

**The presence or absence of older siblings and variation in infant goal directed motor development**

Running Head: Siblings and infant motor development

## ABSTRACT

This study investigates the relationship between having an older sibling and early goal-directed motor development. In a longitudinal study, infants were filmed playing with their mother and were observed at 5 and 12 months of age. After each observation, they were assessed with the Mental Bayley Scale. From the mother-child interaction, playing was coded in terms of the production of infant goal directed actions. Results indicated that infants with siblings produced less goal directed actions at 5 months than infants without older siblings, but at 12 months they produced relatively more goal directed actions than infants without older siblings. There was no relationship with scores on the Mental Bayley Scale. In order to examine differences in adult behavior that may account for variation in infant motor performance, maternal level of motionese was scored with no differences found between the sibling - no sibling groups. These results suggest that the early trajectory of motor development may be altered if the infant has an older sibling.

## KEYWORDS

Infants, Motor development, Goal directed action, Siblings, Social cognition

## INTRODUCTION

Siblings, like other family members, are important in the development of the individual. Research has focussed on sibling contributions to social (Brody, Kim, Murry & Brown, 2003), emotional (Howe & Ross, 1990) and cognitive development (Perner, Ruffman & Leekam, 1994). Recently, it has been shown that cognitive and motor development are highly linked during infancy (Diamond, 2000; von Hofsten, 2004). Despite these associations, connections between the presence or absence of a sibling and how this may relate to the motor development of younger siblings have not yet been made.

How siblings facilitate development, provide new experiences and change the environment of other siblings is a relatively unexplored area of developmental psychology. Most research on the construction of the family has focussed on parental variables, such as maternal personality (e.g. Wiesenfeld, Whitman & Malatesta, 1984) or paternal involvement in child rearing practices (e.g. NICHD Early Child Care Research Network, 2000). The role of siblings in the development of the individual has focussed mostly on how the presence or absence of siblings is correlated to social and emotional outcomes later in development (see Brody, 2004). This is despite evidence suggesting that properties of the early developing brain make it particularly sensitive to environmental variables (e.g. de Haan, Belsky, Reid, Volein & Johnson, 2004).

In parallel and in isolation to research investigating relations between sibling presence and later child development, much work has been conducted on early motor development. This research has investigated how motor control of the trunk scaffolds to complex manual abilities within the space of a few months (e.g. Bertenthal & von Hofsten, 1998). Other research has grappled with relations between motor milestones and how this may affect developmental outcomes (Newell, Liu & Mayer-Kress, 2003). Clear links have been shown between cognitive abilities and motor abilities. For example, Diamond (2000) shows a complex picture of the interrelation between motor development, development of the neocerebellum area of the infant brain, cognitive abilities and development of the dorsolateral prefrontal cortex.

One study has investigated the role of siblings in imitative acts. Barr and Hayne (2003) found via parental report that in families with older siblings, infants at the age 12 months to 18 months with older siblings performed more spontaneous imitative acts than those infants without older siblings. This was despite the same sample showing more explicit parental instruction of actions to those infants without siblings. Further, those infants with siblings would imitate substantially more actions produced by other children than those infants without siblings. This suggests that older siblings serve as a model for new motor activities for the infant.

There are strong theoretical grounds to suggest that having a sibling may expose an infant to an environment that may facilitate successful goal-directed motoric behaviors. Much theory exists that suggests a strong

relationship between action perception and action production (e.g. Prinz, 1997). Indeed, research into the relationship between the perception of action and the production of action has shown that even young infants use knowledge of action processes to achieve goals (Sommerville, Woodward & Needham, 2005). It is therefore possible that the raw frequency of observed goal directed actions is increased for the infant with siblings whereas the infant with no sibling can only observe the behavior of the caregiver. This may result in different sensitivities to the parameters of goal directed behaviour, depending on the presence or absence of a sibling in the life of a developing infant.

In addition to the frequency of observed motor acts, it is possible that the motor execution of movements that are related to goal directed behavior may differ between an older sibling and an adult. A sibling less than four years older than an infant may produce actions that are more akin to the motor abilities of that infant when compared with differences in motor abilities between an infant and an adult. Relatively more gross motor action may accompany goal directed action by a preschooler when compared with the execution of the same action by an adult. It is possible that adults realise the difference between their motor abilities and that of their infant. For example, it has been shown that adults produce actions differently when instructing an infant in object use when compared with instructing an adult (Brand, Baldwin & Ashburn, 2002). This change in motor behavior is presumably in order to enhance the structure of the motor action that achieves the goal or to highlight the correct motor procedures with which to interact with an object. In so

doing, the adult behavior is conjectured to facilitate infant learning (Brand, Shallcross, Sabatos, & Massie, 2007). However, it is conceivable that the majority of parental actions observed by the infant are not geared to facilitate infant understanding and are produced for the efficient attainment of goals rather than the facilitation of infant understanding. Thus, as well as observing relatively less goal directed actions, the infant without siblings may observe relatively more human movement that cannot be enacted by their biomechanical makeup, such as walking or standing.

We examined the potential role of siblings by observing infants at play with their mother at both 5 months and 12 months of age. These two ages were assessed in order to index whether the performance of goal directed actions is related to the capacity to detect and interpret these actions in others. There is no evidence to suggest that infants younger than 6.5 months detect agentive goal-directed movement, (Kamewrai, Kato, Kanda, Ishiguro, & Hiraki, 2005) however by 12 months, much literature suggest that this ability is well entrenched (e.g., Csibra, Bíró, Koós, & Gergely, 2003; Reid, Csibra, Belsky & Johnson, 2007). 5 and 12 months of age were selected in order to index behaviour prior to and following the attainment of this capacity.

The aim of the present study is to investigate the potential role of siblings in the development of the ability to produce motor actions. We measured the quantity of successful goal directed actions by the infant at 5 and 12 months of age. We predicted that infants with siblings would produce more successful goal directed actions than those without siblings, for the perception

of actions affords new motor understanding in infants, with correlated motor outcomes (Sommerville, Woodward & Needham, 2005). We also tested infants at each age with the mental Bayley Scales of infant development (Bayley, 1993), in order to investigate whether any differences observed in motor production were related to mental development. In addition, we assessed maternal motionese to examine whether differences in the behavior of the primary caregiver may relate to differences in results obtained between the sibling and no sibling samples.

## MATERIALS AND METHOD

### Participants

72 infants (41 males, 31 females) were observed in a play session at an average age of 5.0 months, or 169 days  $\pm$  24 days. 33 of these infants had young siblings, defined as less than 4 years older than the infant whereas 39 had no siblings. Of the 33 infants with young siblings, 11 infants had an additional, second sibling, who was more than 4 years older than the infant. All infants were observed again in a second session at an average age of 12.0 months, or 378 days  $\pm$  36 days. Of these, the data for a subsample of 40 infants was assessed to examine maternal motionese behaviour during the play session. 20 of these infants had an older sibling(s). All infants were born full term (37-41 weeks) and were in the normal range for birthweight. Another 8 infants were tested but were excluded as a result of fussiness or failure to complete Bayley measures.

### Mother-infant interaction and coding

A colorful mat (2X3 m) was placed on the floor in order to create a psychological boundary for play. A variety of toys were made available that were suitable for the age of the infant (i.e. graspable rattles for 5 month old infants, toy pianos for 12 month old infants). These objects were selected to be items that were of potential interest to the mother and infant and which infants could manipulate in multiple ways. Mothers were told that every infant was different and that we were interested in understanding how infants play. Mothers were not instructed further than this basic information in order to avoid bias in their behavior, such as producing many object directed actions rather than other types of behavior, such as singing nursery rhymes or engaging in rough and tumble play. The dyad was seated and given time in which to become accustomed to the play area. The experimenter recorded this semi-structured play session with a digital video camera, placed on a tripod approximately 2 meters from the play area behind a curtain that occluded the experimenter and camera. Filming lasted from three to five minutes, depending on infant compliance. The infant had also undergone testing with the Bayley Scale for mental development. From the mother-child interaction, two measures were coded related to infant motor behavior: fine motor goal directed action and gross motor goal directed action. One measure was coded related to maternal motor behavior examining the level of motionese evident during the play session.

### Infant motor activity

For infant motor activity, we utilized infant coding systems devised by Reid, Belsky and Johnson (2005) as, unlike other coding strategies, this allowed us to code behaviour for goal directed actions. During the play session, each 10-second epoch was scored for the presence of specific aspects of infant fine and gross motor activity. Motor activity scores for each aspect of motor activity were individually operationalised as the number of epochs in which these activities were observed. Assessment of the five-minute interaction between mother and infant was made individually for fine and gross goal directed motor activity, with each being scored separately from the other. We assessed successful goal directed activity as this allowed us to further define motor activity. Specifically, extraneous actions with no apparent object or mother-related action, such as random waving arms, could be selectively removed from our definition of motor activity as could non-successful goal directed actions. *Fine motor goal directed action* was operationally defined to occur when the infant grasped or manipulated a toy in a semi-dextrous fashion (e.g., pressing buttons, holding objects, and twisting toys). *Gross motor goal directed action* was operationally defined as when the infant used gross motor movements to interact with toys and objects (e.g., whole arm or limb movements; whole hand movements such as hitting an object or toy). As infants interacted with their mother for differing periods of time, the total motor scores were converted into a ratio of the amount of time spent in play, thereby controlling for differences between infants in time scored.

As two individuals coded these data, inter-rater reliability was conducted on a subsample of seven subjects. Pearson correlations were high, with infant fine motor at 0.91 and infant gross motor at 0.99.

### Bayley Scale Measures

The testing room was divided into two sections. One section housed the filming equipment and an experimenter who scored the Bayley mental scale measures online. Another section of the room featured a table, approximately 2 feet wide and 4 feet long, and two seats on which the tester and parent sat. The infant was seated on the mothers lap. The tester sat next to the infant such that both infant and tester were sitting facing the occluded camera. Bayley scores on the mental scale (second edition, Bayley, 1993) were scored online in a video display by an experimenter who was not the testing experimenter.

### Motionese Measures

In order to measure modifications in mother's infant directed action, a scale developed by Brand et al., (2002) was used. One component, proximity, was not included in the coding as the present study featured naturalistic interactions rather than the infant constrained in a highchair. The scale measured *interactiveness, range of motion, enthusiasm, simplification of action, repetition, rate of presentation and punctuation*. Three additional behaviours were also scored as outlined in Reid, Belsky and Johnson (2005). *Mother related toy presentations* assessed the frequency of changes in maternal agenda, such as changing the object of focus due to her own

attention span. *Infant related toy presentations* indexed whether the mother or infant changed the objects available to the infant due to the desires of the infant. The final behaviour measured was *simplification of environment*, assessing the awareness of the mother to elements within the play area that may distract the infant from the object of focus.

All measures had 5-point ratings based on the behavior observed during the 5 minute play period. Zero represented no frequency/intensity, Four represented high frequency/intensity. A single, combined measure was obtained through summing the scores, and would therefore range from 0-44 (see Reid, Belsky & Johnson, 2005). A mixed design for analysis was used, with one within subject variable: infant (5 months and 12 months), and one between subject's variable: sibling(s) or no sibling.

## RESULTS

In this study, it was predicted that infants with siblings would produce more successful goal directed actions than those infants without siblings. Because Bayley scores were measured on both times of testing, traditional repeated measurements ANCOVAs or MANCOVAs cannot be used. Repeated measurement ANCOVA/MANCOVA only allows including covariates, which have values that do not change over time (time-independent covariates) and we, therefore, used a multilevel modeling (or general linear mixed model) analyses, conducted with each of the two motor measures as the dependent variables (fine motor, gross motor). These were paired with time of testing (5 or 12 months), existence / non-existence of a sibling as fixed categorical

factors, Mental Bayley Scores as a fixed continuous factor and infant's ID as a random factor (see Pinheiro & Bates 2000). We also tested an interaction between time of testing and infant's id (using a random intercept and slope model) to assess if the changes over time are similar between infants. A detailed introduction of the use of multilevel modelling to describe developmental changes in infant can be found in Lavelli and Fogel (2005). Cohen's  $d$ , the standardized difference between two means, is presented as a measure of effect size for the main results (Cohen, 1988). Cohen cautiously defined effect sizes of  $d=0.2$  as "small",  $d=0.5$ , as "medium" and  $d = 0.8$ , as "large".

For gross motor goal directed activity, there was an effect of time of testing [ $F(1,70)=80.07, p<0.001$ ], indicating less gross motor activity at 12 months than at 5 months. There was also a two way interaction indicating an effect on infant gross motor goal directed activity of time of testing by presence/absence of a sibling [ $F(1,70)=4.95, p=0.029$ ]; see Figure 1. Specifically, at 5 months, those infants with siblings produced less gross motor goal directed actions than those infants without siblings (with siblings,  $M= 10.0, SE = 0.89$ , without siblings,  $M= 11.58, SE=0.82$ ; Cohen's  $d = -0.31$ ). At 12 months, those infants with siblings produced more gross motor goal directed actions than those infants without siblings (with siblings,  $M= 5.41, SE=0.62$ , without siblings,  $M= 3.95, SE=0.57$ , Cohen's  $d= 0.41$ ). This effect did not change if we included the specific number of siblings as a continuous covariate in the analysis. In a further analysis, we also tested for the potential confounding effect of mental development by including the mental

Bayley scale as a covariate with the stability of the infants' responses over time investigated by including an interaction between infant and time of testing. Neither the mental Bayley scale ( $p > 0.4$ ) nor the interaction between infant and time of testing were significant ( $p = 0.19$ ) and did not change the effects of the other variables. No effects were found for assessments of fine motor production. No differences were found between sibling – no sibling groups in the level of motionese displayed by the mother during the interaction session.

## DISCUSSION

The aim of this study was to examine the potential influence of having a sibling on infants' motor responses during free play. The results suggest that siblings may play a role in motor development in relation to goal attainment. It is possible that linkages detected between having a sibling and infant motor production reflect, at least in part, the role of siblings in shaping motor development.

There are a number of possibilities as to why having a sibling appears to reduce gross motor production at 5 months, and facilitate gross production at 12 months. One possibility is that at younger ages, those infants with siblings may experience less stimulating care (see Dunn, 1992). The parent's attention may be divided in two ways (towards the infant and the sibling), with the net result being that the infant with an older sibling may have received less stimulating care by the pressed caregiver when compared with those infants who have no siblings. For example, for the infant with no sibling, toys may be placed by a parent strategically out of their reach in order to

deliberately facilitate trunk and arm motor activity and movement.

Comparatively, toys and objects may simply be passed by the parent to the infant with siblings in order to reduce fussiness and increase compliant behaviours. The net result is a reduction in the need for producing gross motor actions, such as crawling and reaching. Such an interpretation is supported by evidence that suggests that more linguistic attention is given to older siblings than to younger children by parents (Wellen, 1985). Further, younger siblings encounter less child-centered maternal conversation than older siblings (Woollett, 1986).

The results of the present study fit with action perception and production studies, which indicate that perception leads to action, but not indiscriminately: Infants' own knowledge and abilities matter (e.g. Gergely, Bekkering & Király, 2002; Hauf & Prinz, 2005). This is one explanation for the increase in successful goal directed actions in infants with siblings at 12 months of age. Infants at this age are capable of detecting goal directed activity whereas there is no evidence for this ability at 5 months of age. In addition to this cognitive ability, there are multiple changes across a raft of domains, not limited to neuronal development, muscular recruitment and coordination of muscular synergies. Changes in these characteristics are no doubt also important for the production of successful goal-directed behaviors.

These results also fit well with research suggesting a common system mediating the perception of action and the production of action (e.g. Prinz, 1997; Hauf & Prinz, 2005). Specifically, the effects found in this study were

observed in gross motor rather than fine motor goal directed actions. The infant's motor repertoire contains a larger amount of gross motor components than an adult. This is also true of children under five years of age (see Brakke, Frigaszy, Simpson, Hoy & Cummins-Sebree, 2007, for a brief review). Thus it is possible that infant observation of siblings performing actions (with a correspondingly more closely aligned biomechanical construction to themselves than that of infant to adult) may be related to the results seen in this study. Prior research on imitation (Barr & Hayne, 2003) supports this proposition.

Previous studies investigating atypical development have found that there is a relation between fine motor abilities and cognitive development (e.g. Connor, Sampson, Streissguth, Bookstein, & Barr, 2006; Singer & Fagan, 1984). The results of the current study do not add further support to these findings. However, studies that have found these relationships have not used the Bayley Scales as their measure of cognitive development. It is possible that the Bayley measure (Bayley, 1993) does not have the sensitivity required to detect these relations (see Niccols & Latchman, 2002). Another possibility is that the infants in our sample were fatigued by the demands of the testing situation, negatively impacting on fine motor activity with its related attentional requirements. However, fatigue was mostly observed during the Bayley assessment and was not observed during the following mother-child interaction, suggesting that this possibility is less likely.

It must be acknowledged that there is an important limitation to the conclusions drawn from this study. The study's correlational design precludes the drawing of strong conclusions about cause and effect. In order to confirm that siblings have a role in their younger sibling's motor development, future studies may consider experimental manipulations of infant experience such as a training experiment where one group of infants is exposed to goal directed actions and another group serves as a control. In this instance, we would predict that the trained group would produce more successful goal directed actions than the control group. It should be noted that current study does not inform on *how* siblings affect goal-directed motor development. However, as a first study in this area, these results nonetheless provide much needed direction for future research on this topic.

In summary, the results of this study demonstrated that at 5 months, infants with siblings produced less gross motor goal directed actions than those without, whereas at 12 months, infants with siblings produced more gross motor goal directed actions than those infants without siblings. This study suggests that social experience may play some role in the development of motor abilities. To what extent social experience and motor development are related remains an open question.

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## FIGURE CAPTIONS

Figure. 1. Frequency of goal behavior exhibited at 5 and 12 months of age (time 1 and time 2, respectively) as a function of presence/absence of a sibling (dark = siblings, light=no siblings). The interaction between time, siblings and goal behavior is evident with decreased number of goal behaviors at 5 months for infants with siblings, and increased goal behaviors at 12 months for infants with siblings. Error bars indicate summed standard error for each cohort.