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The Waxing and Waning of Movement: Implications for Psychological Development

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Age-related changes in movement may have unappreciated implications for various psychological domains. To identify when it might play a key role in such domains, we describe a developmental trajectory for movement from infancy to adulthood. Participants in 12 studies (total $N = 840$) ranged in age from 6 weeks to 52 years, and all wore instrumented motion recorders that measured limb movement throughout 1 or 2 full days. We found an inverted U-shaped pattern in limb movements per hour that peaked in middle childhood, later than expected. This developmental pattern in motor activity has theoretical relevance for various aspects of physical, cognitive, social, and emotional development and implications for ADHD, educational practice, sex differences, functional immaturity, and the regulation of arousal.

Movement epitomizes childhood. From the first flutterings in the womb to the preschooler on the move, or the playful child and the adolescent who sleeps until noon, parents, grandparents, and teachers are variously charmed, amazed, and frustrated at the level of movement displayed by their children. Adults sometimes find it hard to keep pace with the young child, who seems to be constantly on the run. At times, in fact, parents complain of their child's constant movement, yet lethargy is never taken lightly. Parents immediately notice a sudden drop in their child's typical activity level and worry that it may be a sign of coming illness. Lack of energy is generally considered anathema to the picture of healthy childhood, and energetic movement is its triumph.

Despite its developmental salience, childhood movement as a research focus seems almost orthogonal to other areas of developmental investigation. This separation is unfortunate. We argue for movement's integration with other explanations of behavioral development. To facilitate this process, we

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will examine in this paper the role of movement in the research literature, present evidence for a developmental trajectory, and suggest ways in which childhood movement is arguably salient for several developmental domains.

One approach to studying movement is to study the specifics and complexities of infant and toddler motor development on one hand and skilled motor performance in adults on the other. For example, more than 60% of published journal articles on motor development cited in the American Psychological Association's PsycLIT database since 1988 have focused on infancy and the preschool years, and more than 60% of articles on motor performance have focused on adults. This focus on specific motor skills is important, but its specificity has inhibited the integration of motor development with other developmental domains. We have approached the study of movement from the individual differences tradition, which generally does not focus on developmental change. Somewhat to our surprise, our individual differences perspective has led us back to developmental change. At the same time we have discovered potential linkages between childhood movement and research topics not normally associated with it.

The study of children's movement and motor activity has a long empirical history, extending back at least 80 years. For example, early investigators looked for relations between measures of motor activity level and other variables such as age, gender, and situation (e.g., see Goodenough, 1930; Koch, 1934; Koch & Streit, 1932). Fales (1937a), for example, constructed a rating scale from expert judges' evaluations of the vigorousness of 651 preschooler play activities and then applied the scale to the question of sex differences (Fales, 1937b).

Motor activity also received early theoretical attention. Freudians, for example Kris (1940/1975), viewed motor activity as part of an expressive process, which could not be separated from a person's unintentional reactions. Restraint in motor discharge was thought to be provided by the ego process of thought, and individual differences could be conceptualized in terms of intra psychic dynamics. Learning theories largely supplanted psychoanalytic approaches to developmental psychology in the 1950s and 1960s and eschewed interpretations of motor behavior that involved internal motivation and drive states. Learning theorists conceptualized individual differences in terms of variation in learning histories and situational influences.

Against this backdrop, Thomas and Chess began in 1956 an empirical longitudinal study of individual differences in children (Thomas & Chess, 1977). They had been impressed by clinical evidence of infant individuality and by correlations between environment and child outcomes that were weaker than implied by learning theories. Based on their analysis of parent interview material, Thomas and Chess developed a nine-factor model of childhood temperament from the infancy data of the first 22 children in their study (Thomas & Chess, 1977, pp. 20–21). Their first factor was Activity Level, which they characterized as the motor component of a child's functioning and which emphasized typical daily activities such as playing, dressing, handling, and eating.

Rating measures of temperament followed. Carey and his colleagues (Carey, 1970; Carey & McDevitt, 1978; Medoff-Cooper, Carey, & McDevitt,1993) used the Thomas and Chess model to develop parent-completed temperament rating measures for infants and children. Alternative conceptualizations of temperament emerged, as well. Buss and Plomin (1975, 1984) also used parental ratings but developed a factorial model in which Activity was one of three core dimensions, along with Emotionality and Sociability. In the Buss and Plomin model, individual differences in Activity encompass various elements: rate of movement, duration, amplitude, preference for high energy work or games, and chafing at enforced idleness.

Individual differences in activity level are also found in adult personality measures. Activity is a facet of Extraversion, one of the factors in the widely used prominent Big Five model of adult personality (Costa & McRae,1988; Goldberg, 1990). Adult dimensions are thought to have developmental origins. For example, Martin, Wisenbaker, and Huttunen (1994), argued that ''. . . activity level assessed in childhood and adolescence should developmentally precede Extraversion of the Big Five . . .'' (p. 169). In a similar vein, Hagekull (1994) hypothesized that individual differences in childhood activity would be predictive of individual differences in Extraversion in adulthood.

Rating measure approaches to the study of individual differences have dominated the field because they capitalize on the knowledge of informants (e.g., the self, parents, and teachers). Ratings, however, suffer from various well-known drawbacks such as bias and unreliability (Hoyt & Kerns, 1999). Several strategies have been used to minimize informant bias. In the case of questionnaire-style instruments, low-inference, focused items have been used in place of global, high-inference items. For example, Rothbart's (1981) *Infant Behavior Questionnaire* utilizes activity items such as, ''During feeding, how often did the baby squirm or kick?'' This item is more focused than a global item like, ''The child is very energetic'' (Buss & Plomin, 1984, p. 102).

Other approaches to the measurement of motor activity minimize bias and have been used for many years (see Cromwell, Baumeister, & Hawkins, 1963). A straightforward method is to observe the child directly with some standardized system of recording. One of the earliest of the observational approaches was published by Sweeny, Hejinian, and Sholley (1929). They identified 15 preschool activity situations (e.g., outdoor construction activity), and for each activity situation they constructed a 5-level behaviorally anchored scale designed to capture the intensity of the activity. A methodological variant of the observation coding scheme is to lay out a grid on the floor of an observation room and to count the number of grid crossings in a given time interval (see, for example, Partington, Lang, & Campbell, 1971).

Another general approach to the measurement of movement has been to use some form of instrumentation. One of the earliest applications of instrumentation to the measurement of behavior was done by Curtis (1937), who harnessed pedometers to sheep and pigs in a 16-day study of diurnal cycles of spontaneous activity. Researchers began to use pedometers with children in the 1960s. Schulman, Kaspar, and Throne (1965) sought to relate measures of brain damage to behavioral symptoms, including motor activity. They measured activity with self-winding wristwatches in which the winding mechanism was modified to record movement. Bell and his colleagues (Bell, 1968; Halverson & Waldrop, 1973, 1976) were also early users of this approach and studied movement with packets of three actometers strapped to the backs of preschool children in specific settings, e.g., indoor and outdoor free play.

The measurement methodology that one selects depends on one's purposes and conceptual approach to studying movement. We conceptualize activity level as an individual differences dimension, a perspective shared by temperament researchers (Goldsmith et al., 1987). These investigators emphasize behavioral tendencies that have a biological or constitutional foundation and are early appearing and stable across time and situation. This general temperament approach is more integrated with other psychological domains. However, it has limited developmental utility because methods used by temperament researchers tend to be age-specific and do not allow for direct cross-age comparisons.

Our measurement approach is to consider typical daily movement frequency summed over many instances and situations with a common movement measure. This approach is not limited to specific ages, so we can more directly address the issue of age-related change. We believe that age-related changes in child movement have unappreciated implications for various psychological domains. A first step toward unraveling these implications is to understand and describe the general course of movement from infancy to adulthood.

Certainly, anecdotal observation suggests that children are more active than adults, a contrast that implies a downward trend in movement from childhood to adulthood. On the other hand, low levels of neonatal activity suggest that there is an upward trend in movement from infancy to sometime in childhood. Taken together these two observations lead us to predict a curvilinear pattern in movement across childhood.

Empirical evidence also points to an inverted U-shaped pattern of activity across childhood (Eaton, 1994; Pelligrini & Smith, 1998). Based on 42 within-study age-activity comparisons, Eaton (1994) inferred the presence of a general inverted U-shaped pattern of movement that peaked sometime between 2 and 6 years. Pellegrini and Smith (1998) also reported curvilinear age-related changes in play, which is one expression of children's movement.

However, they argued that the movement component of play shows three different age-related peaks: rhythmic stereotypies at 6 months, exercise play at 4 years, and rough and tumble play in boys from 7 to 11 years.

The preceding evidence relies on studies with different measures taken at different ages. Thus, they do not provide a direct assessment of age differences in movement. Mixing measures across ages makes it impossible to compare directly the mean level of movement measured one way at one age with a second measure at another age. To overcome these shortcomings, we have collected data from 12 studies that all used the same instrumented measure of limb movement at all ages.

The measurement approach shared by these 12 studies involves the recording of limb movements throughout typical days in the lives of the participants. This global approach is objective, aggregates movement counts from almost all activities in a day, and is situationally inclusive. With this approach, we will describe the general pattern of age-related change in motor activity from infancy to adulthood and discuss the implications that that pattern may have for various developmental domains.

METHOD

Participants

Participants in 12 different studies (total $N = 840$) wore motion recorders on two or more limbs for 1 or 2 full days (see Table 1). Participants in Studies 1 to 6 were under 18 months of age. Study 5 comprised a sample of twins, who were first studied as infants and then again at 3 years (Study 7). Study 8 included preschoolers and early school-aged children. Study 9 was a cross-sectional study of school-aged children and adolescents. Studies 10–12 were all conducted with university undergraduates. All participants in these studies were drawn from nonclinical populations living in and around a medium-sized midwestern city. Virtually all samples of activity were collected on weekdays. For children attending school, data collection occurred during the school year and on school days. Although data on ethnic and racial group membership was not collected in most of the studies, the samples were predominantly middle-class and of European extraction. Recruitment was carried out using a variety of methods, including solicitation through prenatal classes, birth announcements, hospitals, day care centers, and public advertisements.

Equipment

All of these studies used Kaulins and Willis Model 101 motion recorders, or actometers, to record limb movements. This recorder is a modified woman's mechanical wristwatch (watchcase diameter of 25 mm, weight of 10 g excluding band). The instrument is an objective, ecologically valid measure

TABLE 1
Studies, Sorted by Mean Age of Sample, and Their Descriptive Statistics

Study	Site[a]	Days[b]	*N*	Age in years Mean	Min	Max	%
1. Miller, Barr, & Eaton, 1993	A	2	52	0.1	0.1	0.1	46
2. McKeen, Eaton, Miller, & Barr, 2001, Study 2	A	2	40	0.1	0.1	0.1	38
3. McKeen, Eaton, Miller, & Barr, 2001, Study 3	A	2	40	0.5	0.5	0.6	48
4. McKeen, Eaton, Miller, & Barr, 2001, Study 4	A	2	43	0.5	0.4	0.5	63
5. Saudino & Eaton, 1991	A	2	124	0.6	0.5	0.9	48
6. Ingenmey & Eaton, 1995	A	2	40	0.8	0.5	1.2	50
7. Saudino & Eaton, 1995	A	2	110	3.0	2.7	3.5	49
8. Campbell, Eaton, & McKeen, in press	WA	1	85	5.5	3.9	7.0	47
9. Campbell, Eaton, McKeen, & Mitsutake, 1999	A	1	184	11.0	7.1	14.9	48
10. McKeen, 2000, Study 1	W	1	21	21.4	18.5	31.2	52
11. McKeen, 2000, Study 2	W	1	84	22.3	16.7	50.0	54
12. Eaton, Rothman, McKeen, & Campbell 1998	W	2	17[c]	24.6	18.0	52.0	59
Combined sample			840	6.8	0.1	52.0	49

[a] Site of actometer attachments: A, all limbs; W, both wrists; WA, one wrist and one ankle.
[b] Number of full days that instruments were worn.
[c] Sample of those participants with known ages.

that is equally applicable to infants and adults. When worn on the wrist or the ankle, the actometer is responsive to the typical movements of the limb. The actometer provides a frequency or count measure of movement that is not responsive to the intensity of the movement (see Eaton, McKeen, and Saudino (1996) for validity and other details on using actometers). Therefore, individuals will not have higher activity scores simply because they are taller and have longer limbs. Another advantage of the actometer is that it can be worn in natural settings for several days with little monitoring and without disturbing daily routines. In addition, actometer readings are not biased by the typical measurement problems found with self-reports and observer ratings (e.g., the perceptual salience of movement in certain situations).

General Procedure

In all studies actometers were snugly strapped to the participant's limbs, either with a standard, buckled wristband, a velcro sports band, or a plastic, hospital-style band. The type of band used varied with the site of attachment, arm vs. leg, and age of the participant. To obtain a representative measure of daily activity, instruments were worn for one or two 24-h periods, depending on the study. See Table 1 for study-specific details. The participant or parent of the participant also recorded those times when he or she removed the actometers (for example, during bathing).

An actometer registers 1 s for approximately five changes in direction (Eaton et al.,1996). Using this information we estimated the number of limb movements from the number of elapsed actometer seconds by multiplying elapsed actometer seconds by 5. We then created a rate measure by dividing the number of movements by the number of hours the actometer had been worn. The resulting *movements per hour* measure is common to all studies in the analysis.

RESULTS

For all studies, actometers were worn on two or more limbs (see Table 1). The mean arm movement score for all participants in all studies was 806, $SD = 456$. Participants in nine studies also had one or more leg-movement scores. For this subset of participants, who were all under 16 years of age ($n = 718$), an arm-and-leg movement score was calculated based on the mean of arm and leg readings, $M = 1008$, $SD = 697$.

An estimate of the reliability of the preceding summary scores is provided by the correlations among limb scores. Only data from individuals with four limb scores were used for these reliability correlations. Thus, studies conducted on participants over 15 years of age, who did not wear instruments on all four limbs, were excluded from the reliability analysis, as were younger participants who did not have data from all four limbs. The resulting reliability sample had an *n* of 603 and a gender composition, 48.6% female, that was virtually identical to that of the full sample (see Table 1). Because chronological age (CA) was strongly correlated with limb movements (*r*'s between CA and each limb ranged from .50 to .75), we also calculated partial correlations by removing the linear effects of chronological age from the interlimb correlations. The raw and partial correlations are shown in Table 2. The strong relationships indicate substantial within-person consistency in level of limb movement and provide empirical justification for the aggregation of limb scores into composites.

TABLE 2
Movement per Hour Means, Standard Deviations, and Correlations by Limb (Raw and Age-Partialled)

Limb	Mean	*SD*	RA	LA	RL	LL
Right arm (RA)	664	396	—	.85	.79	.80
Left arm (LA)	795	492	.80	—	.83	.80
Right leg (RL)	1081	951	.67	.77	—	.90
Left leg (LL)	1028	940	.68	.73	.79	—

Note. $n = 603$. Raw correlations are above the diagonal, and age-partialled correlations are below. All correlations are significant, $p < .0001$.

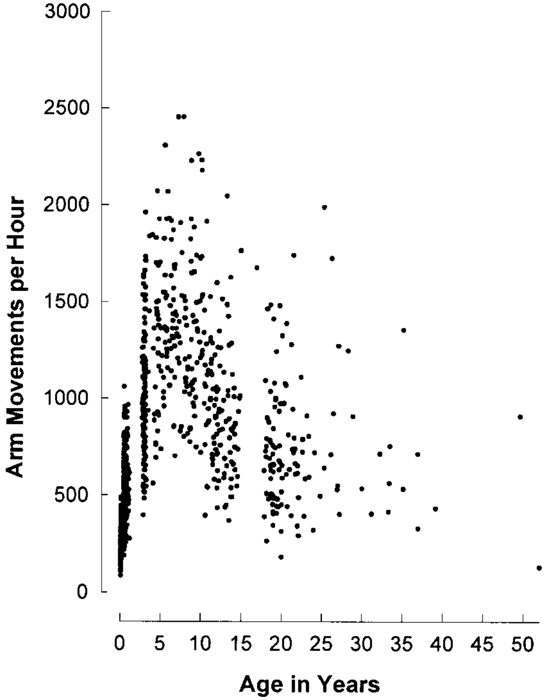

FIG. 1. Mean arm movements per hour by age in years (N = 840).

We conducted two age-by-sex analyses of variance, one for arm movement scores and one for arm-and-leg movement scores. In order to test for our curvilinear hypothesis, we partitioned age into linear and quadratic components. For arm movements, both age contrasts were significant, $F_{linear}(1,834) = 206.5$, $p < .0001$, $F_{quadratic}(1,834) = 162.0$, $p < .0001$. As Fig. 1 illustrates, arm movements display both a linear increase from infancy through childhood and an inverted-U pattern, with a peak in the 7- to 9-year age range. The same pattern is found when both arms and legs are involved (see Fig. 2).

Gender was not a significant predictor of movements per hour, either alone or in interaction with age. In effect size terms, males were more active than females by .11 *SD*'s (Cohen's *d*) for both the arm and the arm-and-leg movement per hour variables.

DISCUSSION

Movement is essential for survival and physical development and enables children to develop muscle strength, kinesthetic awareness, and motor skills. Infants learn to crawl and walk, and these major milestones provide infants with an early means for exploration (Piaget, 1952). This exploratory activity

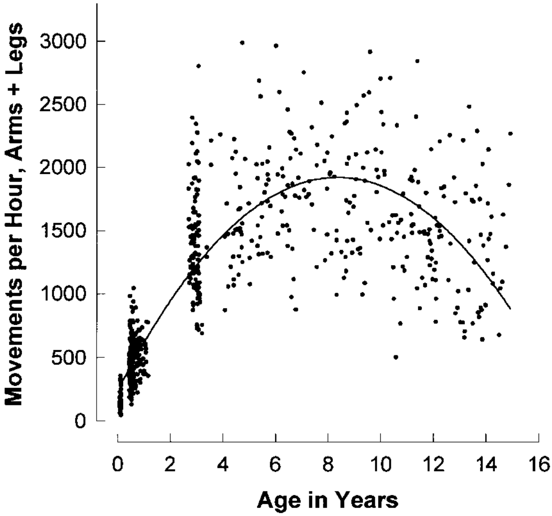

FIG. 2. Mean arm-and-leg movements per hour by age in years ($N = 718$).

continues as preschoolers refine their early motor skills and as older children somersault, hang from a balance bar, throw and catch a ball, ride a bicycle, and swim. Beyond these specific exemplars of movement, larger developmental patterns are discernable in our data. We found that the limb movements of a large number of infants, children, and adults, measured as they went about their daily lives, waxed and waned in an inverted U-shaped developmental pattern across age. The peak in rate of movement came between 7 and 9 years of age, somewhat later than we had expected.

Our results are based on large behavioral samples of movement from the variety of situations encountered in daily life. A number of methodological strengths flow from this approach. Our instrumented measure sidesteps the problems of informant bias and registers movements, be they socially salient or not. A related virtue of our approach is that the data are not restricted to one or two settings, a limitation of many observational coding studies of activity. Further, our aggregation over limbs reveals a high degree of reliability, as shown by the high interlimb correlations in Table 2. The coherence of limb movements means that the same developmental trajectory is observed for both arms and legs.

Another strength of our findings is that they are paralleled in other literatures. For example, the running activity of rats increases, levels, and then declines over age (Reed, 1947). More importantly, a similar, curvilinear inverted U-shaped age-related pattern is reported for children's play (Pelligrini & Smith,1998). Although Pelligrini and Smith differentiated physical exercise play into three types, with different peaks at different ages, Byers (1998) took an alternative position. He hypothesized that ''. . . the apparently purposeless locomotor acts that we call play show smoother, more continuous development . . .'' (p. 599). Our aggregate movement measure encompasses each of the various types of play described by Pelligrini and Smith, so our single-peaked pattern does not argue directly against their three-part model of exercise play. Nevertheless, our data seem more compatible with Byers' (1998) position, and our movement trajectory certainly applies in a general way to an understanding of play. Unlike the play literature, our measure is about movement throughout the day, not just in play settings.

The issue of movement in play settings is relevant for questions of gender differences. Typically, boys are observed to be more active than girls (see meta-analytic reviews by Campbell & Eaton, 1999; Eaton & Enns, 1986). Qualitative differences seem to characterize sex differences in children's play. For example, boys are much more likely to engage in rough and tumble play (DiPietro, 1981) and to cover more territory (Geary, 1998); whereas girls are more likely to engage in play parenting with younger children and dolls (Geary, 1998). Such qualitative differences occur in specific situations that may misrepresent the overall picture of boys' and girls' movement. Girls may forego rough and tumble play for other pursuits that are similarly active. Most studies that report sex differences in motor activity measure behavior in specific situations, whereas our full-day actometer measure is more general and inclusive. Our full-day data show that females are not inactive. Less clear is what they are doing when most active.

An inclusive, all-day measure of movement like ours has a limitation, namely that information about specifics, e.g., type of play, situational context, and the like, is unmeasured. Thus, we cannot draw conclusions about the qualitative nature of movements and their specific purposes. However, a quantitative composite can be scientifically useful. Ambient temperature, for example, does not tell us all we would want to know about how pleasant a given day might be, but it does provide important and scientifically useful patterns, e.g., the seasonal cycle in temperature. In the same way, our aggregate measure of movement revealed an intriguing developmental pattern.

This developmental pattern covers a wide age range, but there are several gaps in the ages represented. We have no data from 15- to 17-year-olds and sparse data after early adulthood. As well, our reliance on cross-sectional data restricts our interpretations to discussions of age differences rather than of directly measured change. Also, it is clear from Fig. 1 and 2 that there is tremendous variability around measures of central tendency. Of course such variability includes errors of measurement, but it also is reflective of the welter of influences on how active one might be on a particular day.

Without information about specific situations, our summary measure represents an unknown mix of individual activity preferences and putative contextual influences. Some contexts encourage more activity than do others, e.g., the playground vs. the classroom. With this in mind, we used procedures to minimize unnecessary contextual variation in each of the summarized studies. For example, data in our studies were collected on weekdays, and for school-aged children, on days when they attended school. Moreover, because data was collected over 1 or 2 full days, the influence of a particular context is more diluted than it would be for shorter periods. In any given day, we expect both periods of restricted and unrestricted activity. All individuals' activity may be contextually constrained at times, but when restrictions are removed, individual preferences for more or less activity should surface.

Although field studies cannot disentangle the interaction of individual preference and contextual influence, our results point to a strong individual component of this interaction. We reason that the preschool environment provides more freedom for, and encouragement of, motor activity than does the elementary school setting. If this is the case and if contextual influence predominates, we would expect activity to decline as children move from preschool to elementary school settings. Thus, our finding of a peak for activity in middle childhood is particularly surprising. The mismatch between the observed trajectory and the presumed age-graded restrictions of the elementary classroom implies that individual processes are potent.

The interaction of individual preferences with situational differences has been characterized as niche-picking by Scarr and McCartney (1983). A person's activity will be influenced by the niches they choose. From this perspective our results can be viewed as a developmental trajectory in niche-picking. The 9-year-old, when given the choice between a run-and-play niche and the sit-and-chat niche, will almost certainly choose the former. Adults, as we all know, will almost invariably choose the latter. This age pattern in the data leads us to the larger question (though not necessarily to the answer): How might we account for a pattern of increasing movement followed by a decreasing one?

Curvilinearity in a developmental trajectory can signal the presence of a new process. What process could be implicated here? One possibility relates to changes in growth requirements. Movement and tissue growth are both fueled by the same energy source, calories. If calories are expended on growth, they cannot be used to fuel movement. From infancy to middle childhood, activity level accelerates while the rate of physical growth decelerates, a pattern which is consistent with the preceding resource allocation model. Within this framework, the new process in late middle childhood is pubescence, when hormonal changes are systemic and widely influential (Katchadourian, 1977). Growth rates increase and movement starts to decline. The preceding argument would suggest, however, that once adolescent growth is complete, the caloric surpluses no longer needed for growth would be redirected to movement. Yet a postadolescent activity increase is not observed in the data. Aspects of development other than physical growth and energy balance need to be considered.

Cognition might seem far removed or even antithetical to how much children typically move throughout the day. From a developmental perspective, however, movement plays an intimate role in children's exploratory behavior and cognitive development. Both Rousseau and Piaget emphasized the need for children to physically interact with their environment as a part of normal cognitive development (Piaget, 1952; Rousseau, 1762/1948). Piaget's description of the infant's sensorimotor stage of development exemplifies how actions and tactile concrete experiences form the basis of infant cognition. The exploratory and stimulating nature of movement among infants and younger children is a relatively well-accepted proposition (Gibson, 1988). However, in our sample, movement peaks between 7 and 9 years of age. So, throughout the middle-school years children are still displaying very high levels of movement. Among these older children, the exploratory argument becomes less convincing, for movement is only one of their methods of exploration and cognitive stimulation.

How might cognitive development relate to our observed peak in children's movement during late-middle childhood? An intriguing explanation is inspired by Bjorklund's (1997) functional immaturity hypothesis. This hypothesis asserts that seemingly immature, even problematic behaviors, from an adult perspective may be functional during the phase of development in which they occur. The 7- to 9-year age range falls within Piaget's concrete operational stage of development. At this stage, children, although capable of abstraction, still rely on concrete objects to facilitate their thinking. The high levels of movement in middle childhood may serve to direct experiences and cognitive resources toward concrete, varied interactions with the environment. These experiences are highly compatible with children's concrete operational stage of cognitive development. If children need to understand the world in concrete terms before they can begin to understand abstract relations, then it is beneficial for them first to explore their environment in a physical way. Movement, we suggest, supports this concrete understanding. Decrements in movement in early adolescence may signal or accompany a shift toward more abstract, cognitive pursuits.

Applying a functional immaturity interpretation to movement provides an alternative perspective on a common behavioral problem, attention deficit/hyperactivity disorder (ADHD). Children's high levels of movement are typically accompanied by rapid shifts of attention, a central marker for ADHD. We find it intriguing that our observed peak in motor activity corresponds to the peak in the diagnosis of attention deficit disorder at 7 to 9 years of age (Brownell & Yogendran, in press; Szatmari, Offord, & Boyle, 1989). Our data were drawn from nonclinical, ostensibly normal children, so the resulting trajectory could be viewed as the ''natural'' course of age-related movement. It is usually assumed that high levels of movement are negatively correlated with attention. Moreover, attentional difficulties are seen as primary, with excess activity as a common consequence (Barkley, 1997).

Although our data cannot speak to the issue of a causal link between activity and attention, it prompts us to question the idea that attentional difficulties are the cause of overactivity. Our personal experiences with recreational and sporting pursuits convince us that rapid shifts of attention are required if one is moving often or quickly. A child may seem inattentive to a relatively inactive adult observer because the child is highly active. The match of our normal activity peak with the peak for diagnosing ADHD certainly raises for us the possibility that many of the symptoms of ADHD are normative rather than pathological. Steffensson et al. (1999), in a twin-study examination of well-known genetic influences on ADHD, found that general maturity was a partial mediator for genetic influences on ADHD. Their findings lend support to the idea that developmentally immature children, who are likely to be more active than their agemates after age 7 or 8, may be inappropriately at risk for a diagnosis of ADHD.

High levels of restlessness and overactivity have long been associated with concurrent aggressive behavior (Prinz, Connor, & Wilson, 1981) and later antisocial disorders (Richman, Stevenson, & Graham, 1982). However, as noted by Nagin and Tremblay (1999), many research instruments conflate aggression and hyperactivity items, so it is unclear if the hyperactivity or the aggression, or both, are predictive of antisocial outcomes. When Nagin and Tremblay (1999) distinguished hyperactivity from oppositional and aggressive behaviors in a longitudinal study of boys' externalizing and delinquent behavior, they found that childhood hyperactivity was not a predictor of later delinquency, once childhood aggressiveness and oppositional behavior was statistically controlled. Their finding is unsurprising if one assumes that high levels of activity in the elementary school years are normative, not pathological.

A normal peak in movement at around 8 years does not mesh well with adult expectations for quiet, attentive behavior in school. Somewhat paradoxically, recess breaks during elementary school are associated with more on-task behavior and less fidgeting (Jarrett et al., 1998; Pelligrini, Huberty, & Jones, 1995). Pelligrini and Bjorklund (1997) argue that recess breaks enhance school outcomes by reducing cognitive interference associated with prolonged periods of focused attention. From their perspective, recess (and higher levels of motor activity) indirectly facilitates school performance. Given our observed age trajectory in movement, we propose that movement may directly facilitate school performance. Specifically, educational practices would be more effective if they incorporated movement in the later elementary school years as well as in the early ones. For example, the teaching of multiplication and division could easily be adapted to include physical movements to illustrate arithmetic relations.

Incorporating more physical activity into the elementary school environment has additional potential benefits. During the early grade-school years, adiposity begins to increase after having declined during the preschool years. An increased risk for adult obesity is associated with above-average accumulations of fat during middle childhood (Dietz, 1996), an age when obesity first becomes apparent. Patterns of customary physical activity in middle childhood may, therefore, have long-term consequences. Because regular physical activity is more important for weight regulation than sporadic exercise (Saris, 1996), integration of activity in multiple domains around the peak of the activity trajectory in middle childhood is to be encouraged.

Another domain central to children's development is the social sphere. In a variety of ways children's movement influences and constrains social interactions with parents and peers. Parents will throw their infants into the air, bounce them on their knees, and generally encourage social interaction through physical movement. The infant's gradual coordination of movement is greeted with great cheer among family members, but the ability of the toddler to move around may induce more negative social interactions in the form of disciplinary action. For example, child movement often brings about a greater need for parental constraints and limits (White, 1975), such as safety concerns that require the preschooler to learn not to run into the street. Disciplinary issues often focus on the appropriate time and place for motor movement (e.g., playground vs. dinner table). Although this capacity for movement and the interest in ''stretching the limits'' can produce conflict with parents, it also can have positive effects. For example, risky behaviors engendered by movement demand parental awareness and attention.

Later in development, age-related changes in movement may influence peer choices. Playmates may be chosen for the similarity of their styles of play (Maccoby, 1988), and activity preferences may have a great deal to do with determining how siblings get along (Stoneman & Brody, 1993), who children choose as their friends, and what they do together (Eaton & Keats, 1982). For example, very active children will seek social niches that allow for and encourage much movement. Movement as a basis for seeking such niches may reach its zenith between 7 and 9 years. The decline in movement rates in late-middle childhood and early adolescence suggests to us that the socially affiliative value of movement will drop as the overall level of movement declines. This is not to say that it will disappear. Active senior citizens may well seek the company of active peers in order to enjoy shared pursuits and recreation.

Movement is also involved in the expression of emotion. For example, physical exercise is related to reduced depression, better mood, and less stress in adults (Biddle, 2000; Hassmen, Koivula, & Uutela, 2000). Children too, express their emotions in movement, whether it is in limb-flailing temper-tantrums or in wild running and jumping play. Young children are most reliant on physical rather than cognitive emotional expression, whereas older children and adolescents increasingly make use of cognitive approaches to express their emotions (e.g., arguing). We maintain that the waning of movement corresponds to an increasingly sophisticated means of emotional expression and regulation. The ability to inhibit a response develops later than the ability to activate one (Bjorklund & Harnishfeger, 1995), so the cognitive expression of emotion, which requires greater inhibition, will emerge later than the physical expression. It is probably the case that children who are not able to decrease their dependence on movement to express their feelings begin to have increasing social difficulties.

Movement may help to regulate arousal in much the same way as it helps to regulate emotion. Some children prefer highly stimulating activities in order to maintain an adequate level of arousal, whereas others prefer less stimulating activities to maintain their optimal level of arousal (Strelau, 1989). Thus, children's typical levels of movement will include their efforts to engage a more or less stimulative environment.

The observed curvilinear movement pattern over age may represent two different arousal mechanisms. The early waxing of movement may correspond to the needs of children to use movement to maintain an ideal level of arousal. The waning of movement in later childhood may correspond to the diminishing need of children to use movement to maintain a comfortable level of arousal. If movement is used to regulate arousal and movement declines, what is implied about postpeak arousal? We suggest that arousal may come to be regulated more through symbolic means. Perhaps older children and adolescents daydream for arousal regulation, when, as younger children they may have increased or decreased their level of movement.

From the regulation of emotion and arousal to the facilitation of cognitive development, we have outlined a variety of ways in which age-related changes in general movement may influence psychological domains not often associated with movement. In this paper we have discussed the role of movement in several of those domains, physical, cognitive, social, and emotional. In the end, though, children do not move because of its functional role for their development. They move because they enjoy it. Their enthusiasm reflects, in our view, the developmental importance of physical movement in childhood.

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