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Context counts: The different implications of weekday and weekend video gaming for academic performance in mathematics, reading, and science

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A R T I C L E I N F O

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A B S T R A C T

Video gaming has been a source of serious concern for parents and educators, based on the belief that video games disrupt adolescents' academic activities. However, previous studies have been mixed regarding video games' effects on academic outcomes. We revisited this issue by analyzing data on approximately 30,000 adolescents from three large-scale public datasets. We consistently found that the more adolescents played video games on weekdays, the poorer they performed on standardized assessments of mathematics, reading, and science. In contrast, weekend video gaming was positively associated with academic performance. Our findings suggest that weekday and weekend video gaming may be differentially associated with academic outcomes, depending on the context in which it occurs.

Video gaming has become one of the most popular activities for adolescents; research has shown that approximately 83% of adolescents in the U.S. play video games regularly (Williams, Yee, & Caplan, 2008). In view of their widespread availability and popularity, video games have become a source of concern for parents and educators, based on the belief that video games disrupt adolescents' academic activities. In line with these concerns, the displacement hypothesis postulates that irrespective of type or genre, the quantity of video gaming detrimentally influences academic performance by displacing time that might otherwise be spent on educational pursuits (Weis & Cerankosky, 2010).

Although the link between video gaming and academic outcomes has been widely researched, findings have been inconsistent and offer contrasting perspectives on the relation between video gaming and academic outcomes. Specifically, some studies suggest that increased video gaming is negatively correlated with children's and adolescents' abilities to sustain attention for school-related work, which tends to be less immersive or engaging than exciting, fast-paced video games (Bailey, West, & Anderson, 2010; Ennemoser & Schneider, 2007; Swing, Gentile, Anderson, & Walsh, 2010). In a related vein, a number of studies have demonstrated negative associations between the frequency of video gaming and grades (i.e., GPA) in both children and adolescents (e.g., Anand, 2007; Harris & Williams, 1985; Jackson, von Eye, Fitzgerald, Witt, & Zhao, 2011; Swing et al., 2010; Weis & Cerankosky, 2010). Other studies, however, did not find any relationship between video gaming and grades (Creasey & Myers, 1986; Ferguson, 2011; Schie & Wiegman, 1997; for a meta-analysis, see Ferguson, 2015). Furthermore, recent studies suggest that lifelong experience with video gaming improves higher-order cognitive abilities, such as selective attention and task-switching (Green & Bavelier, 2015; Hartanto, Toh, & Yang, 2016; Strobach, Frensch, & Schubert, 2012), which are important skills for academic success.

This discrepancy arose, in part, from crucial methodological shortcomings. Specifically, most studies used school grades that were not entirely objective, owing to differences in assessment practices across various schools (Guskey, 2006). Other studies were underpowered due to small sample sizes, which reduced the findings' reliability (e.g., Bakker, van Dijk, & Wicherts, 2012). Recently, Drummond and Sauer (2014) addressed these issues by reanalyzing data on more than 192,000 fifteen-year-olds in the 2009 administration of the Program for International Student Assessment, which employs standardized tests of science, mathematics, and reading. The authors found that video gaming had little association with adolescents' performance on standardized assessments, which suggests that it may not necessarily affect academic outcomes in adolescents. Despite Drummond and Sauer's large sample size and other notable strengths, however, their conclusion warrants caution due to several limitations.

First, the dataset in Drummond and Sauer's (2014) study classified students as video gaming on a daily, weekly, or monthly basis. This coarse-grained classification scheme may not precisely represent the actual frequency of video gaming. For instance, weekly video-game players, who typically play for longer periods each time (e.g., 10 h), may actually spend more hours in one week than daily video-game players, who typically spend less time each day (e.g., 30 min). Accordingly, a more precise index of video-gaming frequency is needed to examine the relation between video gaming and academic performance (for a similar argument, see Latham, Patston, & Lynette, 2013).

Second, Drummond and Sauer (2014) did not directly account for potential third variables, such as gender, race, family composition, non-English home language, and SES, that might confound the relationship between video gaming and academic outcomes. For instance, gender differences have been found in frequency of video gaming (Desai, Krishnan-Sarin, Cavallo, & Potenza, 2010) and mathematical performance, with the latter a possible consequence of stereotype threat (Spencer, Steele, & Quinn, 1999; Stoet & Geary, 2013). Likewise, race, SES, and family composition can indicate important aspects of adverse home conditions that are associated with lower academic achievement. Specifically, studies have demonstrated that children from low-SES (Sirin, 2005), racial minority (Kao & Thompson, 2003), single-parent (Amato, 2001), or non-native English speaking families (Genesee, Lindholm-Leary, Saunders, & Christian, 2005) are more likely to have lower educational outcomes. Moreover, these children are more frequent video gamers because of their positive attitudes toward video games (Duggan, 2015) and lack of resources to participate in other after-school programs or recreational activities (Carson, Spence, Cutumisu, & Cargill, 2010). Although Drummond and Sauer's multilevel model could have implicitly controlled for the above-mentioned confounding variables by taking into account between-school variances in academic achievement, the influence of such confounding variables is unknown and thus needs to be directly controlled for.

Third, Drummond and Sauer's (2014) dataset did not allow for a distinction between weekday and weekend video gaming, which could have differential effects on academic performance. Adolescents generally spend more time engaging in leisure activities on weekends than on weekdays (Yeung, Sandberg, Davis-Kean, & Hofferth, 2001) and more time studying or doing school work on weekdays than on weekends (Huston, Wright, Marquis, & Green, 1999). Therefore, weekday video gaming may be more detrimental than weekend video gaming, because the former likely displaces time that could be dedicated to school work (Sharif & Sargent, 2006). These limitations suggest the need to re-examine, with more refined measurement and analysis, the relationship between frequency of video gaming and academic outcomes.

To address these issues, we analyzed three public large-scale datasets from the Early Childhood Longitudinal Study (ECLS; 8th graders; Tourangeau, Nord, Lê, Sorongon, & Najarian, 2009), Education Longitudinal Study (ELS; 10th graders; Ingels, Pratt, Rogers, Siegel, & Stutts, 2004), and National Education Longitudinal Study (NELS; 12th graders; Ingels et al., 1994). Many important features of these datasets allowed us to address the methodological limitations of previous studies. First, the studies' nationally representative sample of approximately 30,000 adolescents enabled us to resolve issues of low power and lack of generalizability (e.g., Anand, 2007; Creasey & Myers, 1986), thereby increasing our findings' reliability. Second, because the studies used standardized assessments of academic performance, we were able to address the inherent subjectivity of school appraisal, which is vulnerable to non-veridical influences, such as bias in teachers' subjective judgments due to students' attitudes (Drummond & Sauer, 2014). Importantly, the studies employed standardized assessments in mathematics, reading, and science, which in turn increases the content validity of the measurement.

Third, instead of classifying participants as individuals who play video games on a daily, weekly, or monthly basis, the studies directly assessed the hours spent video gaming per day, thus providing a more precise and exhaustive estimation of video-gaming frequency. Fourth, given the dataset's comprehensiveness, we were able to control for potentially important confounding variables that had not been considered in previous studies. Finally, the studies differentiated video gaming on weekdays from weekends, which offers a unique opportunity to compare either similar or different relations of weekday and weekend video gaming to academic performance. For instance, given that weekend video gaming is less likely to displace time that could be dedicated to school work than weekday video gaming (Sharif & Sargent, 2006), weekday and weekend video gaming might have different relations to academic achievement. However, the directions of their relationships may not necessarily be different. For instance, if video gaming potentially impairs the ability to sustain attention (Bailey et al., 2010; Ennemoser & Schneider, 2007), video-gaming frequency on both weekdays and weekends should be negatively associated with academic performance. In contrast, if video gaming enhances higher-order cognitive abilities (Green & Bavelier, 2015; Hartanto et al., 2016) that are conducive to academic success, video gaming on both weekdays and weekends should be positively associated with academic performance.

1. Method

1.1. Participants

The sample consisted of 8971 eighth graders from the ECLS (female = 50.2%, age ~14 years old); 13,979 tenth graders from the ELS (female = 50.8%, age ~16 years old); and 8064 twelfth graders from the NELS (female = 52.2%, age ~18 years old).

Table 1
Demographics and main characteristics of participants in the ECLS, ELS, and NELS.

	ECLS (8th graders)	ELS (10th graders)	NELS (12th graders)
Gender (% girls)	50.16	50.80	52.17
Socioeconomic status (SES)[a]	0.16 (0.80)	0.05 (0.73)	0.05 (0.78)
Ethnicity			
White (%)	61.93	58.05	72.87
Hispanic (%)	17.30	14.16	11.15
African-American (%)	9.86	12.52	7.98
Asian (%)	6.81	9.54	7.13
Native American (%)	1.83	0.81	0.88
Multiracial (%)	2.28	4.91	–
Non-native English speaker (%)	14.90	16.62	11.11
Family Composition			
Living with both biological parents (%)	65.79	59.94	69.1
Living with one biological parent only (%)	19.20	20.55	17.34
Living with one biological parent and a stepparent (%)	11.27	15.38	11.67
Living with nonbiological parent(s) or guardian(s)	3.74	4.13	1.89

Note. SDs are shown in parentheses.
[a] SES was indexed by five indicators of household income, maternal and paternal education, and maternal and paternal occupational prestige scores.

Participants completed standardized assessments of math, reading, and science and self-reported video-gaming habits.

All of the studies employed a multistage probability sample design to select a nationally representative sample of students in the U.S. (for more details on sampling for the ECLS, ELS, and NELS, see Tourangeau et al., 2009; Ingels et al., 2004; and Ingels et al., 1994, respectively). Data collection for the ECLS, ELS, and NELS took place during the year 2007 (8th graders), 2002 (10th graders), and 1992 (12th graders), respectively. Table 1 summarizes the demographics and main characteristics of participants in the three studies.

1.2. *Measures*

1.2.1. *Video-gaming frequency*

Similar measures of video-gaming frequency were used on the ECLS, ELS, and NELS. Frequency of video gaming was based on self-reported hours of playing either video or computer games per day and separated into weekdays and weekends. Notably, the rating scales used in each study were similar but not identical. The ECLS measured the frequency of video gaming as a continuous variable based on reported hours (range = 0–24 h), but the ELS and NELS measured this using, respectively, a 7-point Likert scale (0 = *0 h*, 1 = *1 h*, 2 = *2 h*, 3 = *3 h*, 4 = *4 h*, 5 = *5 h*, 6 = *6 h or more*) and a 6-point Likert scale (0 = *don't play video games*, 1 = *less than 1 h per day*, 2 = *1–2 h per day*, 3 = *2–3 h per day*, 4 = *3–5 h per day*, 5 = *5 h or more per day*). Since video-game frequency was rated on different scales across the three studies, we converted the ECLS's video-game-frequency measures so that they would be comparable to the ELS's 7-point Likert scale, which ranges from 0 (*0 h*) to 6 (*6 h or more*).

1.2.2. *Standardized assessment of academic performance*

Standardized psychometric assessments of mathematics, reading, and science were administered across the ECLS, ELS, and NELS and served as objective indicators of academic performance; note that the assessment of science was not included in the ELS. The standardized assessments in each study were developed in a relatively similar manner, based on the framework derived from the National Assessment of Educational Progress, and examined by a panel of curriculum specialists in each subject area. Trained assessors administered the tests to each group of students, using hard-copy booklets. The assessment for each subject took approximately 30 min to complete.

Each subject assessment was developed using a two-stage approach to maximize its accuracy while minimizing its duration. Specifically, in the first stage (routing stage), a set of routing items with various levels of difficulty (low, medium, and high) was administered. In the second stage, participants were tested using a set of items of either low, medium, or high difficulty, depending on their performance on first-stage tests. Use of a two-stage assessment process meant that scores could be calculated based on item response theory (IRT), which takes into account each participant's response patterns, each question's difficulty, each item's ability to discriminate high achievers from low achievers, and each item's "guess-ability," i.e., the probability of guessing the correct answer. The IRT procedure then calculates an overall score that is comparable for all participants, regardless of the difficulty of items administered to individual participants in the second stage. This allows for accurate adjustment of a participant's correct guesses on difficult items. The IRT procedure generates two types of scores: IRT scale scores, which estimate the number of items a participant would have answered correctly if he/she had taken the whole set of assessment questions, and IRT standardized scores (T-scores), which produce norm-referenced achievement measurements by estimating the extent to which a participant ranked higher or lower than the national average of 50, with a standard deviation of 10 (for more details, see Tourangeau et al., 2009; Ingels et al., 2004; and Ingels et al., 1994).

1.2.3. Socioeconomic status

In all three studies, SES was indexed by five indicators: household income, maternal and paternal education, and maternal and paternal occupational prestige scores, all of which were obtained from parental interviews. Prestige scores on the ECLS were derived from the 1989 General Social Survey, and those on the ELS and NELS were derived from a revised version (Nakao & Treas, 1992) of the 1961 Duncan Socioeconomic Indicator to accommodate the possibility of changes in occupations and their relative prestige; the revised version is still widely used in empirical research (e.g., Howard, Shankar, & Jagadisan, 2011; Judge, Livingston, & Hurst, 2012; Morris et al., 2012; Wolke, Copeland, Angold, & Costello, 2013). Scores from the five SES components were then z-transformed. The SES index was computed as follows: $SES_i = \frac{\sum_{h=1}^{m} z_{hi}}{m}$, where z_{hi} is the z-transformed score for each SES component and m the number of components. When some of the SES components had missing data (e.g., single-parent family or unemployed parents), the SES index was computed by averaging z-scores for available components (for more details on the computation of SES indices for the ECLS, ELS, and NELS, see Tourangeau et al., 2009; Ingels et al., 2004; and Ingels et al., 1994, respectively).

1.3. Data analysis

We examined the influence of our two key predictors—(a) the frequency of playing video games on weekdays and (b) the frequency of playing video games on weekends—on standardized assessments of academic achievement in mathematics, reading, and science. For each dataset (ECLS, ELS, and NELS), we performed ordinary least squares regression models on the IRT scale scores and IRT T-scores for each subject; lower scores indicate poorer performance, and higher scores indicate better performance. In each model, we included the frequencies of video gaming on weekdays and weekends as predictors. We also controlled for confounding variables (gender, race, SES, home language, and family composition) that may influence academic achievement. Gender, race, home language, and family composition were dummy coded, with male, white, native English speaker, and living with biological parents as reference categories, respectively. SES was mean-centered to improve the interpretation of intercept terms.

For missing data in covariates of critical interest (less than 5% in each dataset), we performed multiple imputation (Rubin, 2004) by using a Markov chain Monte Carlo (MCMC) algorithm with a fully conditional specification procedure to create five imputed datasets. Subsequently, for each criterion variable, we also conducted slope differentiation tests to compare the coefficient estimates of our main predictors, i.e., the frequency of video gaming on weekdays and weekends. This allowed us to examine the differential effects, if any, of video gaming on weekdays vs. weekends on academic performance. Table 2 summarizes descriptive statistics for predictors and criterion variables.

2. Results

2.1. The ECLS

When controlling for covariates of gender, SES, race, home language, and family composition, the frequency of video gaming on weekdays negatively predicted IRT scale scores for mathematics ($B = -2.03$, $SE = 0.18$, 95% CI = [-2.38, -1.67], $p < .001$); reading ($B = -2.84$, $SE = 0.22$, 95% CI = [-3.28, -2.40], $p < .001$); and science ($B = -1.39$, $SE = 0.13$, 95% CI = [-1.64, -1.14], $p < .001$; see Table 3). Negative coefficient estimates for math, reading, and science suggest that frequent video gaming on weekdays is associated with slightly poorer academic performance. In contrast, video-game frequency on weekends positively

Table 2
Descriptive statistics for predictors and criterions in the ECLS, ELS, and NELS.

	ECLS (8th graders)				ELS (10th graders)				NELS (12th graders)			
	M	*SD*	Range	Reliability	*M*	*SD*	Range	Reliability	*M*	*SD*	Range	Reliability
Video game Frequency												
Weekdays[a]	1.24	1.56	0–6	–	1.09	1.60	0–6	–	0.56	0.92	0–5	–
Weekends[a]	2.08	2.01	0–6	–	1.76	2.02	0–6	–	0.83	1.17	0–5	–
IRT scale scores												
Mathematics	143.02	21.39	66.17–172.20	.92	38.42	11.90	12.52–69.72	.92	50.73	13.91	16.97–78.10	.94
Reading	171.77	27.05	85.62–208.90	.87	30.25	9.72	10.20–49.09	.86	34.46	9.74	10.41–51.16	.85
Science[b]	85.32	15.55	28.21–107.90	.84	–	–	–	–	24.18	6.09	10.03–35.96	.82
IRT T-scores												
Mathematics	51.76	9.49	24.17–74.82	.92	51.02	9.91	19.38–86.68	.92	52.68	9.50	29.63–71.37	.94
Reading	51.77	9.70	26.24–78.91	.87	50.87	9.93	22.57–78.76	.86	52.23	9.40	29.01–68.35	.85
Science[b]	51.71	9.38	21.77–74.25	.84	–	–	–	–	52.14	9.65	29.7070.81	.82

Note. Reliability coefficients were based on alpha coefficients reported in manuals for the ELCS (Tourangeau et al., 2009), ELS (Ingels et al., 2004), and NELS (Ingels et al., 1994). For all criterion variables, higher values indicate better performance.

[a] The scale for video-game frequency differs across the three studies. In the ECLS and ELS, hours of playing video games were reported on a 7-point Likert scale (0 = *0 h*, 1 = *1 h*, 2 = *2 h*, 3 = *3 h*, 4 = *4 h*, 5 = *5 h*, 6 = *6 h or more*). In the NELS, hours of playing video games were reported using a 6-point Likert scale (0 = *don't play video games*, 1 = *less than 1 h per day*, 2 = *1–2 h per day*, 3 = *2–3 h per day*, 4 = *3–5 h per day*, 5 = *5 h or more per day*).

[b] Science was not assessed in the ELS.

Table 3
Coefficient Estimates on IRT Scale Scores and IRT T-Scores for Mathematics, Reading, and Science in the ECLS dataset with Frequency of Video Gaming on Weekdays and Weekdays as Predictors.

	Mathematics				Reading				Science			
	IRT Scale Scores		IRT T-Scores		IRT Scale Scores		IRT T-Scores		IRT Scale Scores		IRT T-Scores	
	B (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta
Predictor												
Weekday video-game frequency	−2.03 (0.18)**	−0.15	−0.86 (0.08)**	−0.14	−2.84 (0.22)**	−0.16	−0.96 (0.08)**	−0.16	−1.39 (0.13)**	−0.14	−0.83 (0.08)**	−0.14
Weekend video-game frequency	0.57 (0.15)**	0.05	0.20 (0.06)*	0.04	1.02 (0.18)**	0.08	0.29 (0.06)**	0.06	0.54 (0.10)**	0.07	0.28 (0.06)**	0.06
Covariates												
Gender (female)	−3.27 (0.43)**	−0.08	−1.64 (0.19)**	−0.09	4.19 (0.53)**	0.08	1.39 (0.19)**	0.07	−3.12 (0.30)**	−0.10	−2.23 (0.18)**	−0.12
Socioeconomic status	8.71 (0.29)**	0.33	4.09 (0.13)**	0.35	11.58 (0.35)**	0.34	4.51 (0.12)**	0.37	6.24 (0.20)**	0.32	3.98 (0.12)**	0.34
Race												
Hispanic	−3.83 (0.64)**	−0.07	−1.68 (0.28)**	−0.07	−7.19 (0.80)**	−0.10	−2.40 (0.28)**	−0.09	−5.26 (0.46)**	−0.13	−3.03 (0.27)**	−0.12
African American	−12.33 (0.73)**	−0.17	−4.93 (0.32)**	−0.16	−15.68 (0.91)**	−0.17	−5.01 (0.32)**	−0.15	−12.48 (0.52)**	−0.24	−6.94 (0.31)**	−0.22
Asian	3.10 (0.87)**	0.04	1.93 (0.39)**	0.05	0.27 (1.08)	0.00	0.15 (0.39)	0.00	−1.16 (0.61)†	−0.02	−0.53 (0.37)	−0.01
Native American	−9.26 (1.50)**	−0.06	−3.46 (0.66)**	−0.05	−13.24 (1.87)**	−0.07	−4.25 (0.67)**	−0.06	−8.53 (1.06)**	−0.07	−4.54 (0.64)**	−0.07
Multiracial	−2.26 (1.34)†	−0.02	−0.93 (0.59)	−0.02	−2.70 (1.66)	−0.02	−0.83 (0.59)	−0.01	−2.14 (0.94)*	−0.02	−1.37 (0.57)*	−0.02
Non-native English speaker	−2.88 (0.68)**	−0.05	−0.85 (0.30)*	−0.03	−4.85 (0.88)**	−0.06	−1.31 (0.31)**	−0.05	−2.57 (0.51)**	−0.06	−1.35 (0.31)**	−0.05
Family Composition												
Living with one biological parent only	−2.29 (0.57)**	−0.04	−1.00 (0.25)**	−0.04	−2.53 (0.70)**	−0.04	−0.78 (0.25)*	−0.03	−1.20 (0.41)*	−0.03	−0.69 (0.25)*	−0.03
Living with one biological parent and one stepparent	−2.81 (0.70)**	−0.04	−1.48 (0.31)**	−0.05	−5.45 (0.81)**	−0.06	−2.11 (0.29)**	−0.07	−1.78 (0.49)**	−0.0*	−1.34 (0.29)**	−0.05
Living with non-biological parent(s) or guardian(s)	−5.69 (1.20)**	−0.05	−2.63 (0.52)**	−0.05	−5.79 (1.54)**	−0.04	−2.13 (0.53)**	−0.04	−3.66 (0.88)**	−0.05	−2.14 (0.53)**	−0.04

Note. SDs are shown in parentheses. Gender was dummy coded with male as the reference category; for race, white was used as a reference; for home language, English as a native language was used as a reference; and for family composition, living with biological parents was used as a reference. $^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .001$.

predicted IRT scale scores for mathematics ($B = 0.57$, $SE = 0.15$, 95% CI = [0.28, 0.85], $p < .001$); reading ($B = 1.02$, $SE = 0.18$, 95% CI = [0.67, 1.37], $p < .001$); and science ($B = 0.54$, $SE = 0.10$, 95% CI = [0.34, 0.74], $p < .001$), suggesting that video gaming on weekends is associated with better academic performance; we note, however, that the effect size of this association is very small.

When similar analyses were performed for IRT T-scores, weekday video-game frequency emerged as a negative predictor of IRT T-scores for mathematics ($B = -0.86$, $SE = 0.08$, 95% CI = [-1.02, −0.70], $p < .001$); reading ($B = -0.96$, $SE = 0.08$, 95% CI = [-1.12, −0.80], $p < .001$); and science ($B = -0.83$, $SE = 0.08$, 95% CI = [-0.98, −0.68], $p < .001$, with small effect sizes. In contrast, weekend video-game frequency emerged as a positive predictor of IRT T-scores for mathematics ($B = 0.20$, $SE = 0.06$, 95% CI = [0.07, 0.33]; $p = .002$); reading ($B = 0.29$, $SE = 0.06$, 95% CI = [0.17, 0.42], $p < .001$); and science ($B = 0.28$, $SE = 0.06$, 95% CI = [0.16, 0.40], $p < .001$), with very small effect sizes.

We further conducted a slope differentiation test on video-gaming frequency on weekdays and weekends. Crucially, for each subject (i.e., mathematics, reading, and science), we consistently found significantly lower coefficient estimates for weekday video gaming than weekend video gaming ($ps < 0.001$), which suggests that weekday video gaming tends to be associated with poorer school performance, while weekend video gaming tends to be associated with better school performance; note that these two findings were associated with small and very small effect sizes, respectively (see Fig. 1). Results support different relationships between weekday and weekend video gaming on academic performance (see Appendix for a multilevel model analysis).

2.2. The ELS

A series of analyses similar to those performed for the ECLS was undertaken for the ELS. When controlling for the same covariates, frequent video gaming on weekdays negatively predicted IRT scale scores for mathematics ($B = -0.77$, $B\ SE = 0.08$, 95% CI = [-0.92, −0.62], $p < .001$) and reading ($B = -0.65$, $B\ SE = 0.06$, 95% CI = [-0.77, −0.52], $p < .001$), with small effect sizes (see

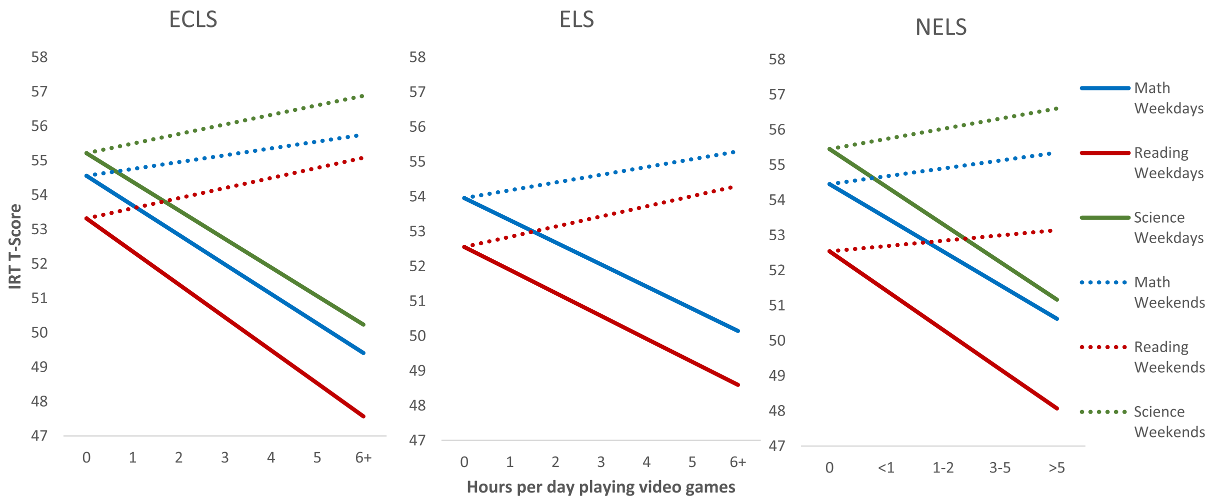

Fig. 1. Regression slopes for IRT T-scores for mathematics, reading, and science as predicted by the frequency (hours per day) of video gaming on weekdays and weekends after controlling for gender, SES, race, home language, and family composition.

Table 4
Coefficient Estimates on IRT Scale Scores and IRT T-Scores for Mathematics, Reading, and Science in the ELS dataset with Frequency of Video Gaming on Weekdays and Weekdays as Predictors.

	Mathematics				Reading			
	IRT Scale Scores		IRT T-Scores		IRT Scale Scores		IRT T-Scores	
	B (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta
Predictor								
Weekday video-game frequency	−0.77 (0.08)**	−0.10	−0.64 (0.06)**	−0.10	−0.65 (0.06)**	−0.11	−0.66 (0.07)**	−0.11
Weekend video-game frequency	0.26 (0.06)**	0.04	0.22 (0.05)**	0.05	0.28 (0.05)**	0.06	0.29 (0.05)**	0.06
Covariates								
Gender (female)	−1.57 (0.19)**	−0.07	−1.31 (0.16)**	−0.07	1.27 (0.16)**	0.07	1.31 (0.16)**	0.07
Socioeconomic status	5.33 (0.13)**	0.33	4.39 (0.11)**	0.33	4.37 (0.11)**	0.33	4.43 (0.11)**	0.33
Race								
Hispanic	−4.67 (0.30)**	−0.14	−3.82 (0.25)**	−0.13	−2.98 (0.25)**	−0.11	−2.96 (0.25)**	−0.11
African American	−7.57 (0.28)**	−0.21	−6.19 (0.24)**	−0.21	−5.19 (0.23)**	−0.18	−5.16 (0.24)**	−0.18
Asian	2.97 (0.36)**	0.0	2.71 (0.30)**	0.10	−0.25 (0.30)	−0.01	−0.03 (0.31)	−0.01
Native American	−5.63 (0.97)**	−0.04	−4.34 (0.81)**	−0.04	−4.06 (0.81)**	−0.04	−4.08 (0.83)**	−0.04
Multiracial	−1.89 (0.41)**	−0.03	−1.58 (0.34)**	−0.04	−1.09 (0.34)*	−0.02	−1.04 (0.35)*	−0.02
Non-native English speaker	−1.24 (0.30)**	−0.04	−1.11 (0.25)**	−0.04	−2.38 (0.25)**	−0.09	−2.50 (0.26)**	−0.09
Family Composition								
Living with one biological parent only	−1.31 (0.23)**	−0.05	−1.07 (0.19)**	−0.04	−0.87 (0.19)**	−0.04	−0.94 (0.20)**	−0.04
Living with one biological parent and one stepparent	−2.21 (0.25)**	−0.07	−1.80 (0.21)**	−0.07	−1.75 (0.21)**	−0.07	−1.84 (0.21)**	−0.07
Living with nonbiological parent(s) or guardian(s)	−3.52 (0.45)**	−0.06	−2.95 (0.37)**	−0.06	−2.45 (0.37)**	−0.05	−2.48 (0.38)**	−0.05

*Note. SD*s are shown in parentheses. Gender was dummy coded with male as the reference category; for race, white was used as a reference; for home language, English as a native language was used as a reference; and for family composition, living with biological parents was used as a reference. $^{\dagger}p < .10$, $^{*}p < .05$, $^{**}p < .001$.

Table 4). In contrast, frequent video gaming on weekends positively predicted IRT scale scores for mathematics ($B = 0.26$, $SE = 0.06$, 95% CI = [0.14, 0.38], $p < .001$) and reading ($B = 0.28$, $SE = 0.05$, 95% CI = [0.18, 0.38], $p < .001$), with very small effect sizes. These findings suggest that video gaming on weekdays and weekends may have different associations with academic performance.

Consistently, the frequency of video gaming on weekdays also negatively predicted IRT T-scores for mathematics ($B = -0.64$, $SE = 0.06$, 95% CI = [-0.76, −0.51], $p < .001$) and reading ($B = -0.66$, $SE = 0.07$, 95% CI = [-0.79, −0.53], $p < .001$), while the frequency of video gaming on weekends positively predicted IRT T-scores for mathematics ($B = 0.22$, $SE = 0.05$, 95% CI = [0.12, 0.33], $p < .001$) and reading ($B = 0.29$, $SE = 0.05$, 95% CI = [0.19, 0.40], $p < .001$).

Furthermore, a slope differentiation test consistently showed significantly higher coefficient estimates for the frequency of video gaming on weekdays than on weekends, $ps < 0.001$. These results indicate that among 10th graders, frequent video gaming on weekdays is associated with poorer academic performance, whereas frequent video gaming on weekends is associated with better academic performance, with small and very small effect sizes respectively. This finding supports differential associations between video gaming on weekdays (compared to weekends) and academic performance.

Table 5
Coefficient Estimates on IRT Scale Scores and IRT T-Scores for Mathematics, Reading, and Science in the NELS dataset with Frequency of Video Gaming on Weekdays and Weekdays as Predictors.

	Mathematics				Reading				Science			
	IRT Scale Scores		IRT T-Scores		IRT Scale Scores		IRT T-Scores		IRT Scale Scores		IRT T-Scores	
	B (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta	*B* (SE)	Beta
Predictor												
Weekday video-game frequency	−1.40 (0.23)**	−0.09	−0.96 (0.16)**	−0.09	−1.16 (0.17)**	−0.11	−1.12 (0.16)**	−0.11	−0.68 (0.10)**	−0.10	−1.07 (0.16)**	−0.10
Weekend video-game frequency	0.33 (0.18)†	0.03	0.22 (0.12)†	0.03	0.16 (0.13)	0.02	0.15 (0.13)	0.02	−0.18 (0.08)*	0.04	0.29 (0.13)*	0.04
Covariates												
Gender (female)	−1.82 (0.29)**	−0.07	−1.24 (0.20)**	−0.07	1.79 (0.21)**	0.09	1.75 (0.20)**	0.09 (0.01)**	−2.09 (0.13)**	−0.17	−3.32 (0.20)**	−0.17
Socioeconomic status	7.20 (0.19)**	0.41	4.92 (0.13)**	0.41	4.33 (0.14)**	0.35	4.19 (0.13)**	0.35 (0.01)**	2.67 (0.08)**	0.34	4.24 (0.13)**	0.34
Race												
Hispanic	−3.47 (0.50)**	−0.08	−2.37 (0.34)**	−0.08	−1.19 (0.37)*	−0.04	−1.16 (0.36)*	−0.04 (0.01)*	−1.80 (0.22)**	−0.10	−2.87 (0.35)**	−0.10
African American	−6.33 (0.54)**	−0.12	−4.32 (0.37)**	−0.11	−3.92 (0.40)**	−0.11	−3.82 (0.39)**	−0.11 (0.01)**	−3.76 (0.24)**	−0.17	−5.96 (0.38)**	−0.17
Asian	3.57 (0.60)**	0.07	2.44 (0.41)**	0.07	1.26 (0.44)*	0.03	1.20 (0.42)*	0.03 (0.01)*	0.47 (0.26)†	0.02	0.75 (0.42)†	0.02
Native American	−5.85 (1.56)**	−0.04	−3.99 (1.07)**	−0.04	−3.77 (1.03)**	−0.04	−3.67 (1.00)**	−0.04 (0.01)**	−2.69 (0.63)**	−0.04	−4.26 (0.99)**	−0.04
Non-native English speaker	0.61 (0.55)	0.01	0.42 (0.37)	0.01	−1.51 (0.39)**	−0.05 (0.01)**	−1.45 (0.38)**	−0.05 (0.01)**	−0.57 (0.24)*	−0.03	−0.90 (0.38)*	−0.03
Family Composition												
Living with one biological parent only	−0.85 (0.41)*	−0.02	−0.58 (0.28)*	−0.02	−0.29 (0.29)	−0.01 (0.01)	−0.29 (0.29)	−0.01 (0.01)	−0.42 (0.18)*	−0.03	−0.66 (0.28)*	−0.03
Living with one biological parent and one stepparent	−2.16 (0.44)**	−0.05	−1.48 (0.30)**	−0.05	−0.66 (0.32)*	−0.02 (0.01)*	−0.64 (0.31)*	−0.02 (0.01)*	−0.82 (0.19)**	−0.04	−1.30 (0.31)**	−0.04
Living with non-biological parent(s) or guardian(s)	−3.70 (1.03)**	−0.04	−2.53 (0.70)**	−0.04	−1.62 (0.78)*	−0.02 (0.01)*	−1.56 (0.75)*	−0.02 (0.01)*	−0.86 (0.43)*	−0.02	−1.36 (0.67)*	−0.02

*Note. SD*s are shown in parentheses. Gender was dummy coded with male as the reference category; for race, white was used as a reference; for home language, English as a native language was used as a reference; and for family composition, living with biological parents was used as a reference. †$p < .10$, *$p < .05$, **$p < .001$.

2.3. The NELS

A similar series of analyses was performed for the NELS. When controlling for the same covariates, we found that frequent video gaming on weekdays negatively predicted IRT scale scores for mathematics ($B = -1.40$, $SE = 0.23$, 95% CI = [-1.85, −0.95], $p < .001$); reading ($B = -1.16$, $SE = 0.17$, 95% CI = [-1.48, −0.83]; $p < .001$); and science ($B = -0.68$, $SE = 0.10$, 95% CI = [-0.87, −0.48], $p < .001$; see Table 5), with small effect sizes. In contrast, frequent video gaming on weekends emerged as a significant positive predictor of IRT scale scores for science with very small effect sizes ($B = 0.18$, $SE = 0.08$, 95% CI = [0.26, 0.34], $p = .022$), but not for IRT scale scores for mathematics ($B = 0.33$, $SE = 0.18$, 95% CI = [-0.03, 0.68], $p = .069$) and reading ($B = 0.16$, $SE = 0.13$, 95% CI = [0.10, 0.41], $p = .232$).

Similarly, we also found that frequent video gaming on weekdays negatively predicted IRT T-scores for mathematics ($B = -0.96$, $SE = 0.16$, 95% CI = [-1.27, −0.65], $p < .001$); reading ($B = -1.12$, $SE = 0.16$, 95% CI = [-1.43, −0.80], $p < .001$); and science ($B = -1.07$, $SE = 0.16$, 95% CI = [-1.39, −0.76], $p < .001$). However, frequent video gaming on weekends emerged as a significant positive predictor of IRT scale scores for science ($B = 0.29$, $SE = 0.13$, 95% CI = [0.04, 0.54], $p = .022$), but did not predict IRT scale scores for mathematics ($B = 0.22$, $SE = 0.12$, 95% CI = [-0.02, 0.47], $p = .069$), and reading ($B = 0.15$, $SE = 0.13$, 95% CI = [-0.10, 0.40], $p = .232$).

Slope differentiation tests for each subject showed significantly higher coefficient estimates for the frequency of video gaming on weekdays than on weekends (*ps* < 0.001). Consistent with the ECLS and ELS, we found a small but significantly negative relationship between video gaming on weekdays and academic performance. However, we found somewhat mixed results (i.e., either a null or very small positive relation between video gaming on weekends and academic performance in mathematics, reading, and science).

3. Discussion

Using three independent, large-scale datasets, we obtained findings that shed light on the theoretical relationship between video gaming and academic performance. Specifically, we found a negative relationship between weekday video gaming and academic performance. In contrast, we found a positive relationship between weekend video gaming and academic outcomes. These results highlight the importance of the context in which adolescents play video games.

We argue that the different relations between weekday and weekend video gaming and academic performance can be attributed to contextual conditions. On weekdays, when students spend most of their daytime hours at school and devote more time in the evening to studying than leisure, frequent video gaming can potentially erode students' engagement in and motivation for learning. Moreover, given that students' free time is relatively more limited during weekdays than weekends, weekday video gaming is more likely to displace time that might otherwise be spent on educational activities. Therefore, weekday video gaming potentially affects academic performance more than weekend video gaming, and this likely accounts for the negative association between weekday video gaming and academic performance. However, this should be interpreted cautiously, owing to small effect sizes (Bs $= -0.09$ to -0.16) and the fact that our dataset did not allow us to directly assess time spent on academically related activities. Therefore, it will be valuable for future studies to corroborate these findings and employ more direct measures of time spent on video gaming and academic activities.

The positive relation between weekend video gaming and academic performance can be attributed to several potential factors. Since weekends are generally devoted to leisure or recreation activities, weekend video gaming may serve as a rewarding and enjoyable leisure experience that can de-stress, energize, and motivate students to focus on their academic goals and achievements during the week. Further, previous studies have suggested that video games are beneficial for academic success, via their facilitating effects on higher-order cognitive abilities (Green & Bavelier, 2015). These explanations, however, should be considered with the following caveats.

First, although the relation between weekend video gaming and academic performance was significant, standardized effect sizes were very small (all Bs < 0.10), which suggests that the positive link between these variables might be trivial. This would be consistent with recent findings that cast doubt on the cognitive benefits of video gaming (e.g., Boot, Blakely, & Simons, 2011; Unsworth et al., 2015). Second, the magnitude of negative coefficients for weekday frequency was much larger than that of positive coefficients for weekend frequency. This suggests that even if video games are positively related to cognitive abilities that are critical for academic success, they do not outweigh the negative associations between (weekday) video gaming and academic outcomes, since interrupted school work more directly influences academic performance.

Our study is not without drawbacks. First, its cross-sectional design limits our ability to determine causality; for instance, a competing explanation for our findings is that academically underperforming students spend more time video gaming during weekdays than do academically capable students, who may prefer investing more time in educational activities. Therefore, future research should ascertain the directionality between video-game frequency and academic performance using longitudinal designs. Relatedly, our study does not answer the question of whether the observed effects of video games can be attributed to either short-term or long-term video gaming. Although adolescents with long-term experience of intense video gaming are more likely to perform better on tasks measuring higher-order cognitive abilities (see Hartanto et al., 2016), our study does not delineate the relative contributions of different durations of video gaming.

Another limitation of our study is that the datasets we analyzed were based on U.S. samples, and therefore our results may not be generalizable to other countries or cultures; replicating our findings with samples from other countries would be an intriguing avenue for future studies. Further, even though we have controlled for a multitude of confounding variables (e.g., SES, gender, etc.), future research should consider other psychopathological factors (e.g., Attention Deficit Hyperactive Disorder, depression) that have been shown to disrupt academic performance (Andrews & Wilding, 2004; Daley & Birchwood, 2010). Lastly, given that the three datasets were collected at different time points (ECLS in 2007, ELS in 2002, and NELS in 1992), it is difficult to draw any clear conclusion about the role of age in the relation between video gaming and academic performance because of possible cohort effects. Adolescent video gamers in the 1990s may have experienced different school curricula or video games from their counterparts in the 2000s. Specifically, since video games are now more complex, advanced, and stimulating than in the 1990s, it is plausible that different video game content or genres might have had different influences on adolescents' cognitive functioning and school activities. Indeed, transfer effects seem to depend on a video game's content and genre, with some (e.g., action video games, exergames) proffering more cognitive benefits than others (e.g., Glass, Maddox, & Love, 2013; Green & Bavelier, 2008; Staiano & Calvert, 2011). Future studies, therefore, should assess the effect of video-game genres on higher-order cognitive abilities and academic outcomes.

Nevertheless, our study has several notable strengths that contribute to the literature. First, we addressed the issues of low power and lack of generalizability found in previous studies (e.g., Anand, 2007; Creasey & Myers, 1986) by employing three independent datasets with large sample sizes. Second, by using a more precise classification scheme for video-gaming frequency, we showed that weekday and weekend video gaming are differentially associated with academic performance; this result could shed light on the null findings of Drummond and Sauer (2014). Third, our study controlled for the risk of potential third variables that could have confounded previous results. Finally, by taking into account the different effects of weekday and weekend video gaming, we were able to elucidate different theoretical predictions on the relationship between video gaming and academic performance.

In conclusion, our study sheds light on widely held concerns about whether video games disrupt adolescents' academic performance. We found that weekday video gaming was consistently associated with poorer academic performance, whereas weekend video gaming was associated with slightly better academic outcomes. These results suggest that video gaming may confer either advantages or disadvantages on academic outcomes, contingent on the context in which it occurs.

Appendix. Multilevel model analysis with two levels (students nested within schools) in the ELCS

Table A
Multilevel Model Summaries of IRT Scale Scores and IRT T-Scores for Mathematics in the ECLS

	IRT Scale Scores			IRT T-Scores		
	Model 1	Model 2	Model 3[a]	Model 1	Model 2	Model 3[a]
Regression Coefficients						
Intercept	149.96 (0.51)**	149.85 (0.51)**	149.74 (0.53)**	54.92 (0.23)**	54.91 (0.23)**	54.88 (0.23)**
Weekdays video-game frequency	−1.92 (0.19)**	−1.89 (0.20)**	−1.84 (0.23)**	−0.82 (0.08)**	−0.82 (0.08)**	−0.81 (0.09)**
Weekends video-game frequency	0.45 (0.15)*	0.46 (0.15)*	0.44 (0.15)*	0.15 (0.07)*	0.15 (0.07)*	0.15 (0.07)*
Gender (female)	−3.41 (0.44)**	−3.33 (0.43)**	−3.33 (0.43)**	−1.74 (0.19)**	−1.74 (0.19)**	−1.72 (0.19)**
Socioeconomic status	8.03 (0.30)**	8.03 (0.30)**	7.93 (0.30)**	3.81 (0.14)**	3.81 (0.14)**	3.79 (0.14)**
Race						
Hispanic	−4.09 (0.69)**	−4.06 (0.69)**	−4.04 (0.69)**	−1.77 (0.31)**	−1.74 (0.31)**	−1.76 (0.31)**
African American	−11.41 (0.81)**	−11.46 (0.82)**	−11.48 (0.83)**	−4.64 (0.36)**	−4.64 (0.36)**	−4.64 (0.37)**
Asian	3.75 (0.94)**	3.69 (0.93)**	3.70 (0.94)**	2.31 (0.49)**	2.33 (0.42)**	2.32 (0.42)**
Native American	−6.79 (1.82)**	−6.72 (1.83)**	−6.36 (1.87)*	−2.48 (0.82)*	−2.61 (0.80)*	−2.44 (0.82)*
Multiracial	−2.11 (1.36)	−1.96 (1.36)	−1.76 (1.37)	−0.83 (0.61)	−0.84 (0.61)	−0.79 (0.61)
Non-native English speaker	−2.92 (0.71)**	−2.85 (0.71)**	−2.84 (0.71)**	−0.85 (0.32)*	−0.96 (0.32)*	−0.95 (0.30)*
Family Composition						
Living with one biological parent only	−2.92 (0.56)**	−2.05 (0.56)**	−2.00 (0.56)**	−0.92 (0.25)**	−0.92 (0.25)**	−0.90 (0.25)**
Living with one biological parent and one stepparent	−2.32 (0.65)**	−2.25 (0.65)*	−2.13 (0.65)*	−1.30 (0.29)**	−1.30 (0.29)**	−1.26 (0.29)**
Living with non-biological parent(s) or guardian(s)	−5.23 (1.11)**	−5.19 (1.11)**	−5.24 (1.11)**	−2.51 (0.50)**	−2.55 (0.50)**	−2.56 (0.50)**
Variance Components						
Residual	293.47 (5.30)**	285.67 (5.46)**	275.66 (5.31)**	58.69 (1.05)**	58.19 (1.09)**	57.06 (1.08)**
Intercept	37.71 (4.29)**	43.32 (5.74)**	59.37 (8.35)**	7.63 (0.82)**	9.73 (1.16)**	10.84 (1.46)**
Weekdays video-game frequency		3.34 (0.95)**	12.62 (2.59)**		0.23 (0.15)	1.30 (0.38)*
Weekends video-game frequency			-[b]			-[b]
Fit Statistics						
−2 Restricted Log Likelihood (-2LL)	68314.95	68296.17	68319.71	55554.26	55544.41	55558.49
Akaike's Information Criterion (AIC)	68346.95	68332.17	68361.71	55586.26	55580.41	55600.49

Note. SEs are shown in parentheses. Model 1 included intercept as a random effect, Model 2 included intercept and weekdays video-game frequency as random effects, and Model 3 included intercept, weekday video-game frequency and weekend video-game frequency as random effects. Gender was dummy coded with male as the reference category; for race, white was used as a reference; for home language, English as a native language was used as a reference; and for family composition, living with biological parents was used as a reference. $^{*}p < .05$, $^{**}p < .001$.

[a] Estimates should be interpreted with caution as convergence has not been achieved.

[b] Test statistic cannot be computed due to redundancy of the covariance parameter.

Table B
Multilevel Model Summaries of IRT Scale Scores and IRT T-Scores for Reading in the ECLS

	IRT Scale Scores			IRT T-Scores		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3[a]
Regression Coefficients						
Intercept	176.69 (0.63)**	176.63 (0.62)**	176.62 (0.61)**	53.57 (0.23)**	53.57 (0.23)**	53.57 (0.23)**
Weekdays video-game frequency	−2.67 (0.23)**	−2.62 (0.25)**	−2.65 (0.26)**	−0.92 (0.08)**	−0.92 (0.08)**	−0.93 (0.08)**
Weekends video-game frequency	0.88 (0.18)**	0.86 (0.18)**	0.89 (0.19)**	0.26 (0.07)*	0.26 (0.07)*	0.26 (0.07)*
Gender (female)	4.06 (0.53)**	4.15 (0.54)**	4.19 (0.54)**	1.35 (0.20)**	1.35 (0.20)**	1.35 (0.20)**
Socioeconomic status	10.65 (0.37)**	10.65 (0.37)**	10.67 (0.37)**	4.23 (0.14)**	4.23 (0.14)**	4.23 (0.14)**
Race						
Hispanic	−6.53 (0.85)**	−6.41 (0.85)**	−6.45 (0.85)**	−2.24 (0.31)**	−2.23 (0.31)**	−2.23 (0.31)**
African American	−14.44 (1.00)**	−14.45 (1.01)**	−14.45 (1.01)**	−4.75 (0.36)**	−4.76 (0.36)**	−4.75 (0.36)**
Asian	1.72 (1.16)	1.65 (1.15)	1.61 (1.15)	0.68 (0.41)	0.69 (0.42)	0.68 (0.42)
Native American	−9.57 (2.24)**	−8.98 (2.23)**	−8.99 (2.26)**	−3.34 (0.80)**	−3.40 (0.79)**	−3.39 (0.79)**
Multiracial	−1.70 (1.69)	−1.68 (1.68)	−1.75 (1.68)	−0.69 (0.61)	−0.68 (0.61)	−0.67 (0.61)
Non-native English speaker	−5.05 (0.88)**	−4.96 (0.88)**	−4.95 (0.88)**	−1.41 (0.32)**	−1.42 (0.32)**	−1.41 (0.32)**
Family Composition						
Living with one biological parent only	−2.16 (0.69)*	−2.25 (0.69)*	−2.24 (0.69)*	−0.70 (0.25)*	−0.69 (0.25)*	−0.69 (0.25)*
Living with one biological parent and one stepparent	−4.88 (0.81)**	−4.92 (0.88)**	−4.93 (0.81)**	−1.93 (0.30)**	−1.92 (0.29)**	−1.92 (0.29)**
Living with non-biological parent(s) or guardian(s)	−5.05 (1.37)**	−4.88 (1.37)**	−4.92 (1.38)**	−1.98 (0.50)**	−1.99 (0.50)**	−1.99 (0.50)**
Variance Components						
Residual	452.09 (8.36)**	441.11 (8.54)**	439.09 (8.94)**	60.71 (1.10)**	60.48 (1.14)**	60.35 (1.13)**
Intercept	52.87 (7.04)**	40.23 (7.74)**	35.97 (8.85)**	5.56 (0.80)**	6.31 (1.05)**	6.14 (1.19)**
Weekdays video-game frequency		4.78 (1.39)*	8,71 (2.90)*		0.10 (0.14)	0.09 (0.25)
Weekends video-game frequency			1.32 (1.46)			-[b]
Fit Statistics						
−2 Restricted Log Likelihood (-2LL)	71691.26	71654.53	71650.51	55643.01	55641.54	55641.24
Akaike's Information Criterion (AIC)	71723.26	71690.53	71692.53	55675.01	55677.54	55683.24

Note. SEs are shown in parentheses. Model 1 included intercept as a random effect, Model 2 included intercept and weekdays video-game frequency as random effects, and Model 3 included intercept, weekday video-game frequency and weekend video-game frequency as random effects. Gender was dummy coded with male as the reference category; for race, white was used as a reference; for home language, English as a native language was used as a reference; and for family composition, living with biological parents was used as a reference. $^{*}p < .05$, $^{**}p < .001$.

[a] Estimates should be interpreted with caution as convergence has not been achieved.

[b] Test statistic cannot be computed due to redundancy of the covariance parameter.

Table C
Multilevel Model Summaries of IRT Scale Scores and IRT T-Scores for Science in the ECLS

	IRT Scale Scores			IRT T-Scores		
	Model 1	Model 2	Model 3[a]	Model 1	Model 2	Model 3[a]
Regression Coefficients						
Intercept	91.10 (0.35)**	91.11 (0.35)**	91.10 (0.36)**	55.44 (0.22)**	55.44 (0.22)**	55.37 (0.22)**
Weekdays video-game frequency	−1.28 (0.13)**	−1.29 (0.14)**	−1.30 (0.15)**	−0.78 (0.08)**	−0.78 (0.08)**	−0.79 (0.09)**
Weekends video-game frequency	0.44 (0.10)**	0.44 (0.10)**	0.46 (0.11)**	0.23 (0.06)**	0.23 (0.06)**	0.25 (0.07)**
Gender (female)	−3.22 (0.31)**	−3.20 (0.31)**	−3.20 (0.30)**	−2.33 (0.19)**	−2.33 (0.19)**	−2.32 (0.19)**
Socioeconomic status	5.86 (0.21)**	5.86 (0.21)**	5.84 (0.21)**	3.80 (0.13)**	3.80 (0.13)**	3.76 (0.13)**
Race						
Hispanic	−4.85 (0.48)**	−4.84 (0.48)**	−4.89 (0.48)**	−2.79 (0.29)**	−2.79 (0.29)**	−2.75 (0.30)**
African American	−11.79 (0.57)**	−11.80 (0.57)**	−11.83 (0.57)**	−6.64 (0.35)**	−6.64 (0.34)**	−6.59 (0.35)**
Asian	−0.10 (0.65)	−0.10 (0.65)	−0.11 (0.65)	0.11 (0.40)	0.11 (0.40)	0.17 (0.40)
Native American	−6.83 (1.26)**	−6.82 (1.27)**	−6.98 (1.26)**	−3.69 (0.76)**	−3.73 (0.76)**	−3.44 (0.78)**
Multiracial	−1.36 (0.96)	−1.37 (0.96)	−1.39 (0.96)	−1.03 (0.59)	−1.03 (0.59)	−0.99 (0.59)
Non-native English speaker	−2.44 (0.50)**	−2.42 (0.50)**	−2.41 (0.50)**	−1.32 (0.31)**	−1.33 (0.30)**	−1.33 (0.31)**
Family Composition						
Living with one biological parent only	−1.00 (0.39)*	−1.02 (0.39)*	−1.01 (0.39)*	−0.60 (0.24)*	−0.60 (0.24)*	−0.55 (0.24)*
Living with one biological parent and one stepparent	−1.54 (0.46)*	−1.52 (0.46)*	−1.51 (0.46)*	−1.23 (0.28)**	−1.23 (0.28)**	−1.21 (0.28)**
Living with non-biological parent(s) or guardian(s)	−3.14 (0.78)**	−3.17 (0.78)**	−3.26 (0.78)**	−1.95 (0.48)**	−1.96 (0.48)**	−1.97 (0.48)**
Variance Components						
Residual	146.22 (2.66)**	143.87 (2.75)**	142.16 (2.82)**	55.50 (0.99)**	55.43 (1.03)**	53.59 (1.05)**
Intercept	15.42 (2.05)**	15.80 (2.65)**	18.11 (3.17)**	5.00 (0.68)**	5.66 (0.93)**	7.98 (1.28)**
Weekdays video-game frequency		1.01 (0.42)*	3.06 (0.86)**		0.03 (0.12)	0.71 (0.12)*
Weekends video-game frequency			0.82 (0.46)			0.65 (0.24)*
Fit Statistics						
−2 Restricted Log Likelihood (-2LL)	62683.59	62674.00	62659.14	54924.41	54922.94	54931.53
Akaike's Information Criterion (AIC)	62715.59	62710.00	62701.14	54956.41	54958.94	54973.53

Note. SEs are shown in parentheses. Model 1 included intercept as a random effect, Model 2 included intercept and weekdays video-game frequency as random effects, and Model 3 included intercept, weekday video-game frequency and weekend video-game frequency as random effects. Gender was dummy coded with male as the reference category; for race, white was used as a reference; for home language, English as a native language was used as a reference; and for family composition, living with biological parents was used as a reference. $^{*}p < .05$, $^{**}p < .001$.

[a] Estimates should be interpreted with caution as convergence has not been achieved.

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