CHILD DEVELOPMENT

Child Development, March/April 2013, Volume 84, Number 2, Pages 752–766

Child Care Quality and Cognitive Development: Trajectories Leading to Better Preacademic Skills

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The associations between trajectories of child care quality from ages 2 to 4 years and children's cognitive performance at 4 years (n = 250) were tested. Distinct quality trajectories were identified: low and high ascending Teaching and Interactions trajectory; low and high Provision for Learning trajectory. Membership in the high ascending Teaching and Interactions trajectory was associated with better numeracy (effect size [ES] = .39, confidence interval [CI] = .21–.66), receptive vocabulary (ES = .41, CI = .14–.68), and school readiness (ES = .32, CI = .06–.58). The results suggest that a pattern of increasing quality of teacher–child interactions during the preschool years, particularly with regard to supporting the development of language, has a moderate impact on children's cognitive development.

Over the past 50 years, nonmaternal child care has gradually become more prevalent, and considerable attention has been given to its role in children's early cognitive and language development (Vandell, Belsky, Burchinal, Steinberg, & Vandergrift, 2010). In large population-based studies, research questions have focused on comparing children receiving different intensities of child care and children evolving in different types of child care settings. Most population-based studies find a positive impact of child care on cognitive development, but some report negative impacts, especially for child care initiated in infancy (e.g., Hill, Waldfogel, Brooks-Gunn, & Han, 2005).

Although a relatively large number of studies compared children receiving different intensities of child care services, fewer studies have examined differences in child care quality. Examining the role of child care quality is important because a positive or negative impact of child care may be detected only under high- or low-quality conditions. Examining the role of child care quality is also important as it may provide information on the aspects of child care services that could be targeted for further improvement of services.

In the present study, we examine the associations between child care quality assessed between 2 and 4 years and children's preacademic skills at 4 years. We had two specific objectives; the first was to examine the extent to which *patterns of change* in child care quality over time predicted cognitive performance. The second was to examine whether or not *distinct dimensions* of quality were particularly relevant to cognitive performance.

Child Care Quality and Cognitive Development

Most studies of quality of care in diverse populations rely on small samples, with three notable exceptions, and the bulk of this work found higher

This study was made possible by grants to SMC, JRS, and RET from the Canadian Institutes for Health Research (MOP 79420), and to SMC from the Canadian Council on Learning and from the Canadian Psychiatric Research Foundation (2005–2006 CPRF).

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 0009-3920/2013/8402-0027
DOI: 10.1111/cdev.12007

quality care to be associated with better cognitive outcomes. The Cost, Quality, and Child Outcomes in Child Care Centers Study (CQO; $n = 826$); the NICHD Study of Early Child Care and Youth Development (SECCYD, $n = 1364$) and the National Early Childhood Research Project (NCEDL) are U.S.based studies relying on large and economically diverse samples and including short- or long-term follow-ups. These studies have shown modest albeit significant associations between higher child care quality and cognitive development (Burchinal et al., 2008; NICHD ECCRN, 2005; Peisner-Feinberg et al., 2001). In NCEDL, the quality of prekindergarten teacher–child interaction was related to better cognitive scores at the end of kindergarten (Burchinal et al., 2008). In the SECCYD, the effects of child care quality during the preschool years were shown to last into middle childhood (Dearing, McCartney, & Taylor, 2009; Downer & Pianta, 2006; NICHD ECCRN, 2005) and adolescence (Vandell et al., 2010). Smaller international studies conducted in Chile (Herrera, Mathiesen, Merino, & Recart, 2005), Sweden (Broberg, Wessels, Lamb, & Hwang, 1997), Bermuda (Chin-Quee & Scarr, 1994), and the United States (Burchinal et al., 2000) have also found benefits of quality child care on children's short-term cognitive development. Apart from the NICHD SECCYD, however, none of these studies examined the impact of change in child care quality over time on children's cognitive development.

Although many reports from the NICHD SECCYD treated the repeated measures of child care quality as an average across time (between 6 and 54 months), some addressed the question of whether the timing of quality was important. NICHD and Duncan (2003) compared the contribution of early (6, 15, and 24 months) and late (36 and 54 months) quality and showed that both periods were significantly and independently associated with pre-K cognitive and preacademic achievement scores. Two studies using hierarchical linear modeling (HLM) individual growth curves showed that both initial levels of quality and increase in quality over time were related to higher preacademic skills (Hirsh-Pasek & Burchinal, 2006; NICHD ECCRN, 2002). In one report, Hirsh-Pasek and Burchinal (2006) also used a trajectory group-based approach and found no significant differences in child outcomes across the four patterns of global quality that were identified. It is possible that the limited amount of variability in the patterns of quality over time could explain the null findings (Hirsh-Pasek & Burchinal, 2006).

In the present study, we examined the patterns of variation in child care quality over the preschool years using a group-based methodological approach (Jones, Nagin, & Roeder, 2001). The method provides a dynamic description of the patterns of variation in quality over time for distinct groups of children and aims at answering the following questions: Are there groups of children exposed to distinct levels of child care quality over time? What proportion of children are assigned to the distinct groups? What patterns of stability or change do we observe? A first advantage of using this approach is that it allows for the identification of groups based on the use of an empirical criterion as opposed to an arbitrary cut-off. Consequently, the proportion of children exposed to varying levels of quality over time is defined without the imposition of a predefined criterion of the level at which quality is considered high or low or the number of children assigned to a given group. As such, it provides a description of the "natural" course of child care quality over time in a population. A second advantage is that, depending on the trajectory patterns identified, it may be possible to examine whether or not variations in child care quality over time are related to variations in child outcomes. For instance, one could test whether consistently high quality is superior to rising levels of quality, or whether consistently low levels of quality is worse that diminishing levels of quality. Such information is important to identify sensitive periods when children are potentially more responsive to quality. Finally, the reliance on multiple measures of quality as well as the grouping of children according to a trajectory pattern that most resemble their own reduces the measurement error related to a single assessment. This is particularly relevant for a phenomenon with potentially important contextual variations such as day care quality.

Specific Dimensions of Child Care Quality

Child care quality studies have used tools to assess process quality, that is, proximal-level interactions and transactions among teachers, children, and materials (Bronfenbrenner & Morris, 1998; Pianta et al., 2005). The Early Childhood Environmental Rating Scale–Revised (ECERS–R; Harms, Clifford, & Cryer, 1998) and its associated instruments, the Infant Toddler Environmental Rating Scale–Revised (ITERS–R; Harms, Cryer, & Clifford, 2003) and the Family Day Care Rating Scale (FDCRS; Harms & Clifford, 1989, 1993) have been widely used to assess child care process quality (Perlman, Zellman, & Le, 2004). These observational instruments

provide assessments of comparable dimensions in different settings (i.e., families vs. centers) and at different ages.

Using the ECERS–R, previous center-based studies identified two main quality factors—Teaching and Interactions as well as Provisions for Learning, which present the best psychometric properties (Clifford et al., 2005; Howes et al., 2008; Pianta et al., 2005). It is suggested that the two factors better reflect the quality of child care settings than the ECERS–R global scale or subscales. The Teaching and Interactions dimension reflects the warmth, the richness and appropriateness of interactions in the classroom. The Provisions for Learning dimension reflects children's access to and use of appropriate learning materials.

The Present Study

In the present study, we examine the associations between child care quality assessed at ages 2, 3, and 4 years and children's school readiness, receptive vocabulary, and numeracy skills and knowledge at age 4 years among a sample of Canadian children. There are four particularly novel aspects to the study. First, we examine the extent to which child care quality varies over time and we identify groups of children who follow distinct developmental patterns of child care quality. This modeling strategy identifies distinct groups without imposing arbitrary cutoffs. Second, we examined associations with cognitive development with two quality dimensions unexplored in previous *longitudinal* analyses—Teaching and Interactions as well as Provisions for Learning. Third, we examine quality over time across a variety of child care settings, some family based and some center based. Finally, a unique aspect of the present study is the follow-up of families starting prenatally and the inclusion of pre- and perinatal control variables known to influence cognitive development such as smoking during pregnancy, birth weight, and prematurity (Huijbregts et al., 2006).

Method

Participants

Participants in the study were drawn from a larger pool (n = 809) of families with a child born between June 2003 and April 2004 and having taken part in a prenatal–perinatal study conducted in four Montreal maternity hospitals (for details, see Kramer et al., 2001). The sample excluded children hospitalized at birth, diagnosed with a disability, adolescent mothers, and mothers who did not speak French or English. Prior to the children's second birthday, families were invited to participate in a follow-up study concerning the development of their preschool child. The first data collection involved 497 families (2005–2006, M = 27.6 months, SD = 3.2; hereafter referred as 2 years); 440 in the second data collection (2006–2007, M = 39.6 months, SD = 3.1; hereafter referred as 3 years), and 396 at the third follow-up (2007–2008, M = 52.7 months, SD = 3.3; hereafter referred as 4 years). Only families using child care on a regular basis (at least 10 hr per week) are examined in this study.

The analysis sample included 257 families for whom at least one quality assessment and *at least one* of the cognitive assessments at 4 years of age were available. Compared to families for whom at least one quality assessment was completed (n = 359), the final sample (n = 257) included a smaller proportion of families with insufficient income (11.3% vs. 30.4%; $\chi^2 = 13.34$, $p > .001$). There were also smaller proportions of single mothers (7.6% vs. 9.5%, $\chi^2 = 0.32$, $p = .57$) and of mothers with lower levels of education (29% of mothers vs. 35.6%, $\chi^2 = 1.35$, $p = .25$), but these differences were not significant. In this sample, 30.4%, 27.9%, and 41.8% of children had one, two, and three assessments, respectively.

Table 1 presents the family and child characteristics of the sample. Most mothers had completed 13 years of schooling (2 years beyond high school) and 11.5% of families had an income considered insufficient according to Statistics Canada. Most parents were born in Canada and the primary language of most children was either French or English. The sample was relatively more advantaged than a representative sample of Quebec families (Côté et al., 2007; Côté et al., 2009).

Table 2 presents the proportions of children attending a center-based or family-based child care setting and the number of hours spent in each type at each age. The proportion of children attending center-based child care increased with age from 68.8% to 89.6%. Children spent approximately 35 hr per week in child care.

Measures and Procedures

We conducted parental interviews (mostly with mothers); child care quality assessments when the children were 2, 3, and 4 years old; and an individual cognitive assessment of the child at age 4 years. All procedures were approved by the Sainte-Justine

Table 1
Sample Description (n = *254*)

		Child age at data collection	*n*	%
Family characteristics				
Insufficient income	Yes	2 years	29	11.5
	No		223	88.5
Maternal education	< 13 years	2 years	75	29.5
	≥ 13 years		179	70.5
Paternal education	< 13 years	2 years	85	38.5
	≥ 13 years		136	61.5
Immigrant mother	Yes	2 years	64	25.2
	No		190	74.8
Single mother	Yes	2 years	20	7.9
	No		234	92.1
Maternal depression[a]	Yes	2 years	97	38.2
	No		157	61.8
Maternal smoking	Yes	Pregnancy	49	19.3
	No		205	80.7
Child characteristics				
Sex	Girls		129	50.8
	Boys		125	49.2
Premature birth[b]	Yes	Birth	20	7.9
	No		234	92.1
Low birth weight[c]	Yes	Birth	10	3.9
	No		244	96.1
Main language[d]	French	4 years	201	79.1
	English		39	15.4
	Other		14	5.5
Only child	Yes	2 years	126	49.6
	No		128	50.4

[a]Lifetime maternal depression assessed when the child was 2 years with a modified life-time depression section of the Diagnostic Interview Schedule (DIS; Roy et al., 2005). [b]Premature birth is birth at or before 37 weeks. [c]Low birth weight ≤ 2500 g. [d]*n* = 20 missing values.

Hospital research center (Reference No. 2094) and McGill Institutional Review Boards (Reference No. A01-B02-05A). Informed written consent was obtained annually from all parents, child care directors, and educators. Children were verbally assented at the 4 years cognitive assessment.

Child Care Quality at 2, 3, and 4 Years

Child care settings attended regularly (i.e., at least 10 hr per week) were invited to participate in the quality assessment. We first obtained parental consent for the child care assessment and then contacted the child care provider (director and educator) to introduce the study. Both the director and the educator needed to agree to participate in the study.

Table 2
Type and Intensity of Child Care During the Preschool Years

	Type			Hours per week		
	Age	*n*	%	*M*	*SD*	Range
Center based	2 years	128	68.8	36.56	8.77	10–52
Family based		58	31.2	36.34	8.60	16–60
				Global = 36.49	8.70	10–60
Center based	3 years	157	80.1	36.43	9.25	10–55
Family based		39	19.9	33.90	10.15	10–50
				Global = 35.92	9.47	10–55
Center based	4 years	198	89.6	34.40	11.89	10–55
Family based		23	10.4	33.22	14.28	10–55
				Global = 34.28	12.13	10–55

Participating child care services were scheduled for a visit by a trained research assistant. Observations took place in the spring and beginning of the summer of each year. We conducted a global observation of the quality of the environment for 3–5 hr. On average across years, 67% of child care providers accepted to be visited by the study team: 64.4% at 2 years, 60.5% at 3 years, and 75.9% at 4 years.

Given that different types of child care settings were assessed at different ages, center-based child care quality was assessed with the ECERS–R (Harms et al., 1998) for children 2½–4 years (43 items) and with the ITERS–R (Harms et al., 2003) for children under 2½ years. Family-based child care quality was assessed with the FDCRS (Harms & Clifford, 1993). The three instruments assess aspects of quality on analogous dimensions. Previous studies have established the similarity of measures between the ECERS and FDCRS (Growing Up in Poverty Project, 2000; Votruba-Drzal, Coley, & Chase-Lansdale, 2004). For each instrument, items were scored using a 7-point scale of quality, ranging from 1 (*inadequate*), 3 (*minimal*), 5 (*good*), to 7 (*excellent*).

Research assistants were trained following the instrument protocol with a specialized trainer. Completion of training required to reach an intraclass correlation greater than .80 for each step of training, with standard videotapes, and in direct observation of pilot child care settings. Reliability of the observations was insured by monthly discussion with the

trainer where specific ratings were analyzed and discussed.

Cognitive Outcomes at 4 Years

During the home visit when the children were 4 years old, cognitive tasks assessing school readiness, receptive vocabulary, and numeracy-related abilities were conducted by a trained research assistant. The cognitive tests were conducted in French (81.4%) or English (18.6%) according to the language most often spoken at home. For 95% of children, the language most often spoken at home was either French (79.1%) or English (15.4%) whereas it was neither French nor English in 5.5% of cases ($n = 14$). In those 5.5% of cases, the tests were administered in English or French depending on the language the child spoke most fluently at 4 years. In the regression models, we controlled for the fact that some children were mainly exposed to another language at home.

The Number Knowledge Task (NKT) measures the development of number concepts (Okamoto & Case, 1996). This test measures the mastery of a series of concepts required for learning math and comprises five levels. The total score corresponds to the number of items succeeded before the child reaches the criteria of three consecutives errors. This test is sensitive and normed for children aged 4–10 years.

The Peabody Picture Vocabulary Test–Revised (PPVT–R) is a receptive vocabulary test assessing the breath of vocabulary a child can understand. A child is asked to identify a spoken word in an array of four pictures, only one of which is correct. The total score corresponds to the number of correct responses until the criteria for failure is reached (ceiling level minus the number of mistakes). There are validated English and French Canadian (Dunn, Dunn, & Thériault-Whalen, 1993) versions of this test.

The Lollipop Test was developed to measure aspects of school readiness and is validated in English (Chew & Lang, 1990; Chew & Morris, 1984) and French (Venet, Normandeau, Letarte, & Bigras, 2003). It includes 52 questions, divided in four subtests concerning knowledge about: (a) colors and forms, (b) spatial relationships, (c) numbers, and (d) letters. Scores attributed to each question range from 0 (*failure*) to 5 (*success*).

Maternal, Child, and Family Characteristics Used as Control Variables

Control variables were collected at age 2 years except for birth weight, prematurity, and maternal smoking during pregnancy, which were collected at birth, and parenting practices, which were evaluated multiple times. Table 1 presents descriptive statistics for the covariates and the age at which the covariates were measured.

Child characteristics. Dichotomous variables were used to reflect whether the child was a boy or a girl and whether the child was an only child or not. Birth weight was coded as low (< 2500 g) versus normal (≥ 2500 g). A child was considered to be born prematurely if born at 37 weeks gestation or earlier. The main language of the child distinguished children who spoke one of the two official languages of Canada—French or English—from those who spoke another language. This variable corresponded to the main language used in the home.

Family and maternal characteristics. Family status distinguished single mothers from those living with a partner. The parental education variable distinguished parents who obtained a technical or preuniversity diploma (≥ 13 years of schooling) from those who did not (< 13 years); maternal immigration status distinguished mothers born in Canada from those born outside Canada. Family income was categorized as either sufficient or not following thresholds established by Statistics Canada for poverty (Statistics Canada, 2008). Calculation of the low-income threshold accounts for the family income, the size of the household and type of community the family lives in (rural, small or large city) and are based on data from the Survey of Household Spending (SHS; National Council of Welfare, 2008). We constructed a socioeconomic status (SES) variable to use as a control variable in the analyses. SES of the family is a composite score including three dichotomous variables: maternal and paternal education ($0 < 13$ years of schooling; $1 \geq 13$ years) and whether the family has an insufficient income according to Statistics Canada criteria (coded as 0) or not (coded as 1). The three variables were summed and divided by 3, yielding a score varying between 0 and 1 with a higher score indicating higher SES.

Maternal lifetime depression was assessed with seven questions from the modified lifetime depression section of the Diagnostic Interview Schedule (DIS; Roy et al., 2005). Mothers endorsing four or more items were coded as having had a major depressive episode. Maternal smoking during pregnancy distinguished between mothers who smoked regularly or occasionally from those who did not.

The Parental Cognitions and Conduct Toward the Infant Scale (PACOTIS; Boivin et al., 2005) was used to assess parenting. The scale has good psychometric

properties and has been used in several Canadian cohort studies (Boivin et al., 2005; Côté et al., 2007; Côté et al., 2009). Three types of age appropriate PACOTIS parenting practices were self-reported by mothers: positive parenting (e.g., congratulating the child; playing with the child), coercive parenting (e.g., physically punishing the child), and consistent parenting (e.g., when asking something to the child, making sure he or she complies [negative coding]). Answers ranged from *not at all what I think or did* (0) to *exactly what I think or did* (10). Positive parenting was assessed yearly wheras coercive and consistent parenting practices were assessed at ages 3 and 4 years. The means of the repeated assessments were standardized and used as covariates.

Statistical Analyses

Analyses were conducted in four steps. In the first step, we conducted factor analyses on items from the ITERS–R, ECERS–R, and FDCRS. In the second, we estimated group-based developmental trajectory models of child care quality between 2 and 4 years. In the third, we conducted descriptive analyses of the associations between quality trajectories, child care, cognitive, family and child variables. In the fourth, we modeled the multivariate associations between quality trajectories and cognitive outcomes at 4 years.

Identification of child care quality factors. We computed mean scores on items from the three quality instruments: ITERS–R, ECERS–R, and FDCRS, and we conducted an exploratory factor analysis to examine the psychometric properties of the two quality factors identified in previous studies: Teaching and Interactions and Provisions for Learning (Clifford et al., 2005; Howes et al., 2008; Pianta et al., 2005).

Identification of quality trajectories. Quality scores on the Teaching and Interactions and Provisions for Learning dimensions at 2, 3, and 4 years of age were analyzed using a semiparametric, mixture model (Jones et al., 2001; Nagin, 2005). The trajectory methodology uses all available developmental data points and assigns individuals to categories on the basis of a posterior probability rule. Resulting groups are meant to represent approximations of an underlying continuous process (Nagin, 2005; Nagin & Tremblay, 2001).

To identify the model with the preferred number of groups, we first estimated models with varying number of trajectories. Second, for each group in the preferred model, we estimated parameters for constant (i.e., intercept) and linear terms. We modeled the data according to a censored normal distribution. Selection of the best fitting model was determined using the Bayesian information criterion (BIC), as well as other fit indices such as the examination of the entropy and comparison of fitted versus observed values. The BIC was calculated as: $\mathrm{BIC} = -2\log(L) + \log(n) \times k$, where L is the model's maximized likelihood, n is the sample size, and k is the number of parameters in the model (Schwarz, 1978). The entropy is an index indicating the extent to which the groups are well separated. The models that minimized the BIC and maximized the entropy were chosen.

The statistical procedure yields, for every subject, the probability to be classified in each of the trajectory groups. For example, consider a child who received high-quality child care at each assessment. For this child, the posterior probability estimate of belonging to a low-quality trajectory group would be near zero, whereas the probability estimate of the child belonging to a high-quality group would be large, that is, close to 1. Each child was assigned to the group for which he or she had the largest posterior probability estimate. This is the group that best conforms to the observed child care quality to which he or she was exposed.

Descriptive analyses. We conducted bivariate analyses (chi squares or analyses of variance [ANOVAs]) to describe the association between the identified quality trajectory groups and the quality instruments, child care type, cognitive measures, and child and family variables.

Modeling the association between child care quality and cognitive outcomes. The main analyses involved multiple regression models on the cognitive measures of school readiness, receptive vocabulary, and numeracy assessments with the following predictor variables: (a) child and family control variables, (b) trajectories of quality between 2 and 4 years, and (c) two types of interactions terms tested in a backward step: Quality × Parenting and the interaction between the two quality trajectories. A criterion of $p < .1$ was used to select interactions terms. Concerning the selection of control variables, we took a conservative approach and selected variables associated with cognitive scores in the present sample as well as those often found to be associated with cognitive outcomes in the literature.

Results

Identification of Child Care Quality Factors

The results from factorial analyses with varimax rotation are presented as supplementary online

material online appendices. The two-factor solution accounted for 43.5% of variance: 24.1%; for the Teaching and Interactions and 19.4% for the Provision for Learning factor. For Factor 1, all items had loadings above .3. For Factor 2, three items had loading below .3 (item numbers 8, 23, and 36). Cronbach's alphas were .88 and .81 for the Teaching and Interactions and Provision for Learning factors, respectively. Mean scores on the Teaching and Interactions and the Provision for Learning factors were 4.0 (SD = .96) and 3.14 (SD = .70), respectively.

Identification of Quality Trajectories

Figure 1a and b depict the trajectory models. Two groups of children exposed to distinct levels of quality on the Teaching and Interactions dimension were identified. The first group comprised children exposed to low and stable quality levels, hereafter referred to as the *low group* (41.0% of children). The second group comprised children exposed to higher initial quality levels slightly increasing over time. Most children, 59.0%, were assigned to this group, hereafter referred to as the *high ascending group*. The trajectory model for Provision for Learning comprised a lower and stable quality group, hereafter referred to as the *low group*, which comprised 75.7% of children. The second group of children was exposed to higher initial quality levels that were mostly stable over time. Only 24.3% of children were assigned to this group, hereafter referred to as the *high group*. The Pearson correlation coefficient between the two quality factors was .77 ($p < .001$).

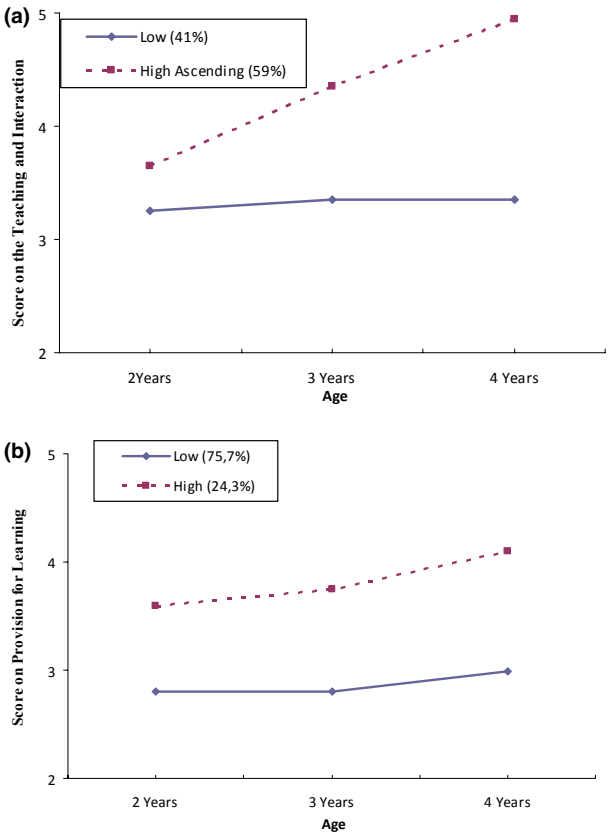

Figure 1. (a) Quality trajectories of Teaching and Interactions, (b) quality trajectories for Provision for Learning.

Descriptive Analyses of the Association Between Quality Trajectories, Child Care, Cognitive, Family, and Child Variables

Table 3 presents (a) the mean quality scores for each quality factor (both global factor scores and by trajectory group) and (b) the mean cognitive scores for each quality factor (both global scores and by trajectory group). The means are presented separately for each of the three quality instruments (ECERS–R, ITERS–R, and FDCRS). T tests indicated that at all three assessment times, the mean scores on the three quality instruments were significantly higher for children in high trajectories, thereby indicating that the trajectory models distinguished groups of children exposed to significantly different levels of quality.

Mean scores on the ECERS–R and FDCRS increased between the ages of 2 and 4 years. The bivariate analyses presented in Table 3 also show that children in the high ascending Teaching and Interactions trajectory had higher scores on all three cognitive outcomes as compared to children in the low trajectories; while children on the high Provision for Learning trajectory had higher scores on the PPVT as compared to children in the low trajectories.

Table 4 presents the bivariate associations between the child and family characteristics for children in the different quality trajectory groups. The results indicate that a larger proportion of children of mothers with higher education, children of mothers who are not single, girls, and children whose main language is one of the official languages (French or English) are exposed to the high and ascending Teaching and Interactions quality trajectory (compared to the low trajectory). There was no difference on the Provision for Learning trajectory.

Modeling the Association Between Child Care Quality and Cognitive Outcomes

Table 5 presents the results of the three sets of multiple regressions (one for each cognitive outcome).

Table 3
T *Tests Comparing Scores on Child Care and Cognitive Measures by Quality Trajectory Groups*

			Quality Factor 1 Language and Interaction			Quality Factor 2 Provision for Learning		
	Mean age of assessment	*n*	Global *M* (*SD*)	Low trajectory *M* (*SD*)	High ascending trajectory *M* (*SD*)	Global *M* (*SD*)	Low trajectory *M* (*SD*)	High trajectory *M* (*SD*)
Quality measure								
ITERS–R[a]	2 years	86	3.3 (0.96)	3.1 (0.98)	3.6 (0.88)*	3.1 (0.73)	2.9 (0.64)	4.1 (0.61)**
ECERS–R[b]	2 years	38	3.1 (1.05)	2.6 (0.91)	3.5 (1.01)*	2.5 (0.82)	2.3 (0.56)	3.8 (0.81)**
	3 years	154	3.9 (1.25)	3.2 (1.06)	4.4 (1.12)**	2.9 (0.82)	2.7 (0.71)	3.9 (0.63)**
	4 years	192	4.2 (1.32)	3.0 (0.84)	5.1 (0.88)**	3.2 (0.92)	2.9 (0.78)	4.3 (0.65)**
FDCRS[c]	2 years	56	3.7 (0.79)	3.4 (0.79)	3.9 (0.76)*	3.3 (0.60)	3.2 (0.61)	3.6 (0.42)*
	3 years	39	4.0 (1.21)	3.4 (1.05)	4.4 (1.16)*	3.5 (0.90)	3.1 (0.73)	4.3 (0.63)**
	4 years	23	4.4 (1.52)	2.8 (0.57)	5.2 (1.16)**	3.5 (0.91)	3.1 (0.69)	4.3 (0.78)*
	Global mean	257	4.0 (0.96)	3.1 (0.55)	4.5 (0.74)**	3.14 (0.70)	2.9 (0.49)	4.2 (0.483)**
Cognitive outcomes at 4 years								
NKT		251	6.1 (4.09)	5.0 (3.69)	6.8 (4.20)**	6.1 (4.08)	5.9 (4.03)	7.0 (4.27)
PPVT		244	49.2 (19.75)	43.2 (17.98)	52.9 (19.94)**	49.2 (19.75)	48.4 (19.45)	52.2 (20.82)
Lollipop		257	37.7 (13.93)	33.6 (13.06)	40.4 (13.88)**	37.7 (13.93)	36.8 (13.82)	41.3 (13.94)*

[a]ITERS–R was used in center-based child care settings with children 2–2½ years. [b]ECERS–R was used in center-based child care settings with children 2½–4 years. [c]FDCRS was used in family-based child care settings with children 2–4 years. [d]Global mean over time and scales calculated on children with at least one quality assessment and one cognitive assessment.
*$p < .05$. **$p < .01$ (difference between lower and higher trajectories).

The results indicate that children exposed to the high ascending Teaching and Interaction quality trajectory had higher scores on each cognitive outcome: numeracy, PPVT, and Lollipop test scores. The Provision for Learning scale had no independent contribution to cognitive outcomes. We tested the interactions between the quality trajectory factors. None of the interactions between quality and parenting or between the two quality factors reached significance. Effect sizes were calculated using the following formula: *B* (traj)/*SD*(*Y*).

Supplementary Analyses

We conducted three additional sets of analyses using either individual quality assessments or mean quality assessments over time. In the first set of analyses, we used the quality scores at each separate time, 2 years (T1), 3 years (T2), and 4 years (T3), to predict the cognitive outcomes at 4 years (T3). The results indicated that quality scores at 2 or 3 years were not significantly associated with any of the cognitive outcomes at 4 years. Quality at 4 years on the Teaching and Interaction dimension was significantly associated with the PPVT score ($B = 3.49$, $SE = 1.35$, ES = .20, $p < .05$), but not with numeracy or school readiness. None of the quality scores on the Provision for Learning dimension were associated with the cognitive scores at 4 years. We note that a lack of power is unlikely to explain these nonsignificant findings since the number of observations in the models were similar to those in the trajectory models (i.e., $n = 265$ at 2 years, $n = 249$ at 3 years, $n = 245$ at 4 years, and $n = 244$–257 in the trajectory models). Thus, the association between child care quality and cognitive outcomes was detected for one of three outcomes and when using contemporaneous cognitive and quality measurements.

In the second set of analyses, we used the mean quality score over the three assessments to predict the cognitive outcomes at 4 years. These analyses yielded similar results as those obtained for the age 4 years quality score. Specifically, the mean score on the Teaching and Interaction dimension was significantly associated with PPVT scores at 4 years ($B = 3.65$, $SE = 1.75$, ES = .20, $p < .05$), but not with numeracy or school readiness. The mean quality score on the Provision for Learning dimension was not associated with the cognitive scores at 4 years. Finally, we used a dichotomous measure of the mean quality score over the three assessments to predict the cognitive outcomes at 4 years. We dichotomized the mean score with similar cutoff points as those obtained in the trajectory analyses in order to compare the results using the two types of variables. These analyses indicated that, similar to the trajectory analyses, the dichotomous mean

Table 4
T *Tests or Chi-Squares Comparing Scores on Child and Family Variables by Quality Trajectory Groups*

			Quality Factor 1 Teaching and Interaction		Quality Factor 2 Provision for Learning	
		Age of assessment	Low	High ascending	Low	High
Family characteristics			% (*n*)	% (*n*)	% (*n*)	% (*n*)
Insufficient Income	Yes	2 years	14.1 (14)	9.8 (15)	13.3 (27)	4.1 (2)
	No		85.9 (85)	90.2 (138)	86.7 (176)	95.9 (47)
SES[a]			0.7 (0.31)	0.8 (0.27)	0.7 (0.31)	0.8 (0.23)
Maternal education	< 13 years	2 years	37.0 (37)	24.7 (38)*	32.2 (66)	18.4 (18)
	≥ 13 years		63.0 (63)	75.3 (116)	67.8 (139)	81.6 (40)
Immigrant mother	Yes	2 years	27.0 (27)	24.0 (37)	24.9 (51)	26.5 (13)
	No		73.0 (73)	76.0 (117)	75.1 (154)	73.5 (36)
Single mother	Yes	2 years	11.0 (11)	5.8 (9)	7.8 (16)	8.2 (4)
	No		89.0 (89)	94.2 (145)	92.2 (189)	91.8 (45)
Maternal depression	Yes	Lifetime	35.0 (35)	40.3 (62)	37.1 (76)	42.9 (21)
	No		65.0 (65)	59.7 (92)	62.9 (129)	57.1 (28)
Maternal smoking	Yes	Pregnancy	21.0 (21)	18.2 (28)	20.0 (41)	16.3 (8)
	No		79.0 (79)	81.8 (126)	80.0 (162)	83.7 (47)
Parenting[b]			*M* (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
	Positive	2–4 years	−0.23 (0.90)	−0.04 (0.85)	−0.09 (0.89)	−0.21 (0.79)
	Coercive	3–4 years	0.03 (0.93)	0.03 (0.97)	0.02 (0.94)	0.08 (1.00)
	Consist.	3–4 years	0.03 (0.96)	−0.15 (1.02)	−0.04 (1.00)	−0.22 (0.99)
Child characteristics			% (*n*)	% (*n*)	% (*n*)	% (*n*)
Sex	Girls	2 years	40.0 (40)	57.8 (89)**	49.8 (102)	55.1 (27)
	Boys		60.0 (60)	42.2 (65)	50.2 (103)	44.9 (22)
Premature birth	Yes	Birth	11.0 (11)	5.8 (9)	8.3 (17)	6.1 (3)
	No		89.0 (89)	94.2 (145)	91.7 (188)	93.9 (46)
Low birth weight	Yes	Birth	7.0 (7)	1.9 (3)*	4.4 (9)	2.0 (1)
	No		93.0 (93)	98.1 (151)	95.6 (196)	98.0 (48)
Main language	French/English	4 years	89.0 (89)	95.5 (147)	92.2 (189)	95.9 (47)
	Other		11.0 (11)	4.5 (7)	7.8 (16)	4.1 (2)
Only child	Yes	2 years	57.0 (57)	44.8 (69)	52.7 (108)	36.7 (18)*
	No		43.3 (43)	55.2 (85)	47.3 (97)	63.3 (31)

[a]Socioeconomic status (SES) of the family is a composite score including three dichotomous variables: maternal and paternal education (0 < 13 years of schooling; 1 ≥ 13 years) and whether the family has an insufficient income according to Statistics Canada criteria (coded as 0) or not (coded as 1). The three variables were summed and divided by 3 yielding a score varying between 0 and 1. [b]Standardized parenting score over the years.
*$p < .05$. **$p < .01$.

score on the Teaching and Interaction dimension was significantly associated with the NKT ($B = 1.64$, $SE = .56$, ES = .39, $p < .01$) and PPVT scores ($B = 7.81$, $SE = 2.81$, ES = .42, $p < .01$). However, contrary to the model using the trajectory variable, quality using the dichotomous mean score was not associated with school readiness. The dichotomous mean quality score on the Provision for Learning dimension was not associated with the cognitive scores at 4 years. Overall, these additional analyses indicate that, as compared to trajectory quality scores, the effect sizes and the significance levels obtained when using a quality score at a single time or a continuous mean quality score are weaker and more inconsistent. The only consistent associations were with the PPVT using quality at 4 years or mean quality scores (continuous and dichotomous).

Discussion

The aims of the present study were twofold. The first was to identify distinct trajectories of child care quality from 2 to 4 years for specific quality dimensions.

Table 5
Multiple Regressions of the Associations Between Child Care Quality Trajectories (Between 2 and 4 Years) and Cognitive Outcomes at 4 Years

	NKT[a] (n = 251)			PPVT-R[b] (n = 244)			Lollipop[c] (n = 257)		
	(Adj. R^2 = .11)			(Adj. R^2 = .13)			(Adj. R^2 = .15)		
	B	*SE*	Effect size	*B*	*SE*	Effect size	*B*	*SE*	Effect size
Block 1. Control variables									
Child variables									
Sex (girl)	−0.36	0.52	.09	2.51	2.51	.13	3.28	1.71	.16
Child language (French/English)	−1.48	1.06	.36	10.81*	5.16	.55	0.10	3.45	.01
Presence of siblings	0.19	0.53	.05	−2.20	2.59	.11	1.30	1.75	.07
Normal birth weight	−0.27	1.78	.37	0.32	8.75	.02	2.90	5.90	.15
Not premature birth	1.51	1.29	.09	−1.50	6.53	.08	−0.35	4.26	.02
Family variables									
Higher SES	2.84**	0.89	.70	13.70**	4.34	.69	12.22**	2.95	.02
Two-parent family	0.01	0.99	.00	2.86	4.86	.15	0.73	3.29	.04
Canadian-born mother	0.21	0.61	.05	3.63	2.96	.18	−0.90	2.02	.05
Positive parenting	−0.40	0.31	.09	1.53	1.55	.07	0.26	1.05	.02
Low coercive parenting	0.59*	0.29	.14	1.86	1.37	.09	1.79	0.93	.12
Consistent parenting	0.55*	0.27	.14	1.19	1.32	.06	1.40	0.90	.10
No maternal smoking during pregnancy	−1.49*	0.64	.37	0.44	3.13	.02	−2.21	2.13	.11
No lifetime maternal depression	0.35	0.52	.09	0.11	2.54	.01	1.54	1.72	.08
Child care hours	−0.02	0.02	.04	0.10	0.12	.05	−0.08	0.08	.06
Block 2. Child care quality trajectories									
Activities and interactions	1.61**	0.56	.39	8.04**	2.72	.41	4.51*	1.85	.32
Provisions for learning	0.23	0.67	.06	−0.61	3.18	.03	1.40	2.20	.07

[a]NKT stands for Number Knowledge Test. [b]PPVT–R stands for Peabody Picture Vocabulary Test–Revised. [c]Lollipop = school readiness test.
*p < .05. **p < .01.

The second was to test if trajectories of child care quality were associated with numeracy, receptive vocabulary and school readiness at age 4 years. We first examined the psychometric properties of two quality factors identified in previous studies: Teaching and Interactions and Provision for Learning. We then identified sets of trajectories reflecting lower and higher quality over time and found that a high and ascending trajectory of Teaching and Interaction between 2 and 4 years had a positive association with numeracy, receptive vocabulary, and school readiness scores at 4 years. The Provision for Learning trajectory had no independent contribution to cognitive outcomes. The effect sizes were moderate (i.e., ES = .32–.41) and similar to those previously reported in the NICHD ECCS (i.e., ranging between .18 and .48 for cognitive outcomes at ages 15, 24, and 36 months; NICHD ECCRN, 2000). These associations were found while controlling for pre- and postnatal factors that could account for the possibility that more advantaged children received higher child care quality and for factors associated with cognitive development. We tested interactions between child care quality and parenting practices and found no evidence of interactions. Our findings are in line with previous studies in suggesting that child care of higher quality contributes positively and moderately to children's cognitive development (Dearing et al., 2009; Herrera et al., 2005; NICHD & Duncan, 2003; NICHD ECCRN, 2006) and that the strongest and most consistent predictors of overall child care quality involves the language stimulation provided by teachers and caregivers (e.g., responding to vocalizations, asking questions, praising, teaching, and talking to children in other positive ways; NICHD ECCRN, 2005). The study extends previous findings by presenting the developmental patterns of child care quality on dimensions that were unexplored in previous longitudinal analyses, in both family-based and center-based settings, and while controlling for pre- and perinatal risk factors.

Patterns of Child Care Quality Over Time

A central aim of the study was to identify distinct trajectories of child care quality using an empirical criterion. We used a group-based trajectory method, which aimed at answering the following questions:

Are there groups of children exposed to distinct levels of child care quality over time? What proportion of children is assigned to the distinct groups? What patterns of stability or change do we observe? We found that a substantial proportion of children were exposed to high and ascending levels of quality of Teaching and Interactions (59%) with a smaller group (41%) exposed to low and stable quality. Conversely, on the Provision for Learning dimension, only a minority of children (24.3%) were exposed to high and stable quality, whereas the majority was exposed to lower quality (75.7%). The use of an empirical criterion allowed the identification of groups without being constrained by an a priori definition of quality.

How does the level of quality experienced by children in the distinct trajectory groups correspond to the ITERS/ECERS/FDCRS guidelines for quality? These guidelines suggest that quality scores between 1 and 2.9 reflect inadequate quality, between 3 and 4.9 minimal quality, and above 5 good to excellent quality. Thus, children in the low groups were exposed to inadequate or barely minimal levels of quality according to the ITERS/ECERS/FDCRS guidelines. Such low levels are characterized by none to very little age-appropriate stimulation of child development and a relatively unpleasant emotional climate in the care environment. Children in the high trajectories were exposed to minimal to good quality according to the ITERS/ECERS/FDCRS guidelines for quality.

We note that child care quality observed in the present study was lower than that reported in the U.S.-based NCEDL sample using the same two factors (Howes et al., 2008). In center-based settings of the present study, mean scores on the Teaching and Interaction and on the Provision for Learning dimensions for the ECERS–R were, respectively, 4.0 (SD = .96) and 3.1 (SD = .70) at 4 years whereas they were 4.43 (SD = 1.29) and 3.79 (SD = .96) in the NCEDL (Pianta et al., 2005). In fact, one unexpected observation of this study is that at all ages the quality scores were slightly higher in family-based settings than those in center-based settings. One possible explanation for this finding is the fact that the criteria for home-based care are much less stringent than those for center care and thus it is easier to get a higher score. For example, activities have to be much more varied and frequent in center-based care compared to home-based care. In addition, six items of the ECERS–ITERS had no equivalent on the FDRS. Although disappointingly low, these quality scores are similar to those obtained in previous reports of child care quality in the province of Québec using the same instruments (Japel, Tremblay, & Côté, 2005) as well as a different instrument (Drouin, Bigras, Fournier, Desrosiers, & Bernard, 2004). These results clearly point to the need for measures that will support the child care network in providing quality to families and children. In the province of Québec as elsewhere in Western countries, guidelines and structural standards are often mandatory, but are clearly insufficient to ensure high process quality (Early et al., 2006; Early et al., 2007; Mashburn et al., 2008; Sylva et al., 2006).

There was remarkable stability in the patterns of quality over time with the exception of the high and ascending trajectory of Teaching and Interaction. This may reflect a genuine increase in child care quality on this dimension or alternatively, the inadequacy of the instruments to capture quality as experienced in younger age groups. In the first assessment (children aged 2–3 years), the ITERS–R was used with children under 2½ years and the ECERS–R with children between 2½ and 3 years. Mean-level scores on the ITERS–R were higher than those on the ECERS–R. This suggests that the ITERS, which was specifically designed to assess child care quality with younger children, may indeed better capture quality assessed with toddlers. Studies assessing the same child care groups of young children with both the ECERS–R and ITERS–R could provide information on this possibility.

Associations Between Quality Trajectories and Cognitive Outcomes

Despite the relatively low levels of quality, the high ascending quality trajectory of Teaching and Interactions was associated with higher cognitive scores on numeracy, receptive vocabulary, and school readiness at age 4 years. In bivariate analyses, both the higher Teaching and Interactions and Provision for Learning trajectories were associated with higher cognitive scores, but in multivariate analyses, only the Teaching and Interactions had an independent contribution.

To interpret with more clarity the results from the trajectory approach, we conducted three additional sets of analyses using either individual quality assessments or mean quality assessment. Overall, these additional analyses indicate that, as compared to trajectory quality scores, the effect sizes and the significance levels obtained when using a quality score at a single time or a continuous mean quality score are weaker and more inconsistent. The only consistent associations were with the PPVT using quality at 4 years or mean quality scores (continuous and dichotomous).

There are two possible explanations for the results. The first is that academic skills at entry to school are more strongly related to higher levels of teaching and interactions with teachers during the preschool years (concurrent association) than in the toddler years (longitudinal association). But, the most plausible explanation for the difference we obtained when predicting the cognitive outcomes with a trajectory variable versus the quality assessment at each time or averaged over time is that both the higher levels and the rising levels of quality captured by the high and rising trajectory account for the meaningful associations with the cognitive outcomes at 4 years. The fact that the mean score over ages 2–4 years had weaker and inconsistent associations with cognitive scores at 4 years suggests that it is not only the overall level of quality that matters but that the pattern of increasing quality (captured in trajectories) also contributes to the prediction. Also supporting the importance of the pattern of quality are the results using a dichotomous mean score. These results were similar to those obtained with the trajectory approach although the association with school readiness was not significant. The dichotomized mean score captures the initially higher level of quality as well as the pattern of increasing quality over time as it uses the same cutoff as the trajectory pattern. This explanation is in line with two studies using HLM individual growth curves showing that both initial levels of quality and increase in quality over time were related to higher preacademic skills (Hirsh-Pasek & Burchinal, 2006; NICHD ECCRN, 2002). We also note that the greater predictive power of the trajectory may be related to the reduction in the measurement error associated with each individual quality assessment.

The Teaching and Interactions dimension reflects quality of the interplay between the educator and the children, that is, the extent to which the educator uses the material or himself or herself to promote children's participation and learning (Harms et al., 1998). High quality indicates an emphasis on using verbal interactions in stimulation of language development, conflict resolution, and the general interactions and greetings exchanged with children. The results point to the importance for child care educators to support communication via personal conversations with children, encouraging reasoning throughout daily activities, providing a balance between listening and talking, and supporting positive interactions during peer interactions as well as during child–adult interactions.

The Provision for Learning dimension reflects the availability, accessibility, and diversity of activities that children can do in an autonomous way (e.g., fine motor skills activities, artistic expression, body movement, symbolic play, science, etc.). The fact that this dimension did not, in itself, contribute to cognitive scores when accounting for the quality of Teaching and Interactions may be due to a number of reasons. First, there was a relatively high inter-correlation between the two quality factors ($r = .77$). Second, there were few children in the high level Provision for Learning quality group (i.e., 24.3%). Third, the overall quality—even of the high trajectory—was minimal. Although a recent study suggested that achievement of minimal quality standards is necessary to contribute to preacademic gains (Burchinal, Vandergrift, Pianta, & Mashburn, 2010), the present results suggest that minimal quality on the Provision for Learning dimension may not be sufficient. The significant association between Teaching and Interaction and cognitive outcomes rather suggest that a moderate level of quality is necessary to obtain a positive impact. Improvements in quality could potentially lead to higher impact on the development of cognitive abilities.

Strengths and Limitations

One of the major strengths of the present study lies in the multiple assessments of child care quality over a period of 3 years in a variety of settings (some home based and some center based). Quality assessments included direct observations of child care environments using well-validated instruments. Given that most previous child care quality studies were conducted in the United States, this study provides information on the associations between quality and preacademic cognitive outcomes in a country with a different geopolitical context and different public policies with respect to the provision of child care services. The sample size was relatively large for a longitudinal study with such detailed observations and standard cognitive testing. Analyses were conducted using a trajectory approach that allowed for identifying patterns of stability and variations in specifics aspects of child care quality that would otherwise not be detected.

Some limitations of the study should be noted. First, the results should be interpreted with caution because they are based on a correlational design and therefore do not allow making inferences about causality. Even if we included a wide range of

covariates, selection effects and unmeasured factors may still partly explain the observed associations. Experimental studies aiming at improving child care quality and examining the impact on cognitive outcomes are needed in order to test the causal role of child care quality. Second, because our sample is relatively advantaged socioeconomically compared to the general population (Côté et al., 2007), results cannot be generalized to the larger population and we could not test interactions between quality and low socioeconomic status. Previous studies suggested that child care may be particularly beneficial for children from poor families (Côté et al., 2007; Geoffroy et al., 2010), and this possibility needs to be tested with large and diverse samples. Third, as in all child care studies involving observations of the environment, it is likely that the lowest quality child care settings are underrepresented. This may have restricted the variability in child care quality and limited our capacity to detect significant associations. Fourth, baseline cognitive measures were not available in this study and the child care observations were conducted during a single visit. Finally, the sample used for the trajectory models included children with at least one quality assessment. Most participants (69.7%) had two or three assessments. It is unlikely that this pattern of missing data had a significant impact on model estimation. However, our relatively small sample size and limited number of assessments certainly impacted on the type of model that best fitted the data. This is because a higher number of assessments over time and a higher sample size represent better the true population heterogeneity. Consequently, models with more groups generally fit the data better for large samples with multiple measurements and models with fewer groups generally fit the data better with small samples with fewer measurements. Studies with more time points and large sample size may therefore provide different estimate of population heterogeneity in child care quality.

Conclusion

This study provides further evidence that child care quality matters for the cognitive development of preschoolers. From a public policy perspective, the significant associations argue for continued reinforcement of stimulating programs and practices in child care. Furthermore, large experimental studies should be conducted to test if improving the quality of these specific dimensions leads to specific improvement in distinct cognitive domains.

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