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Brief Report

The relationship between motor development, gestures and language production in the second year of life: A mediational analysis

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ABSTRACT

This longitudinal study investigated the relationships between motor, gestural and linguistic abilities using two parent report instruments. Motor skills at 12 months significantly correlated with language production at 16, 20 and 23 months, but these associations were mediated by the use of representational gestures.

In recent years several studies have assessed the relationship between motor ability and early language acquisition in typically-developing children (Iverson, 2010). Alcock and Krawczyk (2010) and Nip, Green, and Marx (2011) reported that, at 21 months, children's measures of productive language were significantly predicted by oral motor control. Oudgenoeg-Paz, Volman, and Leseman (2012) found that 16- to 28-month-old children who achieved unsupported sitting and independent walking earlier had larger sizes and faster rates of vocabulary growth. Finally, it has been proposed that a mirror system for grasping, located in the Broca's area, would provide the scaffolding for the emergence of gestures and speech (Rizzolatti & Arbib, 1998).

The present longitudinal study investigates the reciprocal associations between motor abilities, representational gestures and lexical acquisition in a large sample of children examined at 12, 16, 20 and 23 months using two standardized, reliable parent-report questionnaires. It is widely acknowledged that representational gestures play a critical role for communicative development (Iverson & Goldin-Meadow, 2005). In particular, Longobardi, Rossi-Arnaud, and Spataro (2012) have recently shown that: (a) the relationship between gestures and language (as assessed with two repertory lists completed by mothers) changed across the second year of life, such that 12-month-old infants used representational gestures more frequently than words, whereas the reverse occurred for 20-month-old infants; and (b) the correlations between words and representational gestures were positive at 12 and 16 months, but became negative at 20 months, indicating that, at this relatively late stage, children who persisted in the use of representational gestures also produced a smaller amount of words.

The hypothesis to be tested here is that, during the second year of life, the refinement of gross motor skills would influence language learning indirectly, by allowing a more frequent use of representational gestures. As reviewed by Iverson (2010), advances in motor skills such as the attainment of sitting and walking are associated with an overall re-organization of the infants' interactions with their environment, because the hands are no longer necessary to support the body weight and

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can be used to reach and manipulate distally located objects. This is essential to the development of gestural abilities, since manipulating objects and carrying out actions on them to recognize appropriate uses contribute to the formation of semantic representations (Fischer & Zwaan, 2008), and thus the appearance of representational gestures in children between 9 and 16 months of age. More specifically, Capirci, Contaldo, Caselli, and Volterra (2005) showed that meaningful manual actions (i.e., "recognitory gestures", defined as all acts made with the object-referents in hand: Bates and Dick, 2002) precede and share a semantic link with representational gestures (i.e., empty-handed symbolic gestures depicting a characteristic of or an action performed by a referent). All of the three children videotaped by Capirci and colleagues produced communicative manual actions from 10 months of age, and the majority of them had a meaningful correspondence with representational gestures that emerged later. Since the use of representational gestures predicts later language development (Iverson & Goldin-Meadow, 2005), they might potentially mediate the relationship between early motor abilities and later vocabulary size.

Participants were 102 normally hearing children (49 females and 53 males) recruited from nurseries or paediatricians' offices. All infants were full-term and came from Italian-speaking families of medium and medium-high socio-cultural level. Half of them were first-born. No infant had birth complications or neurological deficits.

We employed a longitudinal design consisting of four subsequent evaluations. In the first three assessments (at 12, 16, 20 months), mothers completed the Questionnaire for Communication and Early Language development in the second year of life (QCEL: Camaioni, Caselli, Longobardi, & Volterra, 1991). The QCEL is a standardized and reliable parent report instrument, originally developed as a screening tool for the early assessment of verbal and non-verbal communicative development (Longobardi et al., 2012). It presents two different versions: the Form I, administered at 12 and 16 months, and the Form II, administered at 20 months. Both of them incorporate two repertory lists assessing the use of the same set of 15 words (e.g., mom, ball, water, car, dog, grandmother, etc) and 15 representational gestures (e.g., holding the empty fist to ear for "telephone", bringing the finger to lips for "quiet", etc.). Parents were required to indicate which words and gestures were actually produced by their children and the frequency of use of each item on a three-point scale including: never (0), sometimes (1) and often (2). Each credited word (or gesture) was multiplied by the corresponding frequency rating, and the resulting scores were summed to achieve the variables *word frequency* and *gesture frequency* (range: 0–30).

Additionally, the Form I includes two lists of different motor activities to be used at 12 and 16 months. The motor activities evaluated by the QCEL are seven at 12 months (e.g., the child "crawls"; "walks without support"; "climbs the stairs holding the adult's hand") and eight at 16 months (e.g., the child "downs the stairs joining the feet on each step"; "begins to take off his/her shoes alone"; "drinks from the cup alone"). Parents were again required to indicate which activities were currently performed by their children, along with the frequency on the same three-point scale illustrated above. A global index of motor ability was obtained from these lists, with scores ranging from 0 to 14 at 12 months and from 0 to 16 at 16 months.[1]

In the fourth assessment at 23 months, mothers completed the Toddler form of the Italian version of the Communicative Development Inventory (CDI) – "Il Primo Vocabolario del Bambino: Parole e Frasi", corresponding to the CDI "Words and Sentences" (Caselli & Casadio, 1995). This instrument is appropriate for children between 18 and 36 months and consists of a vocabulary checklist of 680 words, including common nouns, verbs and adjectives. Parents were asked to indicate which words were spontaneously produced by their children.

Preliminary analyses revealed significant increases across the three ages for both the QCEL gesture frequency [M(12 months) = 10.02, M(16 months) = 16.71 and M(20 months) = 20.72: $F(2, 202) = 156.71$, $p < 0.001$] and the QCEL word frequency [M(12 months) = 7.73, M(16 months) = 16.58 and M(20 months) = 23.12: $F(2, 202) = 320.12$, $p < 0.001$]. At 23 months, the mean CDI vocabulary size was 207.14 words ($SD = 130.62$). Mean motor scores were 7.04 at 12 months and 8.75 at 16 months, both of which fell within the range of 1 standard deviation from the corresponding normative means (Camaioni, Caselli, Longobardi, Volterra, & Luchenti, 2008).

Table 1 illustrates the concurrent and predictive correlations with motor scores at 12 and 16 months. Two interesting results can be noted: (a) at 12 and 16 months significant concurrent correlations were obtained between motor ability and gesture frequency, but not between motor ability and word frequency; and (b) motor scores at 12 months correlated with word frequency at 16 and 20 months, as well as with vocabulary size at 23 months; in contrast, motor scores at 16 months did not show predictive correlations with linguistic measures at 16, 20 and 23 months.

Regression analyses were performed for two reasons. First, we tested whether motor abilities at 12 months predicted language production at later ages (16, 20 and 23 months), after controlling for word frequency at 12 months. To this purpose, we conducted a series of hierarchical regression analyses (Hoff and Naigles, 2002). Table 2 (panel A) shows that motor scores at 12 months significantly predicted vocabulary size at 23 months and word frequency at 16 and 20 months, even when the variance explained by word frequency at 12 months was removed.

Second, to ascertain whether gesture frequency at 12 months mediated the relationships between motor ability at 12 months and word frequency at 16 and 20 months, and between motor ability at 12 months and vocabulary size at 23 months, we conducted a *mediational analysis*, following the regression approach illustrated by Frazier, Tix, and Barron (2004). This method examines whether the relationship between the outcome and the predictor remains significant after removing the variance explained by the mediator. Table 2 (panel B) reports the results of the simultaneous regression analyses for the

[1] Raw scores from the QCEL repertory lists of words, gestures and motor abilities can be transformed into T scores (see Camaioni et al., 2008). However, we only report the analyses using raw scores, because the results obtained with T scores were equivalent.