# Motor Milestones & Goal-Directedness during Infancy

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# Abstract

This study investigates the relationship between gross motor milestones and various developmental influences during infancy. A survey of 228 parents revealed a single underlying factor accounting for over two-thirds of variance in the onset of five motor milestones (sitting, standing, crawling, cruising, walking), suggesting consistent early-, typical-, or late-bloomer patterns. Infants demonstrating early motor milestone achievement showed increased goal-directedness across multiple domains and ages. Specifically, 9- to 16-month-old infants with earlier milestone achievement showed enhanced problem-solving abilities, while 3- to 5-month-olds with sharper visual acuity and temperamental distress to limitation, but not necessarily high non-goal-directed activity levels, displayed quicker milestone progression. Results support a theoretical link between physical motor abilities and broader cognitive development. Future research can explore specific questions arising from the identification of a single underlying factor.

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Generations of infancy researchers have focused on motor milestones for the insights they provide into neurological development (e.g., Gesell, 1946), learning (e.g., Zelazo, 1976), and construction of dynamic systems models (e.g., Thelen, 1984). Infants' goal-directedness provides a foundation for several developmental theories (e.g., Case, 1991; Piaget, 1954). Moreover, diverse theoretical perspectives like Piaget’s and Gibson’s models suggest physical action and broader cognitive development are intertwined during infancy (e.g., Piaget, 1954; Adolph 2002) The present study investigates the developmental trajectory of five motor milestones (sitting, crawling, standing, cruising, walking) and examines how the onset of these milestones relates to infants' goal-directedness.

Prior research examines correlates of individual differences in gross motor milestone acquisition. Infants who sleep on their stomachs (e.g., Kuo et al., 2009; Vaivre-Douret et al., 2005) or spend waking hours in more restrictive clothing (e.g., Hayashi, 1992) are slower to creep and crawl. Infants’ nighttime sleep becomes disrupted as they begin to crawl (e.g., Paret, 1983; Scher & Ratson, 1998; Scher, 2005). The onset of crawling is also associated with greater joint attention – when infants look to the same direction as adults (Campos et al., 1997). One goal of the present study is to examine how crawling corresponds with other gross motor milestones. If, for example, those who are late-bloomers at crawling were also late bloomers at sitting and late bloomers are walking, we might use the underlying construct as a more precise measure of gross motor milestone acquisition in future research. Given this goal, the present milestone study asked parents for the on-set of their infant’s milestones, rather than following prior measures that ask parents to review a checklist at a particular moment in time, such as the Alberta Infant Motor Scale (Bodnarchuk & Eaton, 2004).

Multiple domains of empirical research suggest acquisition of gross motor milestones relates to infants' goal-directedness. Examples include the study of problem solving tasks, temperament, and perception. Eight-month-old infants who could crawl were more capable of reaching indirectly for a toy in a transparent box while those who had not yet crawled were more likely to reach 'through' the box (Sha, Dong, Yanping, & Campos, 1999). Infants high in the "distress to novelty" but low in the "activity level" aspects of temperament were those infants most capable of classifying hierarchical categories of objects (i.e, vehicles versus animals) in a forced-preferential looking task. I conjecture that those infants high in distress to limitations but low in activity are the most goal-directed as they seek to the ability to engage their world even if they are not the most active in non-goal-directed ways. Visually impaired infants and toddlers are slower to take their first steps (e.g., Heinz et al., 2001; Sonksen et al., 1984). One promising explanation for the delay is that seeing a goal affords an extrinsic motivation for locomotion in typically-sighted children (Sonksen et al., 1984).

I hypothesize that gross motor milestones occur in stages and progression through these stages reflects a single underlying construct. I further hypothesize that this underlying construct predicts measures of goal-directedness from multiple domains. In particular, I hypothesize that infants who are quicker to achieve motor milestones are: (1) more capable to retrieving a desired toy despite obstacles, (2) more likely to be distressed by limitations when controlling for general activity level, and (3) are more likely to have more detailed visual acuity.

## Method

Two-hundred twenty-eight (228) parents completed a survey about their 1- to 7-year-old child's motor milestones during infancy. A subset of 84 infants had their visual acuity measured at 3- to 5-months old.  A subset of 19 infants had their goal-directedness measures at 9- to 16-months old.  A subset of 58 infants had their goal-directedness measured through temperament at 3- to 5-months old.

Parents answered a survey about five motor milestones – sitting, crawling, standing, cruising, and walking.  Sitting was defined as the infants' ability to sit without help indefinitely. Crawling was defined to include creeping or other quadrupedal locomotion.  Cruising was defined as movement with the help of walls or furniture.  If parents did not know the exact date, they were asked to give a range, either as a range of ages (e.g., 6 to 6.5 months old), a range of time in the past (e.g., 3 to 4 months ago), or as a range of dates (e.g., between mid- to late-June). Using each child's birthdate, I calculated the number of days old for each milestone.  When parents' provided a range, the mid-point was used.

Infants goal-directed problem solving efforts were measured through the Pull-through-Angle task (Grobman, 2010) a variant of Piaget's (1936) means-ends sequencing tasks.  A toy was placed out of reach of the infant upon one of two clothes that stretched back to the infant. Infants completed 16 where the toy was placed pseudo-randomly on the left or right cloth.  Goal directedness was defined by pulls to the cloth upon which the toy rested while controlling for pulls to the other cloth.

Temperament was measured using parents' responses to two sub-scales of the IBQ (Rothbart, 1981).  To assess goal-directed personality, I examined infants "distress to limitations" while controlling for overall "activity level."

The visual acuity of 3- to 5-month-olds was measured using Teller Cards (Teller et al., 1986).  Infants sat upon a parent's lap while they were large cards with alternating black and white stripes on either the left or right side (randomly assigned each trial) while the other side was entirely gray. The black and white stripes became thinner each trial and visual acuity is measured as the thinnest stripes infants can differentiate from solid gray, based on forced preferential looking.

## Results

Consistent with Gesell (1934), I found that infants achieved the motor milestones in a stage-like progression. Aside from standing and cruising, that happen in either order and 94% of the time within a 3-month span, the proportion achieving each milestone after the preceding milestone was over 90%. A factor analysis revealed a single underlying factor accounting for 67.8% of the variance in gross motor milestone on-set (loadings of .62 to .90; Eigenvalue = 3.39). Scree plots and Eigen values suggested no additional factors underlay responses. This suggests a stable individual difference during infancy; infants are rarely late-bloomers for one milestone but early bloomers for another milestone. See figure 1 for histograms and table 1 for descriptive statistics, statistics on the stage-like progression, and factor loadings.

Subsequent analyses correlate goal-directedness measures with the underlying factors; figures show the underlying factor linearly transformed in the age of infants' first steps. This make presentation of results more intuitive and linear transformations do not alter the statistics. Infants who pulled more on the cloth toys sat upon achieved motor-milestones marginally earlier when controlling for pulls to the other cloth and the age of participation in the pull-through-angle task, $r = -.362$, $\Delta r^2 = .131$, $p = .076$, $n = 19$ (Figure 2). Infants who experienced greater distress to limitations achieved motor-milestones earlier, when controlling for general activity level and age of temperament assessment, $r = -.241$, $\Delta r^2 = .058$, $p = .036$, $n = 58$ (Figure 3). Infants with greater visual acuity achieved motor-milestones marginally earlier when controlling for age of visual acuity assessment, $r = -.176$, $\Delta r^2 = .031$, $p = .050$, $n = 82$ (Figure 4).

# Discussion

An underlying gross motor milestone factor unfolds across the first year of infancy. This factor accounted for over two-thirds of the variance, suggesting that infants are consistently early-bloomers, typical, or late-bloomers in the on-set of sitting, standing, crawling, cruising, and walking. Those infants who are early bloomers showed greater goal-directedness in three different domains and at two different ages. Nine- to sixteen-month old infants who were more sophisticated at choosing operators during a problem solving task experienced motor milestones earlier. Three- to five-month-olds with sharper visual acuity proceeded through the motor milestones more quickly. Three- to five-month-olds with temperamental distress to limitation, but not merely high non-goal-directed activity level, were also quicker to reach motor milestones.

Results support the theoretical suggestion that physical motor abilities relate to broader cognitive development. Future research can uncover more correlates of motor development during infancy. Revealing a single factor raises more precise questions for future research. Variation beyond that accounted for by the singe factor may be due to environmental conditions that influence one milestone while leaving other milestones relatively unaffected. Consider the previously mentioned research about putting infants in the prone position during wakeful periods predicted crawling, but not walking (Kuo et al., 2009). To what extent are these studies accounting for unique variance? Consider another example of prior research using a twin-study methodology. Goetghebuer et al., (2003) suggested that 90% of variance in motor milestones may be accounted for by genetics. It is likely at least some of the 68% of variance accounted for by the single gross motor milestone factor in this study is due to consistent environmental conditions. Taken together, more than 22% of the variance may be genetic but not part of a consistently unfolding motor ability. Future research can illuminate this pattern more fully. The present study suggests the importance of motor milestones in infants' development, but also raises more questions for future research.

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Table 1: Descriptive Statistics, Stages, and Factor Loadings of Motor Milestones

| Milestone | Mean Age (Months) | Standard Deviation of Age (Months) | N | Proportion having achieved previous milestone | Factor 1 |
|---|---|---|---|---|---|
| 1. sit | 6.12 | 1.22 | 222 | | .62 |
| 2. crawl | 8.21 | 2.00 | 223 | 91% sit | .85 |
| 3. stand | 10.08 | 2.04 | 216 | 92% crawl | .87 |
| 3. cruise | 10.16 | 1.98 | 218 | 91% crawl | .90 |
| 4. walk | 12.04 | 1.83 | 218 | 91% stand & 97% cruise | .85 |

Figure 1. Histograms of Motor Milestones

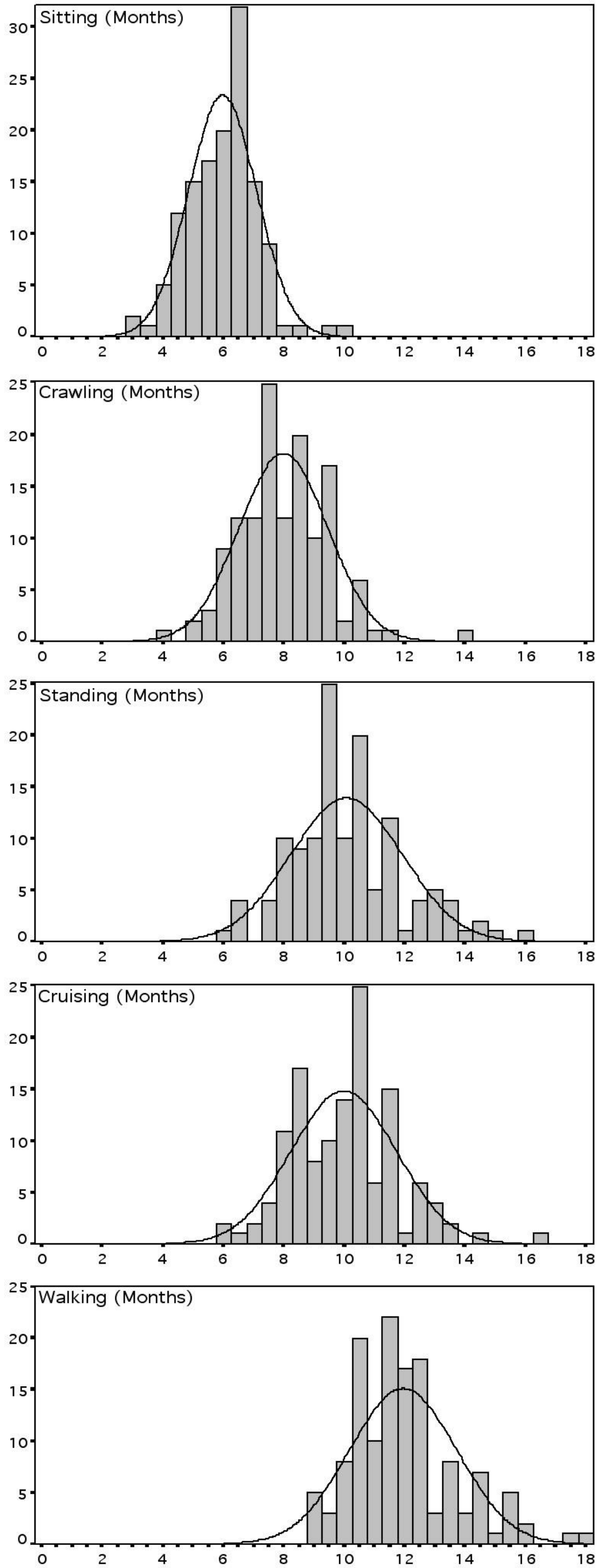

Figure 2. Scatter-Plot of Age of Onset of Walking and Goal-directed Reaches for Cloth

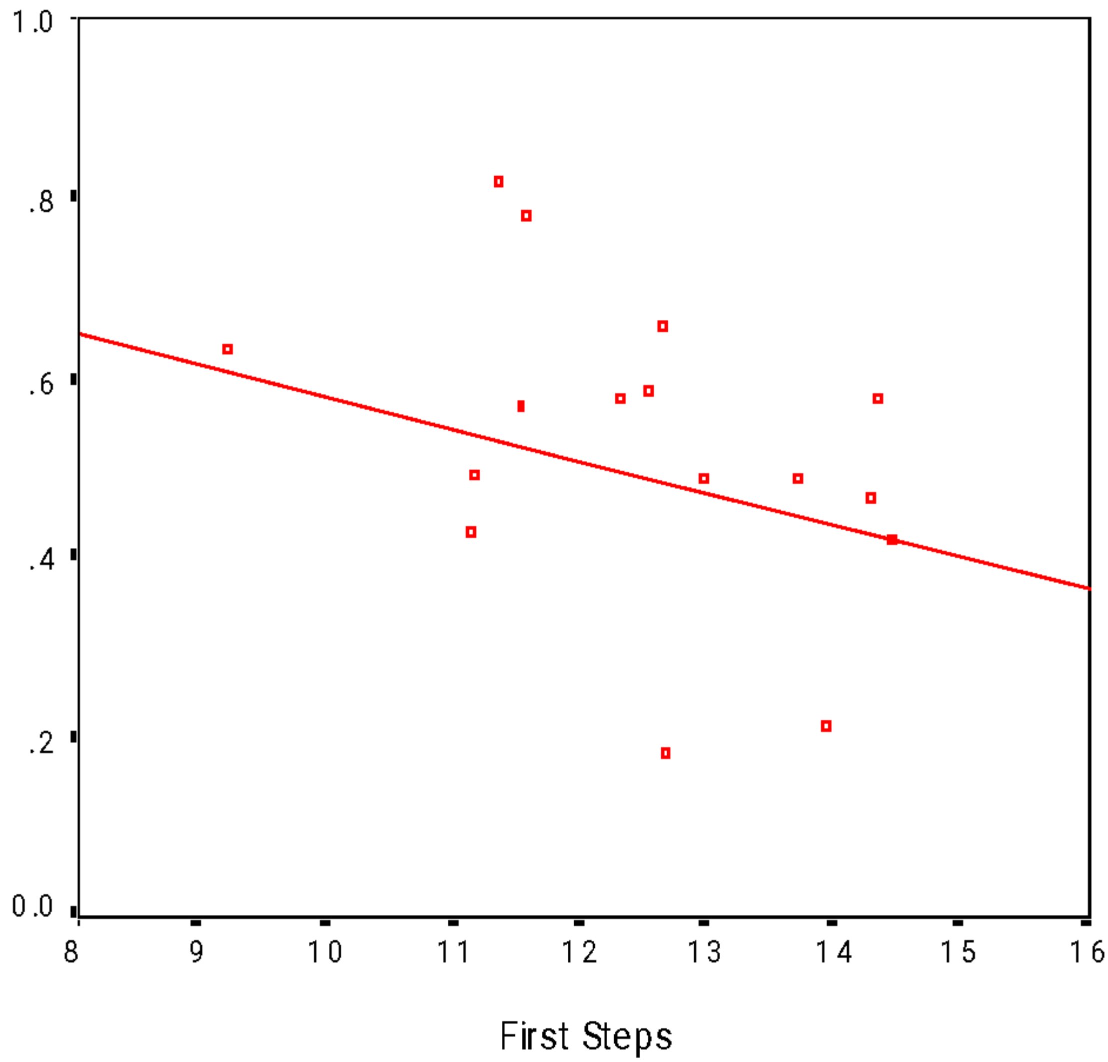

Figure 3. Scatter-Plot of Age of Onset of Walking and Goal-directed Temperament

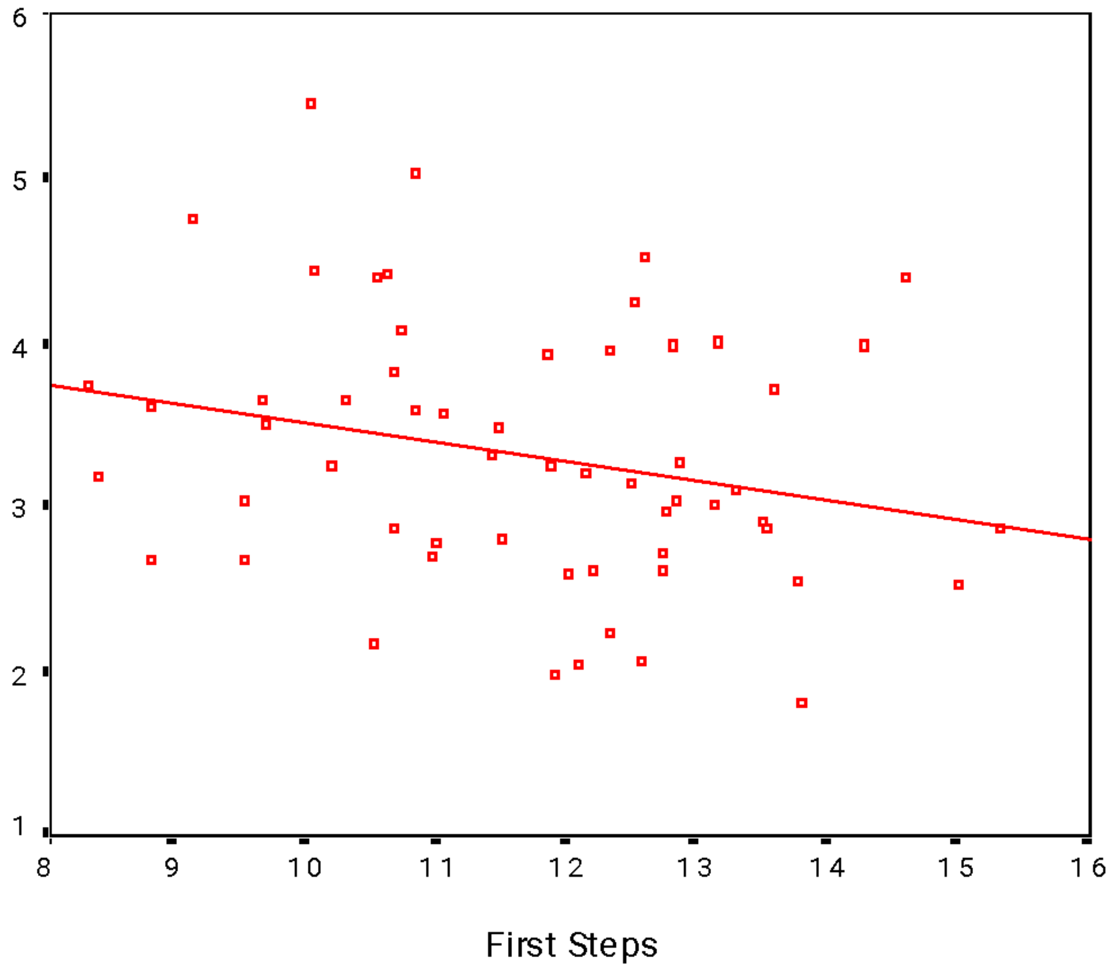

Figure 4. Scatter-Plot of Age of Onset of Walking and Visual Acuity