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Infant recall memory and communication predicts later cognitive development

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Abstract

This longitudinal study investigates the relation between recall memory and communication in infancy and later cognitive development. Twenty-six typically developing Swedish children were tested during infancy for deferred imitation (memory), joint attention (JA), and requesting (nonverbal communication); they also were tested during childhood for language and cognitive competence. Results showed that infants with low performance on both deferred imitation at 9 months and joint attention at 14 months obtained a significantly lower score on a test of cognitive abilities at 4 years of age. This long-term prediction from preverbal infancy to childhood cognition is of interest both to developmental theory and to practice.

Keywords: Recall memory; Deferred imitation; Joint attention; Pre-verbal communication; Cognitive development; Prediction

The present study explores whether early indices of declarative memory and nonverbal communication skills predict performance later in childhood. In a previous study, Heimann et al. (2006) documented a relationship between recall memory at 9 months (deferred imitation), communication skills at 14 months (joint attention (JA)), and gestural communication at 14 months. The current study investigates whether a similar relationship exists between these infant skills and linguistic/cognitive performance measured long after the infancy period—at 4 years of age.

Theories of memory development originally proposed at least two major subsystems (e.g. Schacter & Moscovitch, 1984)—a procedural system available from birth and a declarative system that develops later in childhood. However, new test paradigms, such as deferred imitation, reveal that infants have some sort of nonverbal declarative memory already at 6–9 months, and possibly earlier (Barr, Dowden, & Hayne, 1996; Collie & Hayne, 1999; Hayne, Boniface, & Barr, 2000; Heimann & Nilheim, 2004; Meltzoff, 1988, 1995; Meltzoff & Moore, 1998). Such findings question the traditional view on infant memory.

In the deferred imitation procedure developed by Meltzoff (1988), children are briefly exposed to a target action; the object is then removed without letting the participants touch or play with it. This means that in order to be successful in a deferred imitation task, children need to form an internal representation of the adult's act and store that representation

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in memory. Because the participants are not allowed to handle the object prior to the delay, they cannot rely on a previously executed motor pattern in order to remember the action. After a delay, the object is re-presented and the children have the opportunity to produce the target action without any verbal cues. Tests of deferred imitation under these strict conditions have been proposed to measure preverbal representational ability (Meltzoff & Moore, 1998; Piaget, 1952), recall memory (Bauer, Wiebe, Carver, Waters, & Nelson, 2003; Carver & Bauer, 2001; Courage & Howe, 2004; Courage, Howe, & Squires, 2004; Gross, Hayne, Herbert, & Sowerby, 2001; Meltzoff, 1995), and individual differences (Heimann & Meltzoff, 1996). Additionally, by means of this procedure it has been shown that infants can also access memory of actions presented in one context and imitate those actions in another context (Barnat, Klein, & Meltzoff, 1996; Klein & Meltzoff, 1999; Learmonth, Lamberth, & Rovee-Collier, 2004).

Early nonverbal communication skills are thought to provide a foundation for later language development. Behaviors such as gaze following, reaching and pointing are capacities reflecting both communicative and social development (Baldwin, 1995; Tomasello & Farrar, 1986). Relationships between these infant nonverbal communication skills and later language development have been reported (Brooks & Meltzoff, 2005; Morales et al., 2000; Mundy, Kasari, Sigman, & Ruskin, 1995; Ulvund & Smith, 1996) and deficits in these abilities have been associated with atypical communicative development, such as in autism (Adrien, Rossignol-Deletang, Martineau, & Barthelemy, 2001; Dawson et al., 2004; Toth, Munson, Meltzoff, & Dawson, in press; Mundy, Sigman, & Kasari, 1994).

Joint attention refers to situations where a child and adult mutually focus on an object or event. This pattern of behavior typically develops at about 9-10 months of age. Joint attention is viewed as critical for social (Bakeman & Adamson, 1984; Tomasello & Farrar, 1986), communicative (Baldwin, 1995) and language development (Carpenter, Nagell, & Tomasello, 1998; Morales et al., 2000; Morales, Mundy, & Rojas, 1998; Ulvund & Smith, 1996).

An additional social communicative skill that involves two peoples' joint focus on an object is nonverbal requesting behavior, which children use to obtain a desired object. Object requesting (OR) resembles joint attention abilities but is used to regulate another person's behavior. This skill has also been shown to have specific predictive value for later expressive and receptive language (e.g. Mundy et al., 1995; Mundy, Sigman, Kasari, & Yirmiya, 1988).

Despite a global relationship between joint attention and object requesting, different processes have been suggested for behaviors emitted in *response* to another person's initiation and behaviors *initiated* by the child (Delgado, Mundy, Crowson, Markus, & Schwartz, 2002; Morales et al., 1998; Mundy et al., 1995; Ulvund & Smith, 1996). The suggestion that initiating and responding behaviors rely on differential underlying processes emerge, in part, from results showing that they predict different kinds of later language skills. Behaviors initiated by the child have been associated with expressive language skills (Mundy & Gomes, 1998) and later cognitive competencies (Smith & Ulvund, 2003) while responding to joint attention has been associated with both later expressive and receptive language skills (Morales et al., 1998; Mundy & Gomes, 1998). Moreover, there is some evidence that differential nonverbal communication skills are associated with activity in different brain areas. Initiating joint attention (IJA) has been related to activity in the frontal-cortical system, particularly in the left hemisphere, while responding to joint attention has been related to activity in the parietal lobes (Mundy, 2003; Mundy, Card, & Fox, 2000).

Recently, Heimann et al. (2006) reported a short-term longitudinal study showing that deferred imitation and joint attention both influence the development of language and communication skills in infancy. Deferred imitation at 9 months was the single strongest predictor of nonverbal communication at 14 months, but the predictive power increased substantially when deferred imitation and joint attention were used in combination. The present study is a follow-up of the same group of children at 4 years with two specific aims. The first aim was to investigate whether deferred imitation and nonverbal communication skills in infancy predict cognition and language later in childhood. This is relevant because the previous study was restricted to showing relationships within the infancy period itself (predictions from 9 to 14 months), whereas the current study investigates long-term predictions from early infancy to later childhood, across the 'language boundary' and to an age which itself has been shown to predict cognitive performance to still later ages. Such long-term prediction studies have been done using speed of processing and visual recognition memory paradigms in infancy (e.g. Bornstein & Sigman, 1986; Colombo, Shaddy, Richman, Maikranz, & Blaga, 2004; McCall & Carriger, 1993; Slater, Carrick, Bell, & Roberts, 1999), but to date no studies have involved assessments of infant recall memory. The second aim was to explore whether early recall memory and nonverbal communication skills bear a mutual or a unique relation to later ability and whether predictions to later functioning are stronger when combining measures of both cognition and communication, rather than employing one domain exclusively (as is more common in previous studies of infant–childhood predictions). This was of special interest since Heimann and Meltzoff (1996) had reported that low performance on deferred imitation tests was stable from 9 to 14 months. Thus, we wanted to observe children