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Original article

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Which time investments in the first 5 years of life matter most for children's language and behavioural outcomes at school entry?

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Abstract

Background: The ways children spend their time is one of the most valuable inputs for healthy child development. It is unknown which time investment yields the greatest return for children's language and behavioural outcomes at school entry.

Methods: We used data from the first three waves (2004, 2006, 2008) of the Longitudinal Study of Australian Children ($n = 4253$). At every wave, parents completed 24-h time-use diaries on one randomly selected week and one weekend day. The amount of time children spent on 11 activities at ages 0–1, 2–3 and 4–5 years was analysed. Receptive vocabulary was assessed using the Peabody Picture Vocabulary Test, and externalizing behaviours were measured by the Strengths and Difficulties Questionnaire, completed by parents and teachers at 4–5 years. To identify which time investment in the first 5 years of life mattered most for children's outcomes, a new production function was developed. This production function was estimated using a log–log linear regression model.

Results: Relative to other time investments, time spent on educational activities at 2–3 years of age was the most important time investment for receptive vocabulary and behavioural outcomes at school entry. After adjusting for confounding, every 1 h invested in educational activities at 2–3 years was associated with a 0.95% [95% CI (confidence interval): 0.62, 1.28] increase in receptive vocabulary, and a −5.72% (95% CI: −7.71, −3.73) and −9.23% (95% CI: −12.26, −6.20) reduction in parent- and teacher-reported externalizing problem behaviours. Time invested in play was also important to both receptive vocabulary and behaviour. One hour invested in play at 2–3 and 4–5 years was associated with a 0.68% (95% CI: 0.38, 0.98) and 0.71% (95% CI: 0.39, 1.03) increase in children's receptive vocabulary at school entry. In addition, time invested in play at 2–3 and 4–5 years was associated with reduced problem behaviours at school entry. In contrast, screen time at all ages was associated with poorer parent- and teacher-reported externalizing problem behaviours.

Conclusions: These results suggest that time invested in educational activities at 2–3 years of age yield the greatest return for children's receptive vocabulary and behaviour at school entry.

Key words: Parenting, time investments, child development, time-diary data

Key Messages

- There are fundamental gaps in our understanding regarding which time investment in the first years of life matters most for children's cognitive and behavioural outcomes.
- Understanding how parents invest in their children at different ages is key to uncovering the roots of socio-economic differences in child outcomes.
- Using a new production function to estimate a hierarchy of distinct time investments in the first 5 years of life, time in educational activities at 2–3 years of age was the most important investment for higher language skills and fewer behavioural problems at school entry.
- The results of this study may help inform the design of interventions to support investments that yield the largest developmental benefit before children enter school.

Introduction

Early childhood is widely recognized as a critical period of human development as early life disadvantage can have long-term effects on educational attainment, physical health, social and emotional wellbeing and productivity.[1–4] In the early years children's health and development is largely influenced by their home environment and their interaction with parents.[5] Parents do many things to help their children develop, ranging from basic activities to meet their priority needs, such as providing food and shelter, to sophisticated activities that ensure a stimulating learning environment.[5–7] One way we can think about parenting activities is as 'investments' in children's development.

One of the most valuable inputs for child development is the time invested in the activities that parents do with, and for, their children, as well as those activities that children do apart from their parents.[8] Time-use data from the USA and other countries shows that parents are investing more time in their children than ever before.[9–12] For instance, Ramey and Ramey[10] showed that mothers' time spent on child-related activities in 1995 was 1.74 h more per week than in 1975, and by the year 2000 it had climbed to almost 4 h more per week. Yet, very few studies have used time-use diaries to identify the time investments and the time periods that yield the greatest return for child outcomes. One of the reasons why these questions have not been answered is because few longitudinal studies have incorporated time-use diaries. One exception is Australia's national child cohort study—the Longitudinal Study of Australian Children (LSAC) that collects detailed time investment information through diaries over the life course.

To our knowledge only six studies have used diary data to examine whether children's time use in the first 5 years of life is associated with developmental outcomes,[13–18] and only one study ranked the importance of distinct time investments, but this was for older children (aged 4–8 years[15]). An important finding highlighted by these studies is that time spent on educational activities was associated with better cognitive outcomes,[13–15,18] but only one study found an association with children's behaviour.[14] Despite the knowledge that existing studies offer, no study has examined children's time use by developmental stage on cognitive and behavioural outcomes, and as such, there are fundamental gaps in our understanding regarding which time investment in the first 5 years of life yields the greatest return for children's outcomes at school entry. Although all parenting investments in children's development are important, addressing the critical but unanswered questions about which time investments matter most is fundamental for designing programmes that will have the greatest benefit for children potentially at risk of adverse developmental outcomes at school entry.

Many parents, particularly those living in disadvantaged circumstances, struggle to provide environments that support and promote the optimal health and development of their children. Whereas ample research exists that investigates the role of parenting in child development, there is relatively little evidence on which type of activities/behaviours are most effective in improving children's outcomes.

For instance, only 43% of home visiting programmes that aim to improve children's developmental outcomes through boosting parental abilities are evidence based.[19] Furthermore, the effectiveness of parenting interventions in improving developmental outcomes for socio-economically disadvantaged children is ambiguous.[20,21] Using data from the LSAC, the aim of the present study was to identify which time investment mattered most for children's receptive vocabulary and parent- and teacher-reported externalizing problem behaviour at school entry.

Method

This study used data from the birth cohort of the LSAC, a prospective cohort study that commenced in 2004. The detailed study design and sampling framework have been described elsewhere.[22] Briefly, the sampling framework used two-stage clustered sampling. The first stage selected Australian postcodes and the second sampled children within postcodes.[22] Postcodes were randomly selected and stratified by state/territory and urban/rural status to ensure a nationally representative sample. The Medicare database, which provides medical and hospital coverage for all Australian permanent residents, was then used to randomly select infants born March 2003–February 2004 within each stratum. This method identified 8921 infants who were eligible to participate. Of these, 5107 infants were recruited into the LSAC study. Our analyses use the first three waves of data when children were 0–1, 2–3 and 4–5 years of age. The LSAC study was approved by the Australian Institute of Family Studies Ethics Committee, and parents provided written informed consent.

Exposure: time use

At each wave, trained interviewers administered a face-to-face interview with the primary caregiver and conducted direct child assessments in the child's home. Interviewers also left two 24-h time-use diaries with the primary caregiver to complete on one randomly selected week and one weekend day. The interviewer explained how to complete the diary with the caregiver, and the caregiver was advised of the dates for which they should complete the diary. The caregiver returned the diaries by post.

The 24-hour diaries were completed by the caregiver (usually the mother), beginning at 04:00 hours and finishing at 04:00 hours the following day. The diaries divided the 24-hour day into 96, 15-min blocks, and allowed the caregiver to record the type of activity (from a pre-coded list of 26 activities), who the child was with (seven categories), and the child's location (five categories). The list of possible activities changed at wave 2 and wave 3 as certain types of activities were only meaningful at specific points in time. For example, there was no question for computer use when children were aged 0–1 years but there was a consistent question for children aged 2–3 and 4–5 years.

The 26 time-use activity choices were categorized for analysis into 11 mutually exclusive groups of activities: personal care, emotional care, screen time, listening to music, educational activities, play, physical activity, not sure what the child was doing, social activities, child was bored/doing nothing and organised activities/lessons. Personal care included time spent on the basic needs of children, such as bathing, changing nappies, grooming, providing health care and so forth. Emotional care included holding, cuddling, comforting and soothing the child. Screen time included watching television, DVDs, using a computer. Educational activities included time spent reading, talking and singing to the child, being taught to do chores, colouring, drawing and so on. The activities included in this domain are similar to those of Kalil *et al.*,[23] Hsin and Felfe.,[14] and the same as those used by Fiorini and Keane.[15] Like previous researchers,[13,23] play included quiet free play and other play. We decided not to include quiet free play and other play in the educational activities domain, as from the data available we could not identify what type of play children were undertaking. Physical activity included walking, riding a bicycle or trike, and active free play such as running and climbing. Social activities included visiting people, attending special events or parties. Unstructured time included the child doing nothing, being bored or restless, or awake in bed/cot. Listening to music included listening to tapes, radio, CDs, and the final group included time spent on organized activities/lessons such as a playgroup. An example of how the diary was coded is presented in Supplementary Table 1, available as Supplementary data at *IJE* online. Our groupings were based on human development theory,[24] a review of previous literature[13–15,23,25] and consensus among the research team.

Children could be coded to a number of activities simultaneously, so the sum of time spent on different activities may exceed 24 h. As the aim of this study was to identify the time investment that mattered most for children's receptive vocabulary and behavioural outcomes we did not distinguish between time spent alone, with parents or with other adults/siblings/relatives. We calculated the time spent at each activity as reported by the primary caregiver at 0–1, 2–3 and 4–5 years. Data from both diary days was used to create time spent at each activity for an 'average day'. We multiplied a given activity by five if it came from a weekday diary, by two if it came from a weekend diary, and then divided the sum by seven.

Outcomes: receptive vocabulary and externalizing problem behaviours

Children's receptive vocabulary at 4–5 years was directly assessed in the child's home using the Peabody Picture

Vocabulary Test III (PPVT)—LSAC Australian Short Form.[26] Receptive vocabulary refers to a child's ability at recognizing and understanding spoken words. Children's externalizing problem behaviours at 4–5 years were assessed by both the parent and teacher using the Strength and Difficulties Questionnaire (SDQ). The SDQ contains five sub-scales, measuring pro-social behaviour, hyperactivity, emotional symptoms, conduct problems and peer problems of five items each. The conduct and hyperactivity sub-scales of the SDQ were summed to reflect externalizing behaviours.[27] Childhood externalizing problem behaviours are expressed in children's outward behaviour reflecting a child's negative reaction to his or her environment. These externalizing problems may include disruptive, hyperactive and aggressive behaviours.[28] The score for externalizing problem behaviours ranged between 0 and 20 with higher scores indicating higher risk of behavioural problems.

Confounding

Confounding factors were selected a priori based on existing theory and previous research of common causes of time use and children's development. Confounding factors were measured at each wave. These factors included child birth weight, child age, primary caregiver age, psychological distress of the primary caregiver using the Kessler Psychological Distress Scale (K6),[29] household income, highest level of education in the household, family structure that considered the presence of one or two parents in the household as well as the number of siblings at each wave, number of hours per week worked by the primary caregiver and primary caregiver report of their child's current health status. To address the potential for reverse causation, baseline outcome measures (language skills using the MacArthur Communicative Development Inventory[30] and socio-emotional wellbeing using the Brief Infant Toddler Social Emotional Assessment Scale[31] at 2–3 years of age) were adjusted for in the analysis where possible (wave 3 when children were 4–5 years of age).

Multiple imputation

Multiple imputation using chained equations was conducted under the assumption that data were missing at random. In accordance with best practice,[32] the variables used to predict missingness in the imputation model included the exposure, outcomes, confounders and auxiliary predictors (not part of the estimation model) of missingness such as the primary caregivers country of birth and Aboriginal ethnicity. Twenty imputed datasets were generated and the results of the imputed analyses were combined using Rubin's rules.[33] Results using the complete-case data were not substantively different from the imputed analysis, therefore we report the imputed results.

Statistical analysis

To identify which time investment in the first 5 years of life mattered most for children's receptive vocabulary and parent- and teacher-reported externalizing problem behaviours at school entry, a new production function was developed. This production function can be estimated using a log–log linear regression model. The functional form of the regression model can be written as:

$$Y = \beta e^{\alpha_1 I_1 + \alpha_2 I_2 + \cdots + \alpha_k I_K} C^{\gamma_1} \quad (1)$$

where Y represents the child's outcome, α_1 represents the rate of change between time investments (I_1 e.g. time in educational activities) and the child's outcome, and γ_1 denotes the rate of change between confounding (C, e.g. income) and child's outcome, and β is the intercept.

The log–log-linear model was chosen for several reasons and represents a different analytical approach from previous studies that have modelled a linear relationship between children's time-use and developmental outcomes. First, according to this function even if time investments $= 0$, Y (e.g. child receptive vocabulary) $\neq 0$. This is because some parents may choose not to invest any time in investments such as educational activities, but this does not mean that the child's language skills such as receptive vocabulary $= 0$. Second, log–log-linear models do not assume a constant rate of change between any two points such as with linear regression, but allow the relationship between exposure (X) and outcome (Y) to vary for different levels of X. For example, an additional hour spent on educational activities at very low levels of such activities may have a higher cognitive return than one additional hour spent at a high level of such investment. Thus, for each time investment we used an exponential transformation to estimate the developmental return of time investments. Using the exponential transformation allows the time investments to be independent and yield marginal effects, due to the inherent nature of exponentiation ($e.g.\ e^{I_1}.e^{I_2} = e^{I_1+I_2}$), when all other confounders are balanced. All analyses were conducted using Stata/SE version 15.0 (StataCorp).

Results

As shown in Figure 1 the sample consisted of 4253 children aged 0–1, 2–3 and 4–5 years who participated at all three waves of data collection.

Characteristics of participants over the three waves of the study are shown in Table 1 (results for the complete-case

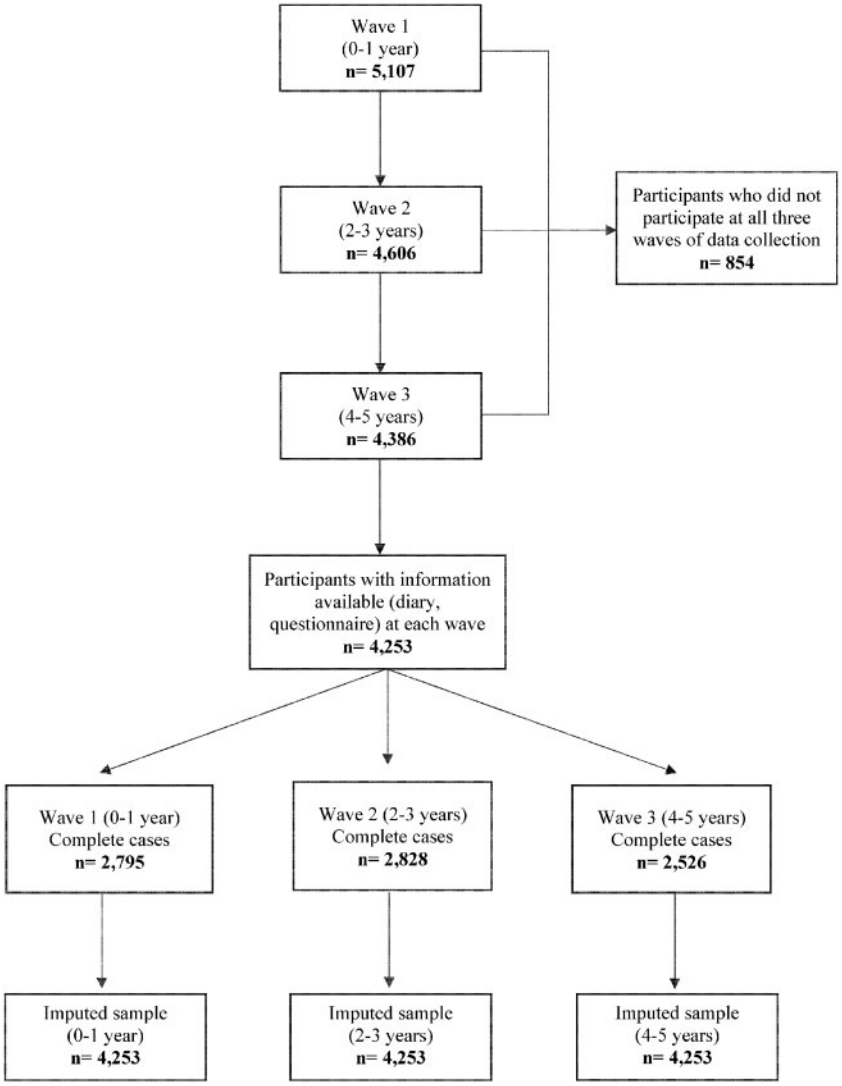

Figure 1. Eligible cohort and numbers included for analyses.

sample are presented in Supplementary Table 2, available as Supplementary data at *IJE* online). The majority of children (~98%) were reported by the primary caregiver to be in good to excellent health. The highest level of education in the household did not change over the three waves of the study, with ~44% holding a bachelor degree or higher at each wave. There was a slight increase in household income over the first three waves from $1274 per week in wave 1 to $1842 per week in wave 3. The average weekly work hours of the primary caregiver increased from 11.8 h when children were aged 0–1 years to 15.6 h when they were aged 4–5 years. The majority of children lived in a two-parent household (92.7% at 0–1 years and 89.2% by 4–5 years). Table 1 also displays the average time spent at each of the 11 activities as h/day by child age. Time invested in personal and emotional care was highest when children were aged 0–1 years (1.5 h/day and 2.1 h/day respectively). Screen time and not sure what the child was doing increased with age whereas time invested in exercise and play decreased with age. Time invested in educational activities was consistent at 0–1 and 2–3 years (1.4 h/day), and increased by 4–5 years (1.7 h/day).

Tables 2–4 present the associations between the 11 different time investments from birth to 5 years and children's receptive vocabulary, and parent- and teacher-reported externalizing problem behaviours at school entry. Results show that relative to other time investments, time spent on educational activities at 2–3 years was the most important investment for children's receptive vocabulary and behaviour at school entry. Specifically, after adjusting for confounding, 1 h invested in educational activities at 2–3 years was associated with a 0.95% [95% CI (confidence interval): 0.62, 1.28] increase in receptive vocabulary, and a −5.72% (95% CI: −7.71, −3.73) and −9.23% (95% CI: −12.26, −6.20) reduction in parent- and teacher-reported problem behaviours.

Time invested in play was also important to both receptive vocabulary and behaviour. As shown in Table 2, 1 h

Table 1. Characteristics of study participants for the multiply imputed sample ($n = 4253$ at each wave of data collection)

	Wave 1 (0–1 year-old) mean (SD) or %	Wave 2 (2–3 years-old) mean (SD) or %	Wave 3 (4–5 year-old) mean (SD) or %
Child factors			
Child sex			
Male	51.2	51.2	51.2
Female	48.8	48.8	48.8
Child age (months)	8.8 (2.6)	33.9 (2.9)	57.6 (2.8)
Birth weight (g)	3427.3 (564.2)	–	–
Child health			
Excellent	62.2	50.8	55.5
Very good	25.4	35.2	32.7
Good	9.2	11.7	9.8
Fair	2.9	2.2	1.9
Poor	0.3	0.2	0.1
Caregivers factors			
Parent 1 age (years)	31.4 (5.3)	33.5 (5.3)	35.5 (5.3)
Parent 1 distress, K6 score	3.5 (3.4)	2.9 (3.2)	3.2 (3.3)
Family factors			
Family structure			
Two-parent family	92.7	90.4	89.2
Single-parent family	7.3	9.6	10.8
Number of siblings			
None	39.1	19.0	10.3
One	37.6	49.6	48.1
Two or more	23.3	31.5	41.6
Socio-economic position			
Household income per week (Australian Dollars)	1274.0 (867.6)	1592.2 (1316.8)	1842.4 (1345.6)
Parent 1, h of work/week	11.8 (15.3)	13.6 (15.4)	15.6 (15.8)
Parent education (highest)			
<Year 12	5.9	5.4	4.6
Year 12 or equivalent	7.1	6.4	5.8
Advanced diploma, certificate, others	43.0	44.1	44.7
Bachelor degree or higher	44.0	44.1	44.8
Time investments (in h/per day)			
Personal care	1.5 (0.7)	0.9 (0.4)	0.9 (0.4)
Emotional care	2.1 (1.8)	0.8 (0.8)	0.5 (0.6)
Screen time	0.6 (0.9)	1.6 (1.2)	1.9 (1.3)
Listening to music	0.5 (1.2)	0.4 (0.7)	0.3 (0.6)
Play	2.4 (1.8)	1.3 (1.2)	1.1 (1.1)
Educational activities	1.4 (2.0)	1.4 (1.0)	1.7 (1.6)
Social activities	0.7 (1.1)	1.2 (1.5)	1.1 (1.4)
Child was bored/doing nothing	1.2 (1.2)	0.8 (0.8)	0.7 (0.7)
Not sure what child was doing	0.3 (1.2)	0.8 (1.9)	0.8 (1.9)
Physical activity	2.0 (2.0)	1.9 (1.4)	1.6 (1.3)
Organized activities/lessons	0.2 (0.6)	0.3 (0.9)	0.9 (1.7)
Outcomes			
Receptive vocabulary score (PPVT)	–	–	65.3 (6.1)
Parent-reported externalizing problem score	–	–	5.4 (3.3)
Teacher-reported externalizing problem score	–	–	3.5 (3.8)

invested in play at 2–3 and 4–5 years was associated with a 0.68% (95% CI: 0.38, 0.98) and 0.71% (95% CI: 0.39, 1.03) increase in children's receptive vocabulary at school entry. In addition, 1 h invested in play at 2–3 years and 4–5 years was associated with a −2.95% (95% CI: −4.84, −1.05) and −3.25% (95% CI: −5.36, −1.15) reduction in parent-reported problem behaviours at school entry (Table 3). Organized activities/lessons at 2–3 (0.44% 95%

Table 2. Unadjusted and adjusted associations between time investments in the first 5 years of life and children's receptive vocabulary scores (PPVT) at 4–5 years using the multiply imputed sample, $n = 4253$

PPVT	Wave 1 (0–1 year-old)						Wave 2 (2–3 years-old)						Wave 3 (4–5 year-old)					
	Unadjusted			Adjusted[a]			Unadjusted			Adjusted[a]			Unadjusted			Adjusted[a]		
	100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI	
Personal care	−1.49	−1.98	−0.99	−0.95	−1.43	−0.48	−0.06	−0.90	0.78	0.22	−0.60	1.03	0.27	−0.66	1.20	0.36	−0.53	1.25
Emotional care	−0.17	−0.37	0.03	0.01	−0.19	0.21	−0.11	−0.57	0.35	−0.08	−0.52	0.35	−0.08	−0.75	0.60	−0.02	−0.64	0.60
Screen time	−0.39	−0.79	0.00	−0.20	−0.58	0.18	−0.58	−0.90	−0.25	−0.34	−0.64	−0.04	−0.36	−0.65	−0.06	−0.05	−0.35	0.25
Listening to music	0.27	−0.02	0.57	0.29	0.00	0.57	−0.29	−0.77	0.20	−0.18	−0.65	0.28	−0.55	−1.35	0.25	−0.46	−1.24	0.33
Play	0.30	0.11	0.48	0.12	−0.06	0.30	0.96	0.65	1.27	0.68	0.38	0.98	0.92	0.59	1.25	0.71	0.39	1.03
Educational activities	0.47	0.28	0.65	0.27	0.09	0.45	1.15	0.80	1.50	0.95	0.62	1.28	0.33	0.07	0.58	0.22	−0.03	0.48
Social activities	0.13	−0.22	0.47	0.18	−0.16	0.52	0.44	0.19	0.69	0.34	0.11	0.57	0.32	0.08	0.57	0.33	0.10	0.56
Child was bored/doing nothing	−0.89	−1.16	−0.61	−0.65	−0.91	−0.38	−0.30	−0.77	0.17	−0.22	−0.66	0.21	−0.44	−0.99	0.12	−0.30	−0.84	0.24
Not sure what child was doing	0.01	−0.28	0.29	−0.10	−0.38	0.19	0.20	0.00	0.39	0.08	−0.11	0.27	0.11	−0.12	0.35	0.04	−0.18	0.25
Physical activity	0.08	−0.08	0.24	−0.02	−0.19	0.14	−0.06	−0.30	0.19	−0.10	−0.33	0.13	−0.01	−0.34	0.32	0.02	−0.30	0.34
Organized activities/lessons	0.62	0.12	1.12	0.27	−0.20	0.75	0.65	0.23	1.07	0.44	0.07	0.82	0.71	0.46	0.96	0.37	0.12	0.62

[a]Adjusted model includes: child birth weight, child age, primary caregiver age, psychological distress of the primary caregiver (Kessler 6), household income, highest level of education in the household, family structure, number of siblings, number of h/week worked by the primary caregiver and child's current health status.

[b]Expected percentage change in Y (PPVT) for a one unit increase in X (time investment).

Table 3. Unadjusted and adjusted associations between time investments in the first 5 years of life and parent-reported externalizing problem behaviour scores at 4–5 years using the multiply imputed sample, $n = 4253$

Parent-reported externalizing problem behaviours	Wave 1 (0–1 year-old)						Wave 2 (2–3 years-old)						Wave 3 (4–5 year-old)					
	Unadjusted			Adjusted[a]			Unadjusted			Adjusted[a]			Unadjusted			Adjusted[a]		
	100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI		100.β[b]	95% CI	
Personal care	3.93	0.83	7.02	1.82	−1.34	4.97	0.78	−4.44	6.01	−0.24	−5.31	4.83	−2.49	−8.07	3.10	−3.19	−8.94	2.57
Emotional care	−0.02	−1.29	1.26	0.05	−1.27	1.37	1.39	−1.28	4.06	1.47	−1.16	4.11	−0.75	−4.78	3.27	−1.14	−4.99	2.71
Screen time	4.98	2.64	7.32	3.55	1.25	5.85	4.33	2.46	6.21	2.57	0.70	4.44	5.67	4.09	7.25	3.90	2.24	5.56
Listening to music	−0.54	−2.26	1.18	−0.87	−2.53	0.78	−0.55	−3.59	2.49	−0.58	−3.53	2.36	3.24	−0.76	7.24	2.63	−1.21	6.47
Play	−1.21	−2.44	0.01	−0.77	−2.01	0.46	−4.15	−6.07	−2.23	−2.95	−4.84	−1.05	−4.66	−6.79	−2.54	−3.25	−5.36	−1.15
Educational activities	−2.67	−3.80	−1.55	−1.97	−3.05	−0.88	−6.72	−8.78	−4.67	−5.72	−7.71	−3.73	−3.27	−4.75	−1.79	−2.79	−4.20	−1.37
Social activities	1.63	−0.31	3.57	0.98	−0.91	2.87	−0.26	−1.80	1.27	−0.23	−1.74	1.28	−0.68	−2.26	0.90	−0.73	−2.30	0.83
Child was bored/doing nothing	2.25	0.43	4.07	1.45	−0.34	3.23	4.59	1.77	7.41	3.50	0.73	6.27	5.55	2.35	8.75	4.29	1.30	7.27
Not sure what child was doing	1.22	−0.66	3.10	1.13	−0.70	2.95	0.93	−0.32	2.17	0.92	−0.29	2.14	1.59	0.46	2.72	1.77	0.65	2.88
Physical activity	0.07	−1.04	1.18	0.18	−0.95	1.32	1.31	−0.29	2.91	1.76	0.20	3.32	−0.05	−1.87	1.78	0.61	−1.23	2.46
Organized activities/lessons	−0.46	−3.87	2.94	−0.26	−3.55	3.03	−0.83	−3.09	1.42	−0.64	−2.85	1.56	0.14	−1.49	1.78	0.93	−0.65	2.50

[a]Adjusted model includes: child birth weight, child age, primary caregiver age, psychological distress of the primary caregiver (Kessler 6), household income, highest level of education in the household, family structure, number of siblings, number of h/week worked by the primary caregiver and child's current health status.

[b]Expected percentage change in Y (parent externalizing problem behaviour scores) for a one unit increase in X (time investment).

CI: 0.07, 0.82) and 4–5 (0.37% 95% CI: 0.12, 0.62) years was positively associated with children's receptive vocabulary at school entry. Similarly, time spent on social activities at 2–3 (0.34% 95% CI: 0.11, 0.57) and 4–5 (0.33% 95% CI: 0.10, 0.56) years was also associated with higher receptive vocabulary scores at school entry (Table 2). In contrast, time spent as screen time at all ages was associated with poorer parent- and teacher-reported problem behaviours (Tables 3 and 4).

Some researchers adjust for baseline outcome (*Y*1) when investigating associations between *X*2 and *Y*2 as it is argued that it addresses the possibility that *Y* causes *X*. There is no agreement over whether to adjust or not for baseline outcomes. Research has shown that baseline outcome-adjusted models can provide biased effect estimates.[34,35] For example, adjusting for baseline outcomes could open a backdoor pathway from the exposure to the outcome through unmeasured confounding, introducing collider bias. Furthermore, one of the assumptions in our study is that later outcomes at each wave are conditionally independent given the exposure and confounding; therefore we do not need to adjust for previous outcomes. However, based on a reviewer comment concerned with the potential for reverse causation we adjusted for baseline outcome measures where possible. The results of these analyses were similar to the main analyses and did not change the conclusions of the paper (see Supplementary Tables 3–5, available as Supplementary data at *IJE* online). Finally, to address whether the effect of time on children's outcomes might differ depending on who the child was with, sensitivity analyses were performed. Similar results were obtained when we examined the effect of parent-only time on children's developmental outcomes.

Discussion

To our knowledge, this is the first study to have estimated a hierarchy of distinct time investments in the first 5 years of life to identify the investment that mattered most for children's receptive vocabulary and behaviour at school entry. We found that after adjusting for a range of potential confounding factors, time spent on educational activities, i.e. time spent reading to a child, being taught to do chores, colouring and drawing, at 2–3 years of age, yielded the largest developmental benefit at school entry.

Our results regarding the importance of educational activities for children's development are consistent with findings from the handful of time-use studies that suggest time spent on educational activities is associated with cognitive benefits. For example, Hsin and Felfe[14] showed that for a sample of 855 children ≤6 years of age, 1 h spent with mothers on educational activities (studying, doing homework and reading or being read to) was associated with a 0.01 standard deviation (SD) increase in children's letter word and applied problem solving scores and a 0.02 SD increase in positive behaviour. Similarly, Hofferth and Sandberg[13] who examined the effect of time spent on different activities with concurrent cognitive and behavioural outcomes for children aged 3–12 years found that reading was positively associated with letter word comprehension, passage comprehension, applied problems and calculation, but not with behavioural outcomes. Our study extends prior research by being the first to quantify that time spent on educational activities at 2–3 years yielded the greatest return for children's receptive vocabulary and behaviour at school entry. By no means is this meant to imply that other time investments do not matter for healthy child development—they certainly do, as shown by the consistent and positive effect of time spent on play, organized activities/lessons and social activities for positive developmental outcomes at school entry.

Our findings that time spent at play was associated with better receptive vocabulary and fewer problem behaviours are consistent with past research and theory that suggest play is an important way children learn and develop.[34,35] However, our findings differ from those obtained by Hofferth and Sandberg[13] who used time-diary data and found no association between time spent at play and cognitive achievement or behaviour. This discrepancy in results may be due to differences in the way activities were coded. Play in our study included unspecified quiet or free play, whereas Hofferth *et al.*[13] included a broad range of activities such as playing computer games, unspecified indoor play and playing social games.

Screen time at all ages was associated with poorer parent- and teacher-reported problem behaviours. Our findings support previous research that has found excessive screen time associated with poorer behavioural outcomes.[36–38] The American Academy of Pediatrics[39] recommends that children <18 months old should avoid the use of screen media other than video chatting and for children aged 2–5 years screen time should be limited to 1 h/day of high-quality programmes. Our analyses showed that, on average, children aged 0–1, 2–3 and 4–5 years exceeded daily screen time recommendations with negative consequences for behaviour.

Strengths and limitations

One strength of this study is the use of time-use diaries at three different times in the child's development. Most studies to date have used questionnaires to determine the effect of time at specific activities on children's development.[40] The disadvantage of this approach is that asking parents

Table 4. Unadjusted and adjusted associations between time investments in the first 5 years of life and teacher-reported externalizing problem behaviour scores at 4–5 years using the multiply imputed sample, $n = 4253$

Teacher-reported externalizing problem behaviours	Wave 1 (0–1 year-old)						Wave 2 (2–3 years-old)						Wave 3 (4–5 year-old)					
	Unadjusted			Adjusted[a]			Unadjusted			Adjusted[a]			Unadjusted			Adjusted[a]		
	$100.\beta^b$	95% CI		$100.\beta^b$	95% CI		$100.\beta^b$	95% CI		$100.\beta^b$	95% CI		$100.\beta^b$	95% CI		$100.\beta^b$	95% CI	
Personal care	2.70	−1.93	7.33	1.09	−3.53	5.72	−0.71	−8.20	6.79	−1.33	−8.73	6.08	−1.12	−10.64	8.39	−1.49	−11.19	8.20
Emotional care	0.55	−1.51	2.61	0.11	−2.06	2.27	5.83	1.47	10.18	5.68	1.35	10.02	1.26	−4.52	7.05	0.90	−4.88	6.68
Screen time	6.22	2.38	10.06	5.62	1.67	9.58	3.63	0.93	6.33	2.71	−0.07	5.48	4.08	1.22	6.94	3.18	0.27	6.09
Listening to music	−0.20	−2.75	2.36	−0.35	−2.92	2.21	2.66	−1.93	7.26	2.66	−1.88	7.19	1.11	−5.53	7.76	1.00	−5.66	7.67
Play	−0.76	−2.49	0.96	−0.26	−2.04	1.53	−3.28	−5.81	−0.75	−2.24	−4.79	0.32	−4.26	−7.67	−0.84	−3.33	−6.85	0.18
Educational activities	−1.30	−3.20	0.60	−0.66	−2.61	1.28	−9.87	−12.90	−6.84	−9.23	−12.26	−6.20	−3.55	−5.98	−1.11	−3.23	−5.69	−0.78
Social activities	−0.49	−3.31	2.34	−0.67	−3.53	2.20	−1.29	−3.31	0.73	−1.07	−3.10	0.95	−4.10	−6.37	−1.82	−4.06	−6.34	−1.79
Child was bored/doing nothing	3.24	0.36	6.13	2.38	−0.61	5.37	1.14	−3.16	5.43	0.46	−3.74	4.67	3.23	−1.47	7.94	2.51	−2.19	7.20
Not sure what child was doing	1.26	−1.55	4.08	1.30	−1.57	4.17	0.37	−1.27	2.00	0.20	−1.46	1.85	1.87	−0.14	3.89	1.92	−0.12	3.96
Physical activity	−1.29	−3.08	0.50	−1.11	−2.94	0.71	1.66	−0.62	3.95	2.07	−0.24	4.37	0.20	−2.52	2.92	0.46	−2.26	3.18
Organized activities/lessons	−3.10	−8.09	1.88	−2.59	−7.57	2.39	−1.11	−4.82	2.60	−1.00	−4.75	2.75	0.37	−1.76	2.51	1.12	−1.06	3.29

[a]Adjusted model includes: child birth weight, child age, primary caregiver age, psychological distress of the primary caregiver (Kessler 6), household income, highest level of education in the household, family structure, number of siblings, number of hours/week worked by the primary caregiver and child's current health status.

[b]Expected percentage change in *Y* (teacher-reported externalizing problem behaviour scores) for a one unit increase in *X* (time investment).

how much time they spend with their children at various activities such as reading to a child may suffer from social desirability and recall bias.[8,41,42] For example, Hofferth[41] found that parents reported higher levels of reading to a child via a question on a survey than what was ascertained through diary reports. The diary on the other hand has been shown to be one of the most reliable and valid method to measure time use, particularly when the behaviours of interest occur on a daily basis.[43] Another advantage of our study was the analytical method (log–log linear regression) that enabled us to establish a ranking of the importance of different time investments. Our study also had the advantage of using validated and reliable measures for receptive vocabulary and behavioural problems in children.

A limitation of this study was that information regarding what activities children were engaged in and how much time they spent at each was collected through subjective parent report that may have over or under estimated time spent at various activities. However, a more objective measure such as direct observation is costly and intrusive and as such, it is not practical to use in large-scale longitudinal studies. Another weakness of the diary is that it does not capture regular but infrequent behaviour such as attending an organized activity that only occurs once per month. Yet this limitation is offset by recording routine behaviour particularly well.[8] Finally, parents with a bachelor's degree or higher are over-represented in the sample, with proportions 12% higher than in the general population.[44] Nonetheless, the LSAC is broadly representative of the Australian population of children[22] and although higher educated parents were overrepresented it is unlikely to greatly change the findings of this study. Numerous studies have demonstrated that even when recruitment is disproportionate in some groups, it does not necessarily introduce bias of the estimated effects.[45–49] The general consensus of this research is that study participants are selected to give valid conclusions for the eligible groups they represent; but they do not need to be representative of a source population on the whole.[46,47,50,51] As our study included lower educated parents we see no reason why the association between time investments and developmental outcomes would be different for those who participated in the study vs those who were theoretically eligible but did not participate.

Conclusions

This study using diary data over the first 5 years of life identified that time spent at educational activities at 2–3 years of age was the most important time investment for higher receptive vocabulary and reduced externalizing

problem behaviours at school entry. Our study reinforces the large body of evidence regarding the importance of cognitively enriched environments for children's cognitive and socio-emotional development,[52,53] and provides new knowledge to inform the design of interventions and/or enhancement of programmes to help reduce inequalities in children's outcomes.

Supplementary data

Supplementary data are available at *IJE* online.

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