger peers did. Future studies might explore in more detail the mechanisms by which relative-age effects may get internalized, and models that can explain alleged cultural differences in their effects.

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SUPPLEMENTARY MATERIAL

Table A1. Frequencies for School Progress and Socioeconomic Status (SES) stratified over Relative-Age Distribution in Quartiles.

			Relative Young		2nd Quartile		3rd Quartile		Relative Old	
Relative-Age:			**1 to 3**		**4 to 6**		**7 to 9**		**10 to 12**	
Birth Month:			**Sept, Aug, July**		**June, May, April**		**March, Feb, Jan**		**Dec, Nov, Oct**	
Total Sample	2230	100.0%	624	100%	569	100%	537	100%	500	100%
Normative Development	1681	75.4%	398	63.8%	441	77.5%	443	82.5%	399	79.8%
Repeated Grade	377	16.9%	185	29.6%	90	15.8%	61	11.4%	41	8.2%
Skipped Grade	48	2.2%	2	0.3%	4	0.7%	7	1.3%	35	7.0%
Special Education	124	5.5%	39	6.3%	34	6.0%	26	4.8%	25	5.0%
Low SES Quartile	547	25.0%	135	24.7%	142	26.0%	149	27.2%	121	22.1%
High SES Quartile	547	25.0%	150	27.4%	141	25.8%	139	25.4%	117	21.4%

Table A2. Relative-Age Effects on Multiple Domains, adjusted for Actual Age at testing and Socioeconomic Status (SES), for Adolescents with a Normative School Progress (n = 1681), and Adolescents who Repeated a Grade (n = 377).

		Normal School Progress Relative-Age Effect			Repeated Grade Relative-Age Effect		
Variable	**Wave**	r_p	**B**	**CI (95%)**	r_p	**B**	**CI (95%)**
Length (cm)	2	-.04	-0.10	(-0.24 to 0.04)	-.01	0.09	(-0.25 to 0.42)
Weight (kg)	2	-.04	-0.13	(-0.30 to 0.05)	.08	0.60*	(0.02 to 1.11)
BMI	2	-.02	-0.02	(-0.07 to 0.03)	.10	0.19*	(0.03 to 0.36)
Pubertal Status	2	-.02	-0.04	(-0.10 to 0.02)	.08	0.07	(-0.07 to 0.19)
Intellectual Development	2	.04	0.06	(-0.01 to 0.13)	-.12	-0.19*	(-0.36 to -0.02)
Sport Competence	2	.01	0.00	(-0.01 to 0.02)	-.01	-0.00	(-0.03 to 0.03)
Fear	1	.01	0.01	(-0.01 to 0.02)	.09	0.04	(-0.00 to 0.08)
Frustration	1	.05	0.02	(-0.00 to 0.03)	.04	0.02	(-0.03 to 0.06)
Depressive Symptoms	1	.01	0.00	(-0.02 to 0.02)	.18***	0.02**	(0.02 to 0.11)
Δ Fear	1-3	-.06[a]	-0.02	(-0.04 to 0.00)	-.11	-0.06	(-0.13 to 0.02)
Δ Frustration	1-3	-.01	-0.00	(-0.03 to 0.02)	-.04	-0.03	(-0.09 to 0.04)
Δ Depressive Symptoms	1-3	.01	0.00	(-0.02 to 0.02)	-.08	-0.03	(-0.09 to 0.04)

[a] = p was 0.052.
T1 = baseline wave, T3 = third measurement wave, Δ = change between T1 (age 11) and T3 (Age 16), BMI = body mass index, CI = Bias Corrected and Accelerated confidence intervals, r_p = partial correlations between relative-age and outcome adjusted for real age at time of testing.
Regression estimates were bootstrapped (k = 10000, bias corrected intervals), and indicate change in outcome per month in relative-age, after adjustment for age at testing. Note that for change variables we also adjusted for change in age between T1 and T3. Details on all measures and procedures can be found in the method section. All correlations between all variables are given in table 2.
***$p<0.001$, **$p<0.01$, *$p<0.05$, two-tailed.

Table A3. Relative-Age Effects on School Progress (Normative Development is reference).

	Adj. for Real Age[a]		Adj. for Real Age & SES[b]	
Binary Outcome	**OR**	**CI (95%)**	**OR**	**CI (95%)**
Repeated Grade	0.83***	(0.80 to 0.86)	0.82***	(0.79 to 0.86)
Skipped Grade	1.47***	(1.30 to 1.67)	1.66***	(1.44 to 1.92)
Special Education	0.96	(0.91 to 1.01)	0.81***	(0.75 to 0.87)

N = 2230 (50.8% women).
[a] The odds are based on bootstrapping (k = 10000).
[b] Odds are not based on bootstrapping.
CI = Bias Corrected and Accelerated confidence intervals, OR = Ratio of the probability that an event will happen to all possible cases for that event.
***$p<0.001$, **$p<0.01$, *$p<0.05$, two-tailed.

Table A4. Relative-Age as the predictor of the Odds of Being Popular or Rejected (Normative Development is reference) in Adolescents with a Normative School Progress and Adolescents who Repeated a Grade, adjusted for Real Age at testing.

School Progress	**Social Status**	r_p	**OR**	**CI (95%)**	***p***	**B**	**CI (95%)**
Normative	Popular	-.00	1.00	(0.94 to 1.06)	0.90	-0.00	(-0.07 to 0.06)
	Rejected	.09***	1.12	(1.05 to 1.19)	0.00	0.11	(0.04 to 0.18)
Repeated a Grade	Popular	.04	1.11	(0.83 to 1.49)	0.55	0.11	(-0.53 to 0.66)
	Rejected	.02	1.04	(0.85 to 1.28)	0.67	0.04	(-0.20 to 0.24)

N = 2230 (50.8% women). In total 137 (8.1%) adolescents were rated as popular and 132 (7.9%) as rejected. Regression estimates are based on bootstrapping (k = 10000).
CI = Bias Corrected and Accelerated confidence intervals, OR = Ratio of the probability that an event will happen to all possible cases for that event, r_p = partial correlations between relative-age and outcome, adjusted for real age at time of testing.
The values for the presented correlations and regression remained almost identical after additional adjustment for family SES.
$^{***}p<0.001$, $^{**}p<0.01$, $^{*}p<0.05$, two-tailed.

Table A5. Social Status stratified over Relative-Age Position in Quartiles and School Progress.

	Normative School Progress				Repeated a Grade			
	Rejected	***n***	**Popular**	***n***	**Rejected**	***n***	**Popular**	***n***
Relatively Young	9.3%	37	7.5%	30	2.7%	5	1.6%	3
Second	6.1%	27	9.5%	42	3.3%	3	1.1%	1
Third	6.5%	29	8.4%	37	4.9%	3	1.6%	1
Relatively Old	9.8%	39	7.0%	28	4.9%	2	2.4%	1
Total	7.9%	132	8.1%	137	3.4%	13	1.6%	6

n = number of subjects.

Table A6. Quartiles of Socioeconomic Status (SES) stratified over School Progress.

	Normative		Repeated a Grade		Skipped a Grade		Special Education	
	%	*n*	%	*n*	%	*n*	%	*n*
Low SES	65.3%	357	22.7%	124	0.9%	5	11.2%	61
Second Q	72.0%	394	21.4%	117	0.7%	4	5.9%	32
Third Q	77.1%	422	15.2%	83	3.8%	21	3.8%	21
High SES	87.6%	479	8.6%	47	3.1%	17	0.7%	4

n = number of subjects, Q = Quartile.

A7. Power Calculations

We calculated the power of all specific linear regression analyses (Selya, Rose, Dierker, Hedeker, & Mermelstein, 2012). In the adolescents with a normative school progress reasonably precise estimations (given 80% power) were guaranteed beyond Cohen's $f^2 = 0.01$ ($\sim R^2 = 0.01$, $d = \sim 0.18$, 2 predictors, $\alpha = 0.05$, and $N \geq 1100$ for all outcomes). In the group of adolescents who had repeated a grade we could estimate effects beyond Cohen's $f^2 = 0.03$ ($\sim R^2 = 0.03$, $d = \sim 0.34$, given 80% power, 2 predictors, $\alpha = 0.05$, $N \geq 320$ for all outcomes). However, we concluded we lacked the power to test for relative-age effects in the group that skipped a grade ($N = 48$, Cohen's $f^2 = 0.24$, $R^2 = 0.19$, $d = \sim 0.98$). These post-hoc power calculations indicate that we obtained reasonably precise estimations in our study, and we are therefore confident that substantial relative-age effects are indeed absent.

REFERENCES

Selya, A. S., Rose, J. S., Dierker, L. C., Hedeker, D., & Mermelstein, R. J. (2012). A practical guide to calculating Cohen's f2, a measure of local effect size, from PROC MIXED. *Frontiers in Psychology, 3*, 111. doi:10.3389/fpsyg.2012.00111