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Free play predicts self-regulation years later: Longitudinal evidence from a large Australian sample of toddlers and preschoolers

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ABSTRACT

Self-regulation skills are foundational to successful participation in society, and predict a suite of positive outcomes throughout life. It has long been asserted that free (i.e., unstructured) play is important for the development of self-regulation, but studies investigating play and self-regulation have faced empirical limitations. The current study used a large sample (n = 2213) from the Longitudinal Study of Australian Children to investigate time spent in unstructured quiet and active play activities at ages 2–3 and 4–5 years as a predictor of self-regulation abilities 2 years later. Children's play was reported by parents who completed a 24-hour time-use diary for 1 random weekend day and 1 weekday. Self-regulation was indexed at ages 4–5 and 6–7 by parent-, teacher- and observer-reported items comparable to similar large, longitudinal studies. Results showed that the more time children spent in unstructured quiet play in the toddler and preschool years, the better their self-regulation abilities at ages 4–5 and 6–7 years, even after controlling for earlier self-regulation abilities and other known predictors. Further, between 1 and 5 hours of preschoolers' unstructured active play time significantly predicted self-regulation 2 years later. This study provides early support for parenting programs designed to increase opportunities for children to spend time in unstructured, free play in the early years.

1 Introduction

Longitudinal studies have shown the impacts of early self-regulation ability extend throughout the lifespan and across multiple outcomes including health, substance addiction, criminal behavior, educational achievement, income, finance management, pregnancy planning, and parenting style (Moffitt et al., 2011; Robson, Allen, & Howard, 2020). One activity that is widely thought to improve self-regulatory and executive skills is play during early childhood (e.g., Elias & Berk, 2002; Gilpin, Brown, & Pierucci, 2015; Slot, Mulder, Verhagen, & Leseman, 2017).

Given the links between caregiving practices and children's self-regulation (e.g., Colman, Hardy, Albert, Raffaelli, & Crockett, 2006), it is important to articulate the benefits of different home practices during the early childhood years. Much debate currently exists over how children's time is best spent at home. The debate has been fueled, for example, by studies showing that parent-structured home activities with young children (e.g., shared reading, music) predict children's later literacy and numeracy performance (Melhuish et al., 2008; Williams, Barrett, Welch, Abad, & Broughton, 2015), possibly intensifying the valuing of parental instruction over unstructured play (Fung & Cheng, 2012; O'Gorman & Ailwood, 2012). While parental beliefs appear to predict the sorts of opportunities provided in the home (Fogle & Mendez, 2006; Lin & Li, 2018; Parmar, Harkness, & Super, 2004), studies suggest that an equal valuing of both unstructured play and adult instruction, rather than one or the other, appears optimal for child outcomes (Lin & Li, 2018).

Parallel to such debates, empirical evidence is mounting that free play in post-industrialized societies is decreasingly prevalent in homes (e.g., Brussoni et al., 2015; Pynn et al., 2019; Witten, Kearns, Carroll, Asiasiga, & Tava'e, 2013) and in early childhood education and care (ECEC) settings (e.g., Bassok, Latham, & Rorem, 2016; Bowdon & Desimone, 2014; Hofferth & Sandberg, 2001), and that adult-structured activities are increasing (e.g., Markowitz & Ansari, 2020). The evidence that time for free play has been declining has sparked particular concern from the pediatric community, wherein free play is upheld for its benefits, par-

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ticularly to self-regulation (e.g., Ginsburg, 2007; Yogman, Garner, Hutchinson, Hirsh-Pasek, & Golinkoff, 2018). Behavioral and attentional self-regulation are likely to be practiced during free, unstructured (rather than adult-guided) play (Barker & Munakata, 2015).

There is a need to explore—and ideally quantify—the role and contribution of young children's unstructured play to their self-regulation abilities, particularly at home, where many young children spend the majority of their waking hours. In this study, we address this need by examining time spent in unstructured play in a large, nationally-representative sample of Australian toddlers and preschoolers and its associations with self-regulation 2 years later.

2. Play: Definitional and measurement challenges

A critical and tenacious issue with play scholarship lies in its definition – and therefore measurement – for play research (Foley, 2017; Lillard et al., 2013). While definitions abound, consensus on them does not (Burghardt, 2011; Göncü & Vadeboncoeur, 2017; Pellegrini & Boyd, 1993). In research published in English, the most widely cited characteristics of play include enjoyment, focus on process over product, and freedom from external rules (Garvey, 1977; Monighan Nourot, Scales, van Hoorn, & Almy, 1987). However, there is no unanimity on these characteristics (Fleer, 2011; Pramling Samuelsson & Carlsson, 2008), and even heavily theorized definitions can draw on completely different—and, at times, opposite (Göncü & Vadeboncoeur, 2017)—characteristics (van Oers, 2013). Play's elusiveness from definition has often been explained by the "ambiguity of play" (Sutton-Smith, 2009, p. 4) and the paradoxes it generates (e.g., being imaginary but simultaneously completely derived from reality) (Göncü & Vadeboncoeur, 2017; Vygotsky, 2004). More recent attempts to define play have settled on a spectrum of "playfulness" (Zosh et al., 2018, p. 6), perhaps only further problematizing the measurement of play to examine its correlates.

An alternative approach proposed to overcome some of this dissensus is to examine universal experiential features of play for those most familiar with play, young children themselves (e.g., Colliver & Doel-Mackaway, 2021). A recent review of research on young children's perspectives on play reveals consistent themes of choice and autonomy (Goodhall & Atkinson, 2019). For example, young children may be more likely to consider an activity as play when they choose its rules (Ólafsdóttir & Einarsdóttir, 2019), and even non-play activities normally directed by teachers (e.g., writing practice) will be considered play if children themselves have the autonomy to structure the activities (Breathnach, Danby, & O'Gorman, 2017). Critically, adult structure may prevent children from perceiving the activity as play (Glenn, Knight, Holt, & Spence, 2012; Sandberg, 2002; Wing, 1995). Characterizing play in terms of child choice and autonomy aligns with contemporary definitions of play, where "more" and "less" playful activities are seen on a continuum of how much structure is determined by child and adult (Zosh et al., 2018). "Unstructured play" may thus be considered the most "play-like" form of play (Fisher, Hirsh-Pasek, Golinkoff, & Gryfe, 2008). Structured or guided play is considered less play-like (Zosh et al., 2018).

In the current study, we utilize the Longitudinal Study of Australian Children's (LSAC) time-use diary (TUD) methodology of parent-reported time that their children spend in 26 daily activities, to distinguish between adult-structured activities and children's unstructured play activities (Sanson et al., 2002).

2.1. Play and self-regulation

A central feature of children's unstructured play is its imaginative and pretend content, leading some studies to investigate associations with outcomes of interest. In 2001, Galyer and Evans (2001), using parent-reported frequency ratings, found that preschoolers who pretend-played frequently had higher ratings of emotional regulation than those who pretend-played less often. Albertson and Shore (2009) found that 3–5-year-old children's memory for pretense was correlated with measures of executive functioning, which includes self-regulation (Carlson & Moses, 2001). Symbolic play skills in 4–7-year olds has been associated with inhibitory control, but not other aspects of executive function (Kelly, Hammond, Dissanayake, & Ihsen, 2011). A 2013 comprehensive review of the research on pretend play concluded there was "little support" for its improvement of emotional regulation (Lillard et al., 2013, p. 24); however the review's lead author has since concluded that "there are some suggestions that pretend play might serve a self-regulatory function in humans" (Lillard, 2017, p. 832). Reviews since that time have been more optimistic (Berk & Meyers, 2013; Bodrova, Germeroth, & Leong, 2013; Foley, 2017), but underscore the need for better evidence of a causal link in future research (Berk & Meyers, 2013) and designs which circumnavigate difficulties of play construct validity – a significant challenge when child choice is central to its definition (Foley, 2017).

Some subsequent imagination studies have embraced this challenge for higher quality evidence. For example, Slot et al. (2017) examined the complexity of pretend play, finding it significantly associated with cognitive and emotional self-regulation in 2–3-year-olds, even after controlling for confounds such as age and vocabulary. Other work has focused on fantasy orientation or pretense ability as a potential way to isolate imagination, the former being associated emotional regulation (Gilpin et al., 2015), attentional shifting, working memory (Thibodeau, Gilpin, Brown, & Meyer, 2016) and inhibition (Pierucci, O'Brien, McInnis, Gilpin, & Barber, 2013), and the latter with prepotent response delay (Carlson, White, & Davis-Unger, 2014) and attentional shifting (White & Carlson, 2016). Much of this work has been experimental, allowing more confidence in claims of causality than with correlational research, but have not determined whether these effects last longitudinally.

Other play studies implicate the social nature of play as a contributor to self-regulation. Coplan, Rubin, Fox, Calkins, and Stewart (1994) found that solitary forms of functional and dramatic play were associated with ratings of child impulsivity, suggesting a link between a tendency to socially interact might relate to self-regulation. Elias and Berk (2002) found complex sociodramatic play predicted 3- and 4-year olds' self-regulation during clean-up class time, whereas solitary dramatic play was negatively associated. Similar findings were reported by Ivrendi (2016) in a study of Turkish kindergarten children: interactive but not solitary play was associated with self-regulation, even after accounting for age, family income and social skill. Fantuzzo, Sekino, and Cohen (2004) found positive social engagement in play was associated with several emotional regulation measures. Recent observational work has suggested that preschoolers' social pretend play was the only predictor of their gains in inhibitory control, not solitary pretend or social non-pretend play, suggesting it is the combination of sociality and pretense which are implicated in inhibition development (White, Thibodeau-Nielsen, Palermo, & Mikulski, 2021). It is possible that the child's negotiation of their mental structuring with other children in an egalitarian social environment, rather than one that is organized and controlled by adults, is behind self-regulation development (Barker & Munakata, 2015).

Other studies appear to emphasize the narrative aspects of pretend play, with story-telling then -acting interventions increasing preschoolers' self-inhibition (Nicolopoulou, Cortina, Ilgaz, Cates, & de Sá, 2015) and inhibitory control (White & Carlson, 2021). As

with imaginative pretense, narrative is most likely to be child- rather than adult-structured.

Another approach has been to link physical activity in play with self-regulation. Time spent in physically active play has been associated with superior self-regulation performance (Becker, McClelland, Loprinzi, & Trost, 2014). In 67% of the studies in a recent systematic review (Carson et al., 2016), early childhood physical activity was found to be significantly associated with measures of executive function. These findings suggest physically active play, particularly if it is autonomously structured by the child, may contribute to self-regulation.

Several studies have contributed to the growing empirical basis of child autonomy, or a lack of adult structure, as central to self-regulation development. For example, Basilio and Rodríguez (2017) found that infants whose parents who responded to and supported child autonomy and challenge during play were more self-regulated. Likewise, when an adult-scaffolded play intervention aimed to increase self-regulation was implemented, Ogan (2008) unexpectedly found the unstructured free-play control group showed significantly more self-regulation gains. Research with 2,222 teachers has suggested that play was most promoting of young children's self-regulation when adults ensured children's autonomy and choices were central to the activities and decisions made (Kangas, Ojala, & Venninen, 2015). Similarly, analyses of self-regulation correlates in different quiet activities suggested its association with play and small-group activities – activities wherein young children presumably have more autonomy than the comparison activities of whole-group and transition activities (Timmons, Pelletier, & Corter, 2016). While drawing conclusions from these studies are limited by potential epiphenomena of play (e.g., adult positive affect), studies examining time use within play-based curricula may isolate the core experience of young children when playing: choice and autonomy (Goodhall & Atkinson, 2019). For example, Goble and Pianta (2017) suggested that 1407 preschoolers' time spent in free choice predicted their average gains in inhibitory control.

Similarly, the more time that 6- and 7-year-olds spent in unstructured activities out of school, the greater their self-directed executive control, and the inverse appeared true for the time they spent in adult-structured activities, even after controlling for age, verbal ability, and household income (Barker et al., 2014). Further, a Canadian study of 6- and 7-year-olds' time in "activities that s/he chose her/himself" (Lehrer, Petrakos, & Venkatesh, 2014, p. 298) – aligning with young children's perceptions of play as any self-chosen activity (Goodhall & Atkinson, 2019) – was associated with positive adaptive behaviors, such as leadership, and lower ratings of externalizing and internalizing problems. While these studies are limited by the size of their samples (Ns = 69–70), participants' ages (none examine play before age 4), and lack of longitudinal associations (which can strengthen causality claims when earlier self-regulation is controlled for; Gershoff, Sattler, & Ansari, 2017, they do suggest an association between choice and regulation that could underlie the play-self-regulation connection.

The current study utilized a similar approach for defining play, one that is aligned with children's own experience of it, and therefore characterized by choice and autonomy. Further, we sought an inclusive measure of all unstructured play, with a simple-to-code bifurcation between quiet and active play to examine potential contributions of active rather than quiet play. In particular, the current study adds to the growing base of quality research on the topic of play by utilizing parent-reported time that their children spend in 26 daily activities, and including a wide range of potential confounding variables, as ways to isolate play from other activities in a large and longitudinal study,

2.2. Self-regulation

Self-regulation, the ability to plan, control impulses and modulate emotional expression, includes some of the most universal societal demands placed on humans (Crafa, 2015). Because it appears to be crucial in so many facets of our daily participation in society, it is likely that heightened self-regulation abilities may predict success throughout life. Research evidence indicates that preschoolers' emotional regulation predicts later academic success (including literacy and mathematical ability) above and beyond that predicted by IQ (Graziano, Reavis, Keane, & Calkins, 2007), as does preschool self-regulation for academic success throughout childhood, adolescence, and into adulthood (Blair & Razza, 2007; Duckworth & Seligman, 2005; McClelland, Acock, & Morrison, 2006). Notably, Moffitt et al. (2011) used longitudinal data that followed 1037 babies for 50 years to show that a composite measure of self-regulation between the ages of 3 and 11 years predicted adult health outcomes, criminal behavior, substance addiction, and financial difficulties, planning and accumulation. Such studies provide a strong rationale for finding levers that can be cost effective in targeting early intervention to improve self-regulation and increase life success, reducing the costs to society of poor outcomes such as high school dropout, obesity, health problems and criminal behavior. For example, the cost of high quality ECEC has been calculated to return in the order of 13 times its value in benefits to society as those children grow up (Heckman, Moon, Pinto, Savelyev, & Yavetz, 2010; Schweinhart et al., 2005). Interestingly, the mechanisms by which these early investments confer later advantages appear to be mostly related to self-regulation (i.e., reductions in aggressive, compulsive, and rule-breaking behaviors), suggesting the long-term effectiveness of improvements to self-regulation as an intervention target (Heckman, Pinto, & Savelyev, 2013; Howard, Vasseleu, Neilsen-Hewett, & Cliff, 2018). Regarding more specific self-regulation functions, research suggests attentional control development occurs before age 7 (Posner & Rothbart, 2007).

In the current study, we applied a behavioral- and temperament-based model of self-regulation (Howard & Williams, 2018; Moffitt et al., 2011), in contrast to a cognitive, neurosystems-based model (Liew, 2012), as the former has been associated with a suite of positive quality of life outcomes and good predictive validity to adolescence (Howard & Williams, 2018) and middle life (Moffitt et al., 2011). Moreover, given that studies show varied findings with different components of emotional and attentional self-regulation, including EFs, the current study sought a reliable indicator of children's self-regulatory capacity, with good predictive validity of broad adolescent and later life outcomes (i.e., Howard & Williams, 2018) which in turn is predictive of multiple quality of life adult outcomes (Moffitt et al., 2011).

2.3. Time playing

Given the difficulties of defining play, which are particularly complicated by adult guidance and involvement, the current study utilized an operational definition consistent with children's own definition of play, which includes activities with child choice and autonomy and excludes activities with adult control and structure (Colliver & Doel-Mackaway, 2021; Goodhall & Atkinson, 2019; Wing, 1995). A reliable way to do so across the ages of 2–7 years of age (the range focused upon currently) is to use parent ratings of time spent in quiet and active unstructured play (Ben-Arieh & Ofir, 2002; Hofferth, 2009; Hofferth & Sandberg, 2001; Ziviani, Lim, Jendra-Smith, & Nolan, 2008). Given discrepant categorizations of children's play time across studies of young children's time-use (Bogatić, 2021) this study focused on the whether play was structured by an adult or not.

In the only published quantification of western-heritage parents' views on a definition of play, Fisher et al. (2008) showed that a United States-wide sample of 1130 middle-class mothers considered 26 play activities, both structured and unstructured, to be play for their child of birth to 5 years (p. 309). However, when the 26 activities identified by parents were compared with the rankings of 99 child development "experts" (p. 308) – the majority professors with over a decade of experience in child development – it was revealed that while experts agreed with mothers that the *unstructured* activities "that required imaginative or creative processes, often lacking clearly delineated rules or goals" (p. 309) were indeed "a form of play" (p. 312), experts did not believe the *structured* activities were. Structured activities "had inherent goal-oriented structure, and included life skills and electronic activities" (p. 309). That was a notable difference from mothers' ratings, who included structured activities in their definition of play.

In the current study, we drew on activity categories predefined in the LSAC methodology, which included quiet and active free play, in keeping with the experts' perspectives in Fisher et al. (2008), and aligning with young children's own definition of play as child-chosen and -structured (Goodhall & Atkinson, 2019). We also ensured items that might be deemed play by parents but not experts (such as organized activities) were excluded.

2.4. The current study

The Longitudinal Study of Australian Children (LSAC) is unique in its inclusion of time-use diary (TUD) data records of children's activities. TUD methods were specifically designed for LSAC and applied multi-modal formats across the scope of the study (from infancy to adolescence) to address the key research question "What are the patterns of children's use of their time for activities such as outdoor activities, unstructured play, watching television, reading" (Sanson et al., 2002)(p. 29). Time-use methods have been applied in the social sciences for over 30 years, initially as a tool to record adults' work and family activities (Bauman, Bittman, & Gershuny, 2019; Bittman, Fast, Fisher, & Thomson, 2004; Craig & Mullen, 2011), but more recently as a data collection tool in cross-sectional and longitudinal surveys of children's activity patterns (Chatzitheochari et al., 2015; Harrison, Elwick, Vallotton, & Kappler, 2014). Such TUD methods, using pre-coded activity categories, help respondents to recall activities and have been shown to produce better estimates of daily activities than survey questions (Juster, Ono, & Stafford, 2003; Kan, 2008; United Nations Economic Commission for Europe UNECE, 2013). *Appendix D* details how, to maintain accuracy of the data, parents were instructed to record the child's activities throughout two 24-hour periods, divided into 96 quarter-hour slots, for 1 weekday and 1 weekend day. Recording 1 random weekday and another random weekend day is shown to be more accurate than recollections of a "normal" week (Kan, 2008), and as accurate as a whole week (Tey, Wake, Campbell, Hampton, & Williams, 2007) but without the attrition that comes from the additional burden. Reporting time spent during 2 randomly-selected days reflects natural variation better than respondents' recollections of "normal" because collection across a large sample of random days includes the actual rate of "abnormal" events.

In a novel addition to previous studies on time spent playing at home, the LSAC sample provided play data from a younger age group: toddlers (2–3 years), and preschoolers (4–5 years) and was large-scale enough to control for other predictors associated with self-regulation abilities 2 years later (at 4–5 and 6–7 years). The aim of the current study was to explore the predictive associations between unstructured play at 2–3 and 4–5 years and self-regulation. We also aimed to explore the associations between time spent playing and improvements in children's self-regulation from age 4–5 to 6–7 years.

3. Materials and methods

3.1. Participants

Children were participants in the LSAC, which recruited a nationally-representative sample of 2 cohorts of Australian children (Birth and Kindergarten cohorts) to investigate the social, environmental, and economic impacts on their development and well-being from infancy through to adulthood (Sanson et al., 2002). The *Australian Institute of Family Studies Ethics Committee* granted ethics approval for the LSAC study. Parents and teachers provided written, informed consent for participation; children provided verbal consent.

All data were drawn from the LSAC Birth (B) Cohort, comprising 5107 children born in 2004 (Wave 1 [W1]). The current study used W1 data as well as data collected at age 2–3 years in 2006 (Wave 2 (W2), N = 4606), at age 4-5 years in 2008 (Wave 3 (W3), N = 4386) and at age 6–7 years in 2010 (Wave 4 [W4], N = 4242).

3.2. Procedures

The LSAC data utilized in this study were collected via home visits, interviews with parents, interviewer post-visit ratings, mail-back Time Use Diaries (TUD) and questionnaires from parents, and mail-back questionnaires from the children's classroom teachers.

Time-Use Diaries. The LSAC TUD, developed by Bittman with the LSAC Consortium Advisory Group, collects parent-reported estimates of the amount of time children spend in a range of typical daily activities, in 15-minute time blocks for a 24-hour period (e.g., Brown, Broom, Nicholson, & Bittman, 2010). TUD methods of recording time spent in household activities have shown to be more reliable than stylized questions (Kan, 2008). At W2 (when children were 2–3 years) and W3 (4–5 years), the primary parent (the parent most familiar with the child; the mother in 96% of cases) completed two 24-hour diaries for a randomly-assigned weekday and weekend day (Corey, Gallagher, Davis, & Marquardt, 2014). The LSAC's use of a particular, but randomly chosen day was intended to provide an accurate picture of the true variation of Australian children's activities across the sample of children and also to avoid "the halo effect" that might come from parents reporting a more idealized version of a typical day. Diaries indicated the duration of time spent each of 26 pre-coded activities in 15-minute time intervals. Diaries also recorded where the child was (e.g., own home, at a day care center or playgroup) and who was in the same room or nearby the child. Instructions for completion are included in *Appendix D.* The coding procedure allowed for parents to code multiple activities in one 15-minute period if they occurred simultaneously (e.g., eating and watching television) or if the transition from 1 activity to the next consecutive activity fell within the middle of the 15-minute period (e.g., eating *then* watching television).

3.3. Variables

Time spent playing: Consistent with the categories of play used by Fisher et al. (2008) in parent questionnaires, we used 3 of the 26 LSAC TUD activities: "active free play," "quiet free play," and "drawing, colouring, looking at book, educational games" to signify *unstructured* play activities used by Fisher et al. (2008), p. 309; see Appendix A for a comparison with the LSAC items). We did not include the items for "being read to, told a story, or sung to" and "organised lessons, activities," which were similar to the 12 structured play creative and imaginative activities *not* deemed to be "play"

by experts in Fisher et al. (2008). The selected items in the LSAC TUD, therefore, capture all activities that both mothers and experts would consider to be free play, and none of the non-play or structured play activities that experts did not consider play (but parents might, based on Fisher et al.), ensuring alignment with the current operational definition of play as unstructured.

Our TUD analyses retained LSAC's separation of quiet and active free play, consistent with suggestions that physically active play may make a unique contribution to self-regulation (Becker et al., 2014; Lillard et al., 2013). We included the item for "drawing, colouring, looking at book, educational games" with quiet free play because of the voluntary, creative and imaginative nature of drawing, the free choice that is part of choosing a book to look at, and the connotation of play in the term "games" (Appendix A).

Average daily estimates for time (in hours) in active and quiet play were calculated by summing the total weekday estimate multiplied by 5 with the total weekend day estimate multiplied by 2. The total hours for this "synthetic week" were divided by 7 to generate a measure of average hours per day spent in active and quiet play activities.

Self-regulation: The measure of self-regulation used in the current study was based on the factor structure created by Howard, Vella, and Cliff (2018) for LSAC to match the factor structure used by Moffitt et al. (2011), a reliable measure strongly predictive of adult outcomes. The items selected from the LSAC data set, matched to the Moffitt et al. items are shown in Appendix B. Items reflect children's ability to control attention and thought (e.g., "persists to reach goal"), behavior (e.g., "restless," "overactive"), and emotions (e.g., "often has hot tempers"), and are consistent with the definition cited at the start of this paper (Crafa, 2015). Following the protocols of Howard et al. (2018), parent- (11 items), teacher- (8 items), and observer-report (1 item) ratings were standardized (from original scores of 1–3, 1–5 or 1–6, reversing appropriate items) and averaged to produce a single, standardized composite score for self-regulation at ages 4–5 (W3) and 6–7 (W4). The resulting factor maintained significant interitem correlations and strong internal consistency (α = 0.82 and 0.86 in W3 and W4, respectively), which was comparable to that reported in the Moffitt et al. (2011) study (α = 0.86). The LSAC factor score has been shown to predict academic outcomes throughout school and unhealthy lifestyle factors (e.g., drug use, smoking, unhealthy weight) into adolescence (Howard & Williams, 2018). As such, psychometric reliability and longitudinal predictive validity both support the appropriateness of this measure. Further, correlation between W3 and W4 self-regulation was high (r = 0.66), as reported by Howard et al. (2018). As composite scores were standardized, their mean in the analytic sample was close to zero (Table 3), and relatively high standard deviations indicative that the variation is heterogenous. Normal probability plots of self-regulation at W3–4 indicated that their distribution appeared to have shorter tails (i.e., there are fewer extreme values than would be expected from a normal distribution), but this was not considered a reason to pursue alternative models as the main threat to the validity of estimates from a regression model arise from outliers, and our plots indicated there were none of note.

Background and demographic variables: The analyses included 6 background variables known to predict self-regulation in the LSAC data, including child age (in months) at measurement, child sex (age until 10 and sex appear to predictably associate with self-regulation; Raffaelli, Crockett, & Shen, 2005), Aboriginal or Torres Strait Islander status (ATSI / non-ATSI), family socio-economic position (SEP), languages other than English (LOTE) spoken at home (English/other), and maternal mental health (Howard & Williams, 2018) (Table 2). The variable SEP is a composite measure of parental income, years of education and occupational status (Baker, Sipthorp, & Edwards, 2017). Maternal mental health is a known predictor of children's emotional and attentional regulation, executive functioning and self-regulation (Berthelsen, Hayes, White, & Williams, 2017; Williams et al., 2015). It was assessed in the LSAC study using the Kessler Psychological Distress Scale (K6), a reliable and internally consistent scale (Kessler et al., 2002) that is a preferred tool for screening for any mood or anxiety disorders because of its brevity and consistency across subsamples (Furukawa, Kessler, Slade, & Andrews, 2003). The scale asks how often mothers experienced symptoms such as feeling hopeless, restless, or that everything was an effort.

Two subscales from the *Short Temperament Scale for Children* (STSC) were used to provide early indicators of toddler attentional and emotional regulation (Williams et al., 2015): *persistence* (mean of 5 items such as "child goes back to the same activity after a brief interruption (snack, trip to toilet)" or "stops to examine objects thoroughly (5 minutes or more)" and *reactivity* (mean of 4 items such as "child reacts strongly (cries, screams) when unable to complete a play activity" and "has moody 'off' days when he/she is irritable all day"). All items were measured on a 6–point Likert-type scale.

3.4. Data analysis

Sample: Sampling weights provided for LSAC (Daraganova & Sipthorp, 2011; Sipthorp & Misson, 2009) were used to account for sampling error and ensure the sample was as representative of the broader Australian population as possible. The analytic sample across W2 and W3 was restricted to children whose parents had completed 2 good quality TUD records at W2 (n = 2437) and at W3 (n = 2213). Differences between the analytic sample and the full sample without TUD data were examined using linear and logistic regression. Results summarized in Appendix C indicated that there were no gender differences between the samples. Compared to the sample without TUD data, children with TUD data were more likely to have higher levels of self-regulation, be younger in age, more likely to come from households with a higher SEP and less likely to be of ATSI cultural background or come from a LOTE household. Children in the analytic sample also had mothers who reported better mental health.

Missing data: All data files (across W1–4) were merged. Any children whose primary parent had not completed W2, W3 and W4 were deleted, leaving a sample of 4781. A further 303 children were deleted as they had significant missing self-regulation data (>50% of items) for both W3 and W4, leaving a final impute file of 4478. We also excluded diaries with less than 10 episodes of an activity, as a low number could be indicative of poor recall. Similar to Howard et al. (2018), cases that had over 20 self-regulation items missing across W3 and W4 (>50%) were deleted. Children without gender data or W2 demographic variables were deleted, leaving a sample of 4128 children.

As Nguyen, Carlin, and Lee (2017) suggest, the variables included in a multiple imputation process should be from the model, predict missingness, and predict the variable to be imputed. Auxiliary variables (selected as equivalent measures from earlier waves or from concurrent waves where only similar variables were available) were tested as predictors of missingness using 80 separate logistic regressions with the variables of interest. After testing how predictive each of the auxiliary variables were, non-predictive variables were excluded from the imputation model. A total of 8 final predictors of missingness resulted from these regressions: child gender, ATSI status (Indigenous vs non-Indigenous), family income (<AUD $1000/wk [low]; AUD $1000–$1999/wk [medium]; >AUD $2000/wk [high]), Socio-Economic Indexes for Areas (SEIFA) Index of Relative Socio-Economic Disadvantage (Australian Bureau of Statistics ABS, 2008), language spoken at home (English vs other languages), the primary parent's self-reported highest level of ed-

ucation (<high school, high school, tertiary), W1 Kessler Psychological Distress Scale (Maternal depression) (K6), and W1 child's temperament (irritability and cooperation). Missing data were imputed using Markov Chain Monte Carlo (MCMC) in SAS version 9 and imported to Stata version 15.1 for analysis. Further information on the imputation strategy is available from the lead author upon request.

3.5. Analytic procedure

Descriptive and bivariate analyses were conducted for all variables. The relationship between self-regulation and the TUD play variables were further examined in a series of plots between self-regulation and quiet and active play in accordance with the models investigating the predicted associations: (1) W2 play predicting W3 self-regulation; (2) W2 play predicting W4 self-regulation; and (3) W3 play predicting W4 self-regulation. Results confirmed a linear relationships for all 3 plots and a quadratic relationship for 3, but not 1 and 2.

The predicted associations were then tested in a series of 3 linear regressions on the full imputed dataset with complete TUD data, using Stata version 15.1: W2 play predicting W3 self-regulation; W2 play predicting W4 self-regulation; and W3 play predicting W4 self-regulation. Based on our preliminary findings, the quadratic terms were added to Model 3. The regressions controlled for all the covariates that differentiated the study samples, so the current results are less likely to have been impacted by differences between those families that did and those that did not fill out the TUD. An additional analysis was conducted to check for any impact of imputing values on the regression models (Appendix C).

4. Results

4.1. Time spent in play

As a first step, we examined the TUD measures of quiet and active play as isolated activities by analyzing the time periods when parents indicated children were engaged in play against all of the other activities (n = 23; Appendix A) that could have been simultaneously coded in the same 15-minute period. Results showed that "eating and drinking," "visiting others/special event," "watching TV" and "being read to, told a story, or sung to" had the highest co-occurrence with "quiet free play" across W2 and W3 (3.12%–5.23%) and "visiting others/special event," "eating and drinking" and "riding a bicycle, trike etc." had the highest co-occurrence with "active free play" across W2 and W3 (3.41%–9.95%). Importantly, "organised activities," which indicates adult structure, was only simultaneously coded for 0.7%–1.1% and 0.57%–1.52% across waves of the mean time children were engaged in quiet and active play, respectively. These low percentages provide good evidence of construct validity for the play items to be operationally defined as unstructured play.

Descriptive analyses showed that at W2, toddlers spent an average of 1.91 (SD = 1.28) hours per day (hpd) in quiet play and 1.56 hpd (SD = 1.18) in active play (Table 2). At W3, preschoolers spent 1.80 (SD = 1.29) hpd in quiet play and 1.46 (SD = 1.22) hpd in active play. Correlation analysis showed a moderate association between time spent in play at W2 and W3, for quiet (r = 0.33, $P < 0.01$) and active (r = 0.23, $P < 0.01$) play. Interestingly, at both data collection points, active and quiet play were only weakly correlated: r = 0.10, $P < 0.01$ at both waves (Table 1).

Time spent in quiet play and active play at W2 and W3 was then examined using bivariate correlations with all W2, W3 and W4 variables (Table 1). From this it was possible to see that time spent in quiet, but not active, play at W2 and W3 was positively correlated with W3 and W4 self-regulation (rs = 0.12–0.17, $P <$

Table 1
Bivariate correlations for all variables included in the models

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	W3 Self-regulation	-																				
2	W4 Self-regulation	**0.66**	-																			
3	Sex (Female = 1)	**0.25**	**0.26**	-																		
4	W2 Age	0.01	0.03	0.00	-																	
5	W2 ATSI	**-0.04**	*-0.08*	-0.01	0.00	-																
6	W2 SEP	**0.19**	**0.18**	0.00	-0.01	**-0.16**	-															
7	W2 LOTE	0.02	0.01	0.02	0.01	-0.04	0.00	-														
8	W2 K6	**-0.14**	**-0.14**	-0.02	-0.01	0.04	*-0.08*	0.10	-													
9	W2 Persistence	**0.22**	**0.21**	0.01	**0.07**	0.01	-0.01	0.01	-0.12	-												
10	W2 Reactivity	**-0.26**	**-0.25**	-0.03	0.01	*0.04*	**-0.14**	0.02	**0.20**	-0.02	-											
11	W3 Age	0.00	0.01	0.00	**0.78**	0.00	-0.02	0.01	-0.01	*0.06*	-0.01	-										
12	W3 ATSI	*-0.04*	**-0.06**	0.00	-0.01	**1.00**	**-0.15**	*-0.04*	0.02	0.02	*0.04*	0.00	-									
13	W3 SEP	**0.19**	**0.17**	0.00	-0.01	**-0.15**	**0.91**	0.00	**-0.07**	-0.01	**-0.14**	-0.02	**-0.15**	-								
14	W3 LOTE	0.01	0.03	0.02	0.01	-0.01	0.02	**0.75**	**0.11**	-0.01	0.01	0.01	-0.01	0.02	-							
15	W3 K6	**-0.12**	**-0.11**	0.00	0.00	**0.06**	**-0.06**	*0.05*	**0.52**	**-0.08**	**0.16**	-0.01	**0.06**	-0.05	0.04	-						
16	W2 ECEC/School	**-0.06**	**-0.07**	0.02	0.03	-0.02	*0.05*	-0.01	0.04	*-0.04*	**0.05**	**0.07**	-0.02	**0.06**	0.01	0.02	-					
17	W2 quiet play (hpd)	**0.12**	**0.14**	**0.08**	*0.05*	-0.03	**0.11**	*-0.05*	-0.01	0.04	**-0.09**	0.03	-0.03	**0.12**	*-0.05*	-0.03	**-0.28**	-				
18	W2 active play (hpd)	-0.02	0.01	**-0.14**	0.03	0.01	0.00	**-0.06**	-0.03	0.00	*-0.05*	0.00	0.01	-0.01	-0.06	-0.03	**-0.25**	**0.10**	-			
19	W3 ECEC/ school	**-0.12**	**-0.10**	0.03	**0.15**	0.00	*0.05*	*0.05*	0.03	-0.03	**0.07**	**0.19**	0.00	**0.06**	0.04	0.01	**0.16**	-0.05	0.01	-		
20	W3 quiet play (hpd)	**0.15**	**0.17**	**0.06**	*-0.05*	-0.02	**0.15**	*-0.05*	-0.03	0.02	**-0.11**	**-0.07**	-0.02	**0.14**	*-0.04*	-0.03	**-0.12**	**0.33**	0.04	**-0.31**	-	
21	W3 active play (hpd)	0.03	-0.01	**-0.12**	-0.03	-0.02	*-0.05*	**-0.07**	-0.03	0.02	-0.04	-0.03	-0.02	**-0.06**	**-0.07**	-0.03	-0.05	0.03	**0.23**	**-0.26**	**0.10**	-

Note: Values in bold indicate $P < 0.01$. *Italicized* values indicate $P < 0.05$. ATSI (0 = non-ATSI; 1 = ATSI). LOTE (0 = English; 1 = Other).
ECEC = early childhood education and care setting, including (at W3) the first year of school; hpd = hours per day; K6 = Kessler Psychological Distress Scale (Maternal depression); SEP = Socio economic position; W= Wave.

Table 2
Descriptive statistics for predictor, outcome and control variables at W2–W4

	W3outcomeW2 predictors	W4outcomeW2 predictors	W4outcomeW3 predictors
N	2414	2414	2213
	Mean(SD)	Mean(SD)	Mean(SD)
W3 Self-regulation*	0.02(0.46)	0.02(0.13)	0.03(0.45)
W4 Self-regulation*		0.01(0.50)	0.03(0.50)
Age (mo)*	0.02(1.01)	0.02(1.01)	0.03(1.01)
SEP*	0.10(0.97)	0.10(0.97)	0.12(0.97)
K6*	0.03(1.05)	0.03(1.05)	0.02(1.03)
W2 Persistence	4.25(0.73)		-
W2 Reactivity	2.97(0.96)		-
ECEC/School (hpd)	1.53(2.41)	1.53(2.41)	2.58(2.42)
Quiet play (hpd)	1.91(1.28)	1.91(1.28)	1.80(1.29)
Active play (hpd)	1.56(1.18)	1.56(1.18)	1.46(1.22)
	%	%	%
Female	48.7	48.7	48.1
ATSI	2.7	2.7	2.2
LOTE	15.7	15.7	15.1

Note. ATSI = Aboriginal and/or Torres Strait Islander; K6 = Kessler Psychological Distress Scale (Maternal depression); LOTE = Languages other than English; SEP = Socio Economic Position; W = Wave.
* Standardized scale used for this variable.

0.01) and W2 and W3 family SEP (rs = 0.11–0.15, $P< 0.01$). Active play at W2 and W3 was negatively correlated with child sex (rs = -0.12 to -0.14, $P< 0.01$). In W2 and W3, quiet play and active play were negatively correlated with speaking LOTE (rs = -0.04 to -0.07, $P< 0.05$). W2 quiet play was positively correlated with child age at W2 (r = 0.05, $P< 0.05$) but W3 quiet play negatively correlated with age at W3 (r = -0.07, $P< 0.01$). Active play at W2 and W3 were negatively correlated with being female (rs = -0.12 to -0.14, $P< 0.01$), but not with child age (rs = -0.03–0.03, $P > 0.05$).

4.2. Self-regulation

Descriptive statistics for the variables included in each of the regression models are provided in Table 2, showing the mean self-regulation score was 0.01–0.03 on the Howard et al. (2018) factor.

4.3. Regression analyses

Three regression models using multivariate analyses were run to explore the relationship between time spent playing in as toddlers (age 2–3 years) and self-regulation 2 and 4 years later (Models 1–2); and time spent playing as a preschooler (age 4–5 years) and self-regulation 2 years later (Model 3). Based on our preliminary examination of the nature of the relationships, Model 3 included the quadratic forms of quiet and active play as predictors. Table 3 shows the regression coefficients and standard errors for each variable in each model. Results indicate that time spent in quiet, but not active, play at age 2–3 years was positively associated with self-regulation abilities at age 4–5 and 6–7, after controlling for covariates. Additionally, time spent in quiet and active play at age 4–5 years were associated with self-regulation abilities at age 6–7 years.

The effects of time spent in quiet play as toddlers and preschoolers were noted for all 3 Models. Each additional daily hour of quiet play as toddlers was, on average, associated with a 3% increase in a standard deviation of self-regulation 2 years later, at age 4–5 years (Model 1). Furthermore, time spent in quiet play as toddlers was associated with a 4% increase in self-regulation 4 years later, at age 6–7 years (Model 2). Whilst these coefficients are small, they represent a cumulative effect on self-regulation over the early years that was statistically significant even after controlling for earlier measures of self-regulation abilities (Table 3, *columns 2 and 3*). Model 3, which included the quadratic and linear term for time spent in active and quiet play, showed that at preschool-age, each additional daily hour of quiet play was associated with a 6% increase in a standard deviation of self-regulation and each additional daily hour of active play was associated with a 4% increase in self-regulation 2 years later, at age 6–7 years, after controlling for earlier measure of self-regulation. The quadratic relationships between play and self-regulation were weak (1% decrease in a standard deviation of self-regulation) and only found for Model 3. The negative coefficient indicates a reduction in self-regulation at the top end (higher end) of time in active play, suggesting that mid-ranges (i.e., 1–4 hours) of active play per day in the preschool years were associated with this cumulative effect in the early elementary years, in a U-shape.

Sensitivity analyses with an alternate measure of self-regulation (Sawyer et al., 2015) and these same models showed that quiet but not active play was significantly associated with later emotional regulation (*P*s = 0.013–0.014), suggesting findings are robust.

Table 3
Regression models to predict self-regulation

	Model 1	Model 2	Model 3
Predictor	W2	W2	W3
Outcome	W3	W4	W4
R^2	0.22	0.46	0.50
n	2414	2414	2213
	β (SE)	β (SE)	β (SE)
Sex (Female)	0.23(0.02)***	0.10(0.02)***	0.12(0.02)***
Age (mo)†	0.00(0.01)	0.00(0.01)	0.02(0.01)
ATSI	-0.01(0.07)	-0.04(0.06)	-0.13(0.08)
SEP†	0.08(0.01)***	0.03(0.01)**	0.02(0.01)
LOTE	0.02(0.03)	0.00(0.03)	0.04(0.03)
K6†	-0.04(0.01)**	-0.02(0.01)	-0.01(0.01)
W2 Persistence	0.14(0.01)***		
W2 Reactivity	-0.10(0.01)***		
W3 Self-regulation†		0.67(0.02)***	0.66(0.02)***
ECEC/School†	0.00(0.00)	0.00(0.00)	-0.01(0.00)
Quiet play	0.03(0.01)***	0.02(0.01)*	0.06(0.02)**
Quiet play squared			-0.01(0.00)*
Active play	0.00(0.01)	0.01(0.01)	0.04(0.02)*
Active play squared			-0.01(0.00)*
Intercept	-0.42(0.07)***	-0.09(0.02)***	-0.13(0.03)***

Note: ATSI = Aboriginal and/or Torres Strait Islander; ECEC = early childhood education and care (or school at W3); K6 = Kessler Psychological Distress Scale (Maternal depression); LOTE = Languages other than English; SEP = Socio Economic Position; W = Wave.
* $P < 0.05$.
** $P < 0.01$.
*** $P < 0.001$.
† Standardized scale used for this variable.

As a further check on these results, a series of regressions with imputed and non-imputed samples were conducted (Appendix C). The 3 models showed consistent patterns of associations between quiet play and self-regulation as presented in Table 3. Coefficients for quiet play ranged from 0.01 to 0.03 for Models 1–3.

5. Discussion

Self-regulation skills in early childhood are known to be an important predictor of academic performance in elementary school (Duncan et al., 2007), academic, health, and mental well-being outcomes in adolescence (Howard & Williams, 2018), and wealth, health and other quality-of-life indicators into mid-life (Moffitt et al., 2011; Pandey et al., 2018). Research suggests early parenting practices in the preschool years have a considerable influence on middle childhood self-regulation (Colman et al., 2006), yet little is known about how families' provision of regular unstructured activities might impact the development of regulatory skills (Barker & Munakata, 2015). Parallel to this question are concerns that increasingly busy schedules may be leading to less time for children to choose and direct their own activities during free play (e.g., Yogman et al., 2018). Early childhood education and care (ECEC) curricula around the world (in >85% of developed nations) are also play-based, under the premise that play is a fundamental way young children learn (Organization for Economic Cooperation and Development OECD, 2017), so it is vital to answer the question of whether more time for play support important skills a child can learn: self-regulation (Moffitt et al., 2011). Whether play is causal in learning these skills has been debated for decades, with multiple methodological challenges limiting the conclusions that can be drawn (Lillard et al., 2013). Only specific types of play (e.g., social and imaginative play) have been implicated in experimental work (e.g., Carlson et al., 2014; Thibodeau et al., 2016; White & Carlson, 2021), limiting knowledge about the larger debate on whether adult provision of time for play in general (rather than adult scaffolding play complexity or sociality) facilitates self-regulation development.

The current study sought to provide new evidence to the debate using time-use data from a large, nationally representative and longitudinal sample of Australian children. Primary caregivers (mothers in 96% of cases) documented their toddler's and 2 years later their preschooler's play activities over a 24 hour period for a randomly selected weekday and weekend day. The child's self-regulation abilities were scored 2 and 4 years later via a reliable and highly predictive composite measure completed by the primary caregiver, the child's preschool teacher and a trained observer scored (Howard et al., 2018). After imputing missing data, and controlling for known confounds of self-regulation, as well as earlier self-regulation, the current study showed that time spent in quiet free play (e.g., jigsaw, craft, dress-ups, drawing, looking at books, educational games) at ages 2–3 and 4–5 predicted self-regulation abilities at ages 4–5 and 6–7 years, respectively. Time spent in quiet free play at 2–3 years also predicted self-regulation 4 years later, in early elementary school. In addition, time spent in active free play (e.g., running, climbing, ball games) at ages 4–5 predicted self-regulation at ages 6–7 when the daily hours of active free play were in mid-range (1–4 hours), although it did not predict an increase in a linear manner once longer than 5 hours per day.

The effects of quiet play on later self-regulation were modest, compared with other empirically rigorous studies, which showed larger effects (e.g., Elias & Berk, 2002; Galyer & Evans, 2001). Two of the main possible explanations for these results are the number of covariates accounted for, including earlier self-regulation, and the time elapsed from the predictive play and the measured self-regulation (i.e., 2 and 4 years). While previous play research (e.g., Kelly et al., 2011; Lehrer et al., 2014; Slot et al., 2017) has controlled for a number of background variables (e.g., age, gender, home language), these studies have not controlled for earlier levels of self-regulation as was done in the current study. Further, few studies of play have examined self-regulation outcomes longitudinally, for 4 or even 2 years, during which a host of intervening factors are likely to have "washed out" any effects of time spent playing. While there are some dramatic findings from pretend play experiments (Thibodeau et al., 2016; Thibodeau-Nielsen, Gilpin, Nancarrow, Pierucci, & Brown, 2020; White & Carlson, 2016) as well as parenting interventions (Meuwissen & Carlson, 2019) that show self-regulation measures can be impacted very quickly, in as short a time as less than an hour, how long these effects of remain is not known. The current study offers an important contribution to understandings of the unique impact of the regular provision of unstructured quiet play time on children's self-regulation.

While coefficients we report are small, they reflect an effect on a standardized composite measure of self-regulation (Appendix B), suggesting that an extra hour per day of unstructured quiet play in the toddler and preschool years is associated with a 3%–6% increase of a Standard Deviation in self-regulation 2 and 4 years later. Given that earlier regulation as well as several background variables were controlled for in the analyses, the direction of the effect is less likely to be from self-regulation to time in quiet play. The findings imply a later predictive relationship, which is 1 step closer to causality than concurrent correlation (Gershoff et al., 2017). In contrast to a growing body of research on emotional and behavioral self-regulation and specific play types, such as imaginative pretend play (e.g., Slot et al., 2017; White et al., 2021), these findings show a relationship between hours spent in play activities that are broadly defined, and likely encompass functional, construction, creative and sociodramatic play. Physically active play, on the other hand, appeared to only be associated with self-regulation in a mid-range of hours, and only at 4–5 years of age.

In one of the few time-use studies with implications for play, Barker et al. (2014) found that unstructured time was associated with improved self-directed executive functioning. Similarly, our operational definition of play separated out structured activities from unstructured "free play" (both active and quiet), with results suggesting that unstructured quiet play may predict self-regulation because it provides children with early opportunities for, and practice of, self-direction, used in a suite of later skills and beneficial outcomes. The results align with findings that self-regulatory abilities increased in an experimental study of 3-year-olds when parents were taught to support their child's autonomy in a puzzle play task (Meuwissen & Carlson, 2019). Taken together, these 2 different studies point to an avenue for future research and questions about whether the empirical challenges of implementing interventions with such a child-controlled phenomenon as free play could be circumnavigated by provision of more time as well as support for unstructured play at home.

5.1. Limitations

As identified in our Methods section, the sample of LSAC children whose parents provided TUD data was differed from the children without TUD data, meaning that findings may not generalize to the entire population. The current analyses attempted to account for this by controlling for the variance contributed by all these differences (SEP, ATSI status and LOTE spoken at home), as well as for child age and levels of early self-regulation (Model 4; Table 3), and also by applying sampling weights (Daraganova & Sipthorp, 2011; Sipthorp & Misson, 2009). Because of potential shortcomings of these methods, however, the sample may not accurately represent the full diversity of the Australian population as the overall LSAC sample did. Although the type of play investigated

is time invariant, and the sample large and representative, the variables were measured 15 years ago and it is possible they do not fully reflect the population today.

Another limitation of the current study relates to the direction of the reported association between time spent in quiet play and later self-regulation. The reverse direction is also possible, in that more regulated children may be more likely to engage in quiet play. We tested and controlled for this possibility by including early indicators of self-regulation, persistence and reactivity. Of these, only the latter was a significant correlate of quiet play (W2 r = -0.09; W3 r = -0.11, *P*s < 0.01), indicating that, indeed, less well-regulated children were less likely to spend time in quiet play. Our analysis then tested the predictive relationship between *earlier* play on *later* self-regulation, controlling for earlier self-regulation abilities.

It was not possible, however, to rule out play being an epiphenomenon or self-regulation being equifinal (Lillard et al., 2013); therefore, the current findings should be confirmed by longitudinal, randomized controlled trial intervention studies to test the effects of increased time spent playing on later self-regulation.

A further limitation, as noted above, is the level of detail about children's play that could be gathered via a 24-hour time-use diary. Whilst this method has a strong history of providing accurate, informative data about families' and children's lives (Cano, Perales, & Baxter, 2019; Hofferth, 2009; Kan, 2008), time estimates are broad (episodes of 15 minute), and time "with" others while identifying who the child is with, is limited to the presence of others, with no indication of the child's involvement with others. This leaves unanswered questions about the possible role of adults or older children in the link between time in quiet play and children's development of self-regulation skills in future research.

We also note that while the analyses controlled for time spent in ECEC services or school on self-regulation, these are venues where play occurs. The scope of the current study was confined to children's play activities that were reported by their primary parent, which does conclusively answer the question of exactly when and where children played.

Finally, normal self-report limitations may be applicable to this data. A practical limitation of studying a large cohort such as LSAC is that data collection must rely on parent-report for much of the child-related data. This was particularly true for our operational definition of play, which relied on parents' matching their own understandings of what active or quiet "free play" was to them with the categories outlined in the diary format. The LSAC distinctions between free play and structured or organized activities were similar to distinctions between unstructured and structured play activities made by similar sample of parents to the current sample (large, geographically, culturally and socio-economically diverse) (Fisher et al., 2008), with 2 exceptions: One of the 14 Fisher et al. "unstructured play" items ("participating in organized activities") did not fit conceptually with the play definition as "unstructured," and would have been captured by the LSAC item "organised lessons/activities" and therefore not included in the current analyses. Inversely, 1 of the 12 Fisher et al. (2008) "structured play" activities ("Looking at books or reading on their own") would have been included in the current LSAC quiet play measure (in Item 16, "Drawing, colouring, looking at book, educational game"). This inclusion seems consistent with the current operational definition. Finally, 1 of the 3 examples of activities listed in Item 17 of the LSAC TUD was "jigsaw" puzzles, which, while retaining child choice and leadership, may be considered less "playful" as it is more "goal-oriented" than traditional free play activities (Fisher et al., 2008, p. 312). These limitations suggest the need for consensus definitions of play in future research.

6. Conclusion

Given the importance of self-regulation throughout the lifespan, the current study sought to investigate possible associations between time spent in unstructured play at age 2–3 and 4–5 years and later self-regulation. Controlling for other known confounds and earlier self-regulation, our analysis indicated that the amount of time children engaged in unstructured quiet play at home in their toddler and preschool years modestly predicted their self-regulation abilities 2 years later, including in the first years of elementary school. Parenting interventions that increase opportunities for children to spend time in unstructured, free play in the early years are needed to determine if play could indeed be prescribed as a pediatric recommendation (e.g., Ginsburg, 2007), or if parenting practices (e.g., autonomy support) are casual in the development of early self-regulation abilities (Meuwissen & Carlson, 2019).

Authors' contributions

Yeshe Colliver: Conceptualization; Funding acquisition; Project administration; Roles/Writing - original draft; Investigation; Methodology.

Linda J. Harrison: Project administration; Methodology; Supervision; Writing - review & editing.

Judith E. Brown: Methodology; Data curation; Formal analysis; Visualization; Writing - review & editing.

Peter Humburg: Data analysis review.

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Appendix A
Play item correspondence with parental and expert definitions of play

26 LSAC TUD items (Play items italicized)	14 Unstructured (α = 0.93) and 12 structured play (α= 0.88) activities (Fisher et al., 2008)	Corresponding LSAC TUD item
Not sure what child was doing	*1. Using child-size play sets (like kitchen sets, work benches, doctor's kits, tools) .91*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Sleeping, napping	*2. Going outside to run around or use playground/backyard equipment .90*	*18. Active free play (e.g., running, climbing, ...)*
Awake in bed	*3. Throwing or rolling a ball or using other kinds of age-appropriate sports equipment .85*	*18. Active free play (e.g., running, climbing, ...)*
Eating and drinking, being fed	*4. Using play sets (like Little People and Polly Pocket) or figures (like rescue heroes) .81*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Bathing, dressing, hair care, health care	*5. Using toy vehicles .81*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Doing nothing, bored/restless	*6. Pretending with baby dolls or stuffed animals .80*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Crying, upset, tantrum	*7. Dressing-up or pretending to be a superhero, a doctor, a mom, or anyone else .78*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Arguing, fighting	*8. Using everyday objects found around the house as toys (pots/pans, etc.) .77*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Destroying things, creating mess	*9. Using building blocks or building sets .76*	*17. Quiet free play (e.g., jigsaw, craft, dress-ups)*
Being reprimanded, corrected	*10. Having play dates or getting together with other same-age children .68*	*17-18. Quiet / Active free play (e.g., running, ...)*
Being held, cuddled, comforted, soothed	*11. Coloring, drawing, painting, or doing other arts and crafts, or playing with clay .68*	*16. Drawing, colouring, looking at book...*
Watching TV, video, DVD, movie	*12. Exploring and discovering things inside or outside your house .60*	*18. Active free play (e.g., running, climbing, ...)*
Listening to tapes, CDs, radio, music	13. Participating in organized activities, like Gymboree, play groups .39	21. Organised lessons/activities
Using computer/computer game	*14. Crawling, walking, & running around for no particular reason .35*	*18. Active free play (e.g., running, climbing, ...)*
Being read to, told a story, or sung to	1. Having a book read to them .80	15. Being read to, told a story, or sung to
Drawing, coloring, looking at book, educational game	*2. Looking at books or reading on their own .73*	*16. Drawing, coloring, looking at book...*
Quiet free play (e.g., jigsaw, craft, dress-ups)	3. Listening to music .73	13. Listening to tapes, CDs, radio, music
Active free play (e.g., running, climbing, ball game.)	4. Going on trips like to the library, museum, or zoo .74	20. Visiting people, special event, outing
Being taught to do chores, read, etc.	5. Coming along on a shopping trip .70	26. Being taken places with adult...
Visiting people, special event, outing	6. Doing chores around the house alongside of you or another adult .60	19. Being taught to do chores, read, etc.
Organized lessons/activities	7. Using flash cards with words and pictures or with simple math concepts .70	19. Being taught to do chores, read, etc.
Ride bicycle, trike etc. (for travel or fun)	8. Watching videos on own and singing, dancing, or interacting with the show	12. Watching TV, video, DVD, movie
Travel in car	9. Watching videos with you and singing, dancing, or interacting with the show .57	12. Watching TV, video, DVD, movie
Travel in pusher or on bicycle seat	10. Using a computer alone or with help .60	14. Using computer/computer game
Travel on public transport	11. Sitting quietly watching TV programs or videos .71	12. Watching TV, video, DVD, movie
Being taken places with adult (e.g., shopping)	12. Using electronic products that say words, or numbers when child touches button .58	14. Using computer/computer game

Note: LSAC TUD items 16–18 (italicized) captured unstructured play as defined in items 1–12 and 13, and item 2 of structured play (Italicized) from Fisher et al. (2008). LSAC TUD = Longitudinal Study of Australian Children Time Use Diaries.

Appendix B
Self-regulation item correspondences between Moffitt et al. (2011) and current study, and missing values

Factor	Moffitt et al. (2011) items	LSAC items used in Howard et al., 2018 (rater) [scale]	Loading (M(SD))	W3 incomplete cases (n)	W4 incomplete cases (n)
Impulsive Aggression	Flies off handle (P,T)	Often has temper tantrums or hot tempers (P, T) [SDQ CPS]	0.42(0.07)	566 (P), 1017 (T)	31 (P), 820 (T)
	Fights (P,T)	Often fights or bullies children (P, T) [SDQ CPS]	0.39(0.09)	562 (P), 1017 (T)	31 (P), 820 (T)
	Requires attention (O)				
Hyperactivity	Runs and jumps about (P,T)	Restless, overactive, cannot stay still for long (P, T) [SDQ HS]	0.62(0.10)	567 (P), 1021 (T)	31 (P), 823 (T)
	Cannot settle (P,T), restless (O)	Constantly fidgeting or squirming (P, T) [SDQ HS]	0.60(0.13)	593 (P), 1025 (T)	33 (P), 822 (T)
	"On the go," "driven by a motor" (P,T)	If this child is upset, it is hard to comfort him/her (P) [SDQ RS]	0.27(0.05)	567 (P)	32 (P)
	Difficulty sitting still (P,T)				
	Has short attention span P,T				
Lack of Persistence & Inattention	Fails to finish tasks (P,T), trouble sticking to a task (S)	This child likes to complete one task or activity before going onto the next (reversed) (P) [TPS]	0.43(0.01)	565 (P)	32 (P)
	Difficulty sticking to activity (P,T), brief attention to task (O)	Sees tasks through to the end, good attention span (reversed) (P,T) [SDQ HS]	0.60(0.11)	572 (P), 1018 (T)	32 (P), 824 (T)
	Lacks persistence in reaching goals (O)	Stays with an activity (e.g., puzzle, construction, kit, reading) for a long time (reversed) (P) [TPS]	0.43(0.02)	563 (P)	32 (P)
	Easily distracted (P,T), difficulty paying attention (S)	Easily distracted, concentration wanders (P,T) [SDQ HS]	0.63(0.09)	574 (P), 1018 (T)	32 (P), 821 (T)
Impulsivity	Acts before thinking (P,T), impulsive (O)	Can stop and think things out before acting (reversed) (P,T) [SDQ HS]	0.51(0.13)	577 (P), 1032 (T)	32 (P), 826 (T)
	Has difficulty awaiting turn (P,T, S)	Shares readily with other children (treats, toys, pencils, etc) (reversed) (P,T) [SDQ PSS]	0.40(0.13)	564 (P), 1021 (T)	31 (P), 822 (T)
	Sits excessively between activities (P,T)	Degree of negative mood (withdrawn, uncooperative, angry) to interview (O) [direct observation]	0.19(0.00)	59 (O)	39 (O)
	Talking while others are still talking (S)				
	Low frustration tolerance (O)				
		Total incomplete		1518	890

Note. Factor names parallel those adopted by Moffitt et al. (2011). Notation following items indicates the source of the data: (P) = parent rating; (T) = teacher rating; (O) = observer rating; (S) = self-rating.
Item loadings are the mean across waves and raters with standard deviations (SD).
CPS = Conduct Problems scale; HS = Hyperactivity scale; PSS = Pro-social scale; RS = Reactivity Scale; SDQ = Strengths and Difficulties Questionnaire; TPS = Temperament: Persistence subscale.

Appendix C
Regression coefficients for imputed and non-imputed data

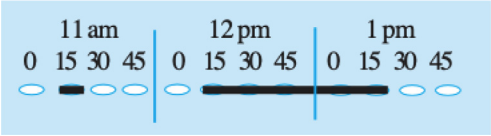
	Model 1 Wave 2 predict Wave 3		Model 2 Wave 2 predict Wave 4		Model 3 Wave 3 predict Wave 4	
	Imputed	Unimputed	Imputed	Unimputed	Imputed	Unimputed
r^2	0.23	0.22	0.46	0.43	0.50	0.46
n	2414	1743	2414	1395	2213	1237
Age of child (std)	0.00(0.01)	0.00(0.01)	0.00(0.01)	0.00(0.01)	0.02(0.01)	**0.01(0.01)**
Female	0.23(0.02)***	0.21(0.02)***	0.10(0.02)***	0.09(0.02)***	0.12(0.02)***	0.09(0.02)***
ATSI	-0.01(0.07)	-0.05(0.06)	-0.05(0.06)	-0.07(0.07)	-0.13(0.08)	-0.08(0.11)
SEP	0.08(0.01)***	0.08(0.01)***	0.03(0.01)**	0.03(0.01)*	0.02(0.01)*	0.01(0.01)
LOTE	0.02(0.03)	0.02(0.03)	0.00(0.03)	0.00(0.03)	0.04(0.03)	0.06(0.04)
Mother K6	-0.04(0.01)**	-0.03(0.01)**	-0.02(0.01)	-0.01(0.01)	-0.01(0.01)**	-0.01(0.01)
T: Persistence	0.14(0.01)***	0.13(0.02)***				
T: Reaction	-0.10(0.01)***	-0.10(0.01)***				
Self-regulation			0.68(0.03)***	0.65(0.03)***	0.67(0.02)***	0.66(0.03)***
ECEC	0.00(0.00)	0.00(0.00)	0.00(0.00)	0.00(0.00)	-0.01(0.00)	-0.00(0.01)
Quiet play	0.03(0.01)***	0.02(0.01)*	0.02(0.01)*	0.02(0.01)*	0.06(0.02)**	0.09(0.02)***
Quiet play squared					-0.01(0.00)*	-0.01(0.00)*
Active play	0.00(0.01)	-0.01(0.01)	0.01(0.01)	-0.01(0.01)	0.04(0.02)*	-0.01(0.02)
Active play squared					-0.01(0.00)*	-0.01(0.00)
Intercept	-0.42(0.07)***	-0.33(0.08)***	-0.09(0.02)***	-0.05(0.03)	-0.13(0.03)***	-0.05(0.03)

Note: *$p<.05$. **$p<.01$. ***$p<.001$. ATSI = Aboriginal or Torres Strait Islander; K6 = Kessler Psychological Distress Scale (Maternal depression); LOTE = Languages other than English; SEP = Socio Economic Position; Std = standardized; T = Temperament; W = Wave.
Bolded = the only discrepancy in patterns across imputed and unimputed data was age, where $P = 0.048$: very close to non-significance.

Appendix D. Wave 2 time use diary instructions

This diary covers what your child has been doing over the 24 hours that started at 4 AM today and ends at 4 AM tomorrow.

Each oval in the diary grid represents 15 min. In the example below, the activity occurred between 11:15 and 11:30, and then again between 12:15 and 1:30.



For each 15 min, please draw a line across the ovals that show:

- what your child was doing, including any travel involved (white rows)
- where he or she was (light shaded section)
- who else was present (medium shaded section)
- whether you paid for the child to do an activity (dark shaded section)

Mark at least one row in each of the white, light shaded and medium shaded sections for each quarter hour.

The white rows show what your child was doing, as well as any travel involved. Most parents mark only 1 or 2 activities per time slot, but you can mark other rows if your child did more than one thing during the 15 min. Please do not mark more than 4 categories for any one quarter hour. Remember to also mark the Travel section if there was any travel involved.

For example:

- Being read a book in bed is both “Awake in bed” and “Being read to, told a story or sung to”
- Sleeping in the car is both “Sleeping, napping” and “Travel in car”

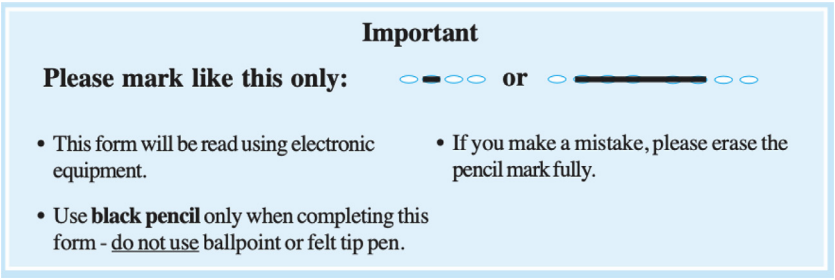
The light shaded section shows where your child was. If your child moved from one place to another during a 15 min time slot, please mark both locations.

The medium shaded section at the bottom of the page shows who was in the same room, or who was near the child if the child was outside. If your child was with more than one person, please mark all that apply.

The dark shaded section at the bottom of the page shows if someone paid for the child to do an activity or to be in care.

You can choose to fill in the diary:

- 2 or 3 times a day, or
- all at once when your child goes to bed or
- in the morning after the diary day.



When you have filled in the diary, please complete the questions on the back page.

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