



Contents lists available at ScienceDirect

Developmental Review

journal homepage: www.elsevier.com/locate/dr



The relation between pointing and language development: A meta-analysis

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ARTICLE INFO

Article history:

Received 5 April 2010

Revised 6 October 2010

Available online 16 November 2010

Keywords:

Pointing

Communication

Language

Declarative

Imperative

Joint attention

ABSTRACT

The use of the pointing gesture is one of the first ways to communicate with the world. This gesture emerges before the second year of life and it is assumed to be the first form of intentional communication. This meta-analysis examined the concurrent and longitudinal relation between pointing and the emergence of language. Twenty-five studies were included into the meta-analysis, including 734 children. The role of several moderators was examined: pointing modality, pointing motive, age at which the pointing was measured, the assessment method of the pointing gesture and language development, the modality of language, SES, and country. The results showed both a concurrent ($r = .52$) and a longitudinal ($r = .35$) relation between pointing and language development. The relation between pointing and language development became stronger with age, and was found for pointing with a declarative and general motive, but not for pointing with an imperative motive. It is concluded that the pointing gesture is a key joint-attention behavior involved in the acquisition of language.

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Introduction

The word *infancy* comes from the Latin word “in-fans”, which means being unable to speak. It is interesting that this definition was chosen to define human beings in the first years of life. It seems that in classical antiquity infants were regarded as being unable to communicate. Today, the word

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infancy is still used in several languages, although the actual meaning has been altered slightly. Indeed, we know that already in the first and second year of life infants develop important communication skills, although they are still not able to use the conventional language. One of the most important ways to communicate during infancy is by using gestures and in particular pointing, which is the extension of the hand and the index finger toward a specific object or event (Butterworth, Franco, McKenzie, Graupner, & Todd, 2002; Butterworth & Morisette, 1996; Leavens, Hopkins, & Thomas, 2004). Although a number of studies investigated the emergence and use of pointing and language during infancy, it is still not clear whether this gesture only precedes language development or whether it also contributes to it. The present meta-analytic study focuses on the relation between the pointing gesture and the emergence of language in order to examine the strength of this relation, and to explore which factors moderate the relation between pointing and language development.

Pointing and language

Between the end of the first and the beginning of the second year infants begin to produce and to understand the pointing gesture in their interaction with other persons. There is a large variation in the age of onset; children start to produce the gesture between 7 and 15 months, with a mean age around 11–12 months (Camaioni, Perucchini, Bellagamba, & Colonnese, 2004; Carpenter, Nagell, & Tomasello, 1998). The ability to use the pointing gesture improves during the second year of life and continues to improve with the onset of language (Carpenter et al., 1998; Dobrich & Scarborough, 1984). Research on the pointing gesture started in the mid-1960s (Bates, Camaioni, & Volterra, 1975; Werner & Kaplan, 1963). The first studies examining the pointing gesture were based on natural observations of the child in the home setting, during interviews, or via parent-report questionnaires (Bates, Benigni, Bretherton, Camaioni, & Volterra, 1979; Werner & Kaplan, 1963). Currently, specific experimental settings are used in order to elicit children's production and comprehension of the gesture (Camaioni et al., 2004; Liszkowski, Carpenter, Striano, & Tomasello, 2006).

There are three main theoretical approaches explaining the relation between pointing and language. Werner and Kaplan (1963) described pointing as a referential and symbolic act related to language. They provided evidence for the assumption that pointing appears often in association with the first demonstrative vocalizations, that is, with vocal reference. For this reason, they considered the pointing gesture as a first step toward true symbolization.

Other researchers have focused their attention on the pre-linguistic socio-cognitive function of the pointing gesture prior to its incorporation into linguistic schemes (Bates et al., 1975, 1979). Bates and colleagues proposed a developmental sequence in pointing from non-communicative to communicative when it is produced together with gaze alternation to the recipient. In this way, only communicative pointing represents the capacity to influence the other person's attentional state about an object/event during triadic interactions (Camaioni, 1993, 1997, for a review). Consistent with this, Delgado, Gómez, and Sarriá (2009) found that infants produce pointing gestures even when they are alone. We can distinguish between a first form of pointing that the child produces without looking at the recipient (pointing-for-self) followed by a form of pointing in which the child looks at the recipient (pointing-for-others). This means that in the beginning the pointing gesture is produced as an egocentric expression of interest and only later serves as a socio-communicative tool.

Communicative pointing or pointing-for-others does not only have a communicative function, but also has a key function in the development of social understanding. Later, the pointing gesture has been considered as one of the key joint-attention behaviors in order to focus others' attention on or to disambiguate the referent during social communication (Brooks & Meltzoff, 2005; Camaioni et al., 2004; Delgado et al., 2002; Mundy et al., 2007). Recently, Tomasello, Carpenter, and Liszkowski (2007) proposed a stronger social-cognitive view of the pointing gesture, also called the "rich interpretation" of the pointing gesture function. According to the authors, already at the age of 12 months the pointing gesture has the function of influencing others' intentional and mental states.

A different theoretical position proposed by Petitto (1988) is that the relation between pointing and language is "socially mediated", which means that the acquisition of language is facilitated not directly by the pointing gesture, but by the social context in which gestures and language are produced. Petitto (1988) found that deaf children started to produce pointing at the same time and in the same

way as non-deaf children. However, this ability did not help them in learning personal pronouns in the American Sign Language. It was therefore concluded that gestures, such as pointing, only provoke social and verbal exchanges that indirectly facilitate the acquisition of language. In a recent study, Kishimoto, Shizawa, Yasuda, Hinobayashi, and Minami (2007) confirmed Petitto's finding that children's pointing gestures elicit an immediate verbal reaction in adults.

The three theoretical perspectives represent three separate key functions of the pointing gesture. Therefore, they can easily be integrated into a comprehensive model of pointing behavior. More specifically, the referential function stresses the symbolic function of the pointing gesture, the socio-cognitive function is based on the attentional and intentional function of the gesture as a first form of communicative behavior; and the social mediating function refers to pointing as behavior that enhances social interaction. Taken together, all three theoretical perspectives support the assumption that pointing has a key role in language development.

Provided that a relation exists between pointing and language, it is of interest to know whether the early pointing gesture during infancy is in fact a predictor of the later linguistic ability. Goldin-Meadow and colleagues found strong evidence for the hypothesis that early pointing predicts later vocabulary (Iverson & Goldin-Meadow, 2005; Özçaliskan & Goldin-Meadow, 2006). Similarly, the age at which children begin to produce the first combinations of gestures and words predicts the age at which they begin to produce the first two-word utterances (Goldin-Meadow & Butcher, 2003; Iverson, Capirci, Volterra, & Goldin-Meadow, 2008; Iverson & Goldin-Meadow, 2005). It has also been found, however, that children have a strong tendency to vocalize when they start to point at objects (Blake, O'Rourke, & Borzellino, 1994; Franco & Butterworth, 1996). Moreover, children produce pointing gestures when they start to talk in order to express words that they do not yet have in their spoken vocabulary (e.g. "Look at that" and pointing to an airplane when the child does not know the name). Only a few studies did not find a relation between pointing and language (Butterworth & Morissette, 1996; Colonnese, Rieffe, Koops, & Perucchini, 2008; Dobrich & Scarborough, 1984; Murphy, 1978). A possible explanation is that the absence or strength of the relation between pointing and language depends on specific features of the studies that act as moderators. These moderators can only be examined by means of a meta-analysis.

Modalities in pointing

The pointing ability consists of the production and the comprehension of the gesture. Infants start to produce the pointing gesture as early as 3–4 months of age (Blake, O'Rourke, & Borzellino, 1994; Fogel & Hannan, 1985; Masataka, 2003). However, the pointing gesture at this age has a different structural configuration than the pointing gesture at a later age. First, the pointing is produced only with the extension of the index finger and not with the concurrent extension of the index finger and hand. Second, the pointing gesture is not produced in a joint-attentional frame, which means that the infant does not check whether the other person is looking at this gesture and to the pointed object/event. For this reason the first production of pointing could be considered as a precursor of the later communicative pointing gesture at the age of 12 months.

There is a general agreement that starting by the second year of life, pointing is an intentional behavior produced to direct or change others' attention (see also Tomasello et al., 2007 for a review). However, Moore and colleagues (Corkum & Moore, 1998; Moore & Corkum, 1994; Moore & D'Entremont, 2001) argued that 12-month-olds do not produce the pointing gesture in order to direct others' attention. They arrived at this conclusion after the observation that often infants are pointing to objects or events that the adults are already looking at. However, they found that around the end of the second year of life infants start to produce more pointing when their parents were looking away. Their conclusion was that the infants' pointing before the age of 15 months is just a way to elicit others' emotional reaction to the self and to enhance the interaction, while at the end of the second year of life it involves the recognition of other persons as intentional agents. This interpretation is at odds with later studies demonstrating that already at the age of 12 months infants show dissatisfaction when the adult reacts to their pointing gesture with positive emotions, but ignores the intended referent (Liszkowski, Carpenter, Henning, Striano, & Tomasello, 2004), or when the adult alighted on the incorrect referent (Liszkowski, Carpenter, & Tomasello, 2008). Similarly, there is empirical evidence showing

that from the age of 12 months the production of the pointing gesture is associated with language development (Camaioni, Caselli, Longobardi, & Volterra, 1991; Desrochers, Morissette, & Ricard, 1995).

Language is related not only to the production of pointing, but also to the understanding of the same gesture, also called pointing following. When infants understand the pointing gesture produced by the recipient, they follow the gesture, identify the referent and turn back to the recipient. The gaze return is often followed by a communicative reaction of the infant as a smile, a vocalization or a gesture (e.g. again a pointing gesture). This behavior is defined as a joint-attention behavior, which is the mutual engagement of the infant and the adult with a mutual focus on a third entity (Tomasello, 1995). The pointing gesture may be considered as an important tool for engaging in joint attention interactions. Several studies have shown the important role of joint attention in early language acquisition (Bakeman & Adamson, 1984; Baldwin, 1995; Mundy & Gomes, 1997; Scaife & Bruner, 1975; Tomasello & Farrar, 1986). Therefore, it might be argued that children who are more sensitive to others' communicative gestures, and in particular to pointing, are also more quickly in the acquisition of their vocabulary (Bates et al., 1979; Brooks & Meltzoff, 2005; Tomasello & Todd, 1983). Moreover, adults generally point toward objects or events of interest and label them, which should stimulate children to improve their vocabulary and comprehension of word meaning (Brooks & Meltzoff, 2008).

There is evidence that pointing comprehension and pointing production are positively related to each other (Carpenter et al., 1998; Colonnese et al., 2008), and that both are related to language development. However, it is still not clear which modality emerges as first, since some studies have found comprehension emerging before production (Bruner, 1983; Carpenter et al., 1998; Leung & Rheingold, 1981), whereas other studies have found production to take place before comprehension (Desrochers et al., 1995; Murphy & Messer, 1977). Moreover, we do not know yet which modality has the stronger relation with language development.

Motives in pointing

According to the socio-cognitive approach, the pointing gesture is an instance of intentional communication, which means that it is a way to direct the attention of the recipient toward a specific object or event for a reason (Camaioni et al., 2004; Tomasello et al., 2007). Bates et al. (1975) examined the onset of intentional communication before speech begins, describing two main motives for the gesture: the imperative and the declarative motives. The imperative communication (through language or communicative signals) is a way to control the behavior of the listener. For example, the child asks for the adult's attention in order to obtain a desired object. Differently, declarative communication is a way to comment about the truth of some event or relation that the child describes. In sum, while in imperative pointing the infant uses the adult as a tool to obtain an object, in declarative pointing the infant uses the object as a tool to obtain the adult's attention. In addition, declarative comes from "declaration", which means to give some kind of information. For example, a child pointing to a dog passing by means to say "a dog is passing". Thus, the pointing gesture with a declarative intention has received more attention in research and has often been elected as the main precursor of language. However, some studies examined the pointing gesture without making a distinction between motives (Harris, Barlow-Brown, & Chasin, 1995; Locke, 2007; Rodrigo et al., 2006).

The present study

The present study is a meta-analytic investigation of the studies that examined the relation between the pointing gesture and language in the last 30 years. In general, our aim was to examine how strong the relation is between pointing and language, and to examine which factors moderate this relation. The advantage of a meta-analysis is that it provides a general picture of the results obtained in different studies, conducted in different countries and at different ages. In addition, by conducting a meta-analysis we can examine factors that cannot be included in single studies, for example, because these factors concern study characteristics that vary between but not within studies. Another important advantage is that a meta-analysis can include studies that have never been published (file drawer problem), for instance, because no significant results were found (Rosenthal, 1995). In the present meta-analysis we also included unpublished studies and presentations at conferences.

In the present study we investigated whether both a concurrent and a longitudinal relation exist between the pointing gesture and language development. Studies that have examined the two abilities at the same time and studies where the pointing gesture was examined first and language was examined subsequently were considered. If a longitudinal relation exists between the pointing gesture and the later use of language this would suggest that these two abilities share the same communicative and socio-cognitive system. In other words, the pointing gesture is a referential way to communicate, which proceeds and promotes later verbal communication. Alternatively, if there is only a concurrent relation between pointing and language, this would give support to the assumption that these two abilities are embedded in the same social context, and are just integrated and support each other.

Next, the relation between pointing and language was examined taking into account a number of moderators that may have an effect on the relation between pointing and language, possibly explaining different results among the studies that are included in the present meta-analytic study. Moderators pertaining to study and sample characteristic were publication status (published vs. not published), country, and family's SES. Moderators dealing with the pointing gesture were type of assessment (observation vs. questionnaire), modality of pointing (comprehension vs. production), motive (imperative vs. declarative), and age of onset. For language, type of assessment and modality (expressive, receptive or both), the time at which language was measured, and the instrument or method were included as moderators. Often, children's language was measured through the MacArthur Communicative Development Inventories: Words and Sentences (CDI:WS; Fenson et al., 1993). In some studies children's production of the pointing gesture was compared with their first production of vocalizations or first words.

Method

Sample of studies

The search method involved inspection of digital databases (Web of Knowledge, Picarta, PsychInfo) using the following keywords: pointing, gesture, declarative, imperative, precursors, language, words, vocabulary, infancy, intentional communication, and joint attention. Inspection of the reference section of relevant literature was an additional search method (ancestry method). Additionally, also unpublished sources were consulted, such as dissertations and presentations and studies under revision, by using Google Scholar, contacting researchers in the field and consulting digital databases of dissertations (e.g., PROQUEST).

Three selection criteria were used to select studies: (a) measurement of infant production and/or comprehension of the pointing gesture; (b) measurement of language by assessing either receptive or expressive language; (c) report of a relation between pointing and language or the presence of data in the article allowing the calculation of a relation between pointing and language development. Exclusion criteria were: (a) subjects with mental or developmental disorders; (b) children older than 60 months; (c) studies in which the pointing gesture was not coded separately from other gestures.

Twenty-five studies conducted between 1978 and 2009, involving 734 children, were included in the meta-analysis. Five studies did not directly report a relation between pointing and language. We contacted the authors to obtain this information. In the majority of the studies the participants were American (12 studies), in six studies the participants were Italian, in four studies the participants were English, in one study the participants were Spanish, in one study Japanese, and in one study half of the children were American and half were Italian. The SES reported in one study was high, in 12 studies was middle-high, in six studies low or middle, whereas four studies did not report on SES. A total of 93% of the participants were Caucasian, 2% were African, 2% were Asian, and 13% were defined as other. Nine studies did not report on ethnicity.

Coding the studies

The following study characteristics were coded: study design (concurrent or longitudinal), age at pointing and language measurement, the difference between these ages in the longitudinal studies

(time span), language measurement (expressive, receptive or mixed), pointing modality (comprehension or production), pointing motive (declarative, imperative or general), the interaction between pointing modality and motive, impact factor, year of publication and publication status (peer review journal articles or book chapters and presentations), measurement mode (questionnaire or observation). Regarding the study design, seven studies measured pointing and language at the same time (concurrent), whereas 14 studies had a longitudinal design, first determining level of pointing and subsequently measuring language. Five studies reported both concurrent and longitudinal data. In these cases, we computed effect sizes for both the concurrent and longitudinal relation between pointing and language. Table 1 reports sample characteristics and effect sizes of the studies included in the meta-analysis.

When the pointing gesture was measured in the same child on more than one occasion, the mean age of the pointing measurements was calculated. When the sample consisted of children of different ages; the average age in months was calculated. Some studies did not report data on a fixed age, but used the onset age of pointing (Butterworth & Morisette, 1996; Carpenter et al., 1998; Desrochers et al., 1995). In these cases, the mean age of onset was used in our analysis.

The pointing motives, that can be imperative, declarative or general, were coded on the basis of the information found in the method section of the papers. Pointing was coded as imperative when the study examined infants' production or understanding of the gesture to ask for an object or an action. Pointing was coded as declarative when the study examined infants' production or understanding of the gesture to share the attention about a specific event or object. Only a few studies examined pointing with an imperative intention. For this reason, when both declarative and imperative pointing had been assessed we only computed the effect size on the basis of imperative pointing. Some other studies examined the general production or comprehension of pointing without distinguishing between imperative and declarative intention (e.g., infants' general production of pointing at home). In these

Table 1

Studies included in the meta-analysis.

Study	N	Pointing			Language		r	
		Age	Mod	Mot	Age	Mod	Conc	Long
Murphy (1978)	32	22.0	Prod	Decl	22.0	Expres	.31	–
Bates et al. (1979)	25	10.0	Prod	Gen	12.5	Mixed	.25 (11.0) ^a	.27
Dobrich and Scarborough (1984)	22	24.0	Prod	Decl	24.0	Expres	.40	–
Camaioni et al. (1991)	23	12.0	Prod	Gen	20.0	Expres	–	.52
Desrochers et al. (1995)	25	12.0	Prod	Decl	24.0	Mixed	–	.43
Harris et al. (1995)	6	9.0	Prod	Gen	9.0	Recap	.70	–
Butterworth and Morisette (1996)	27	11.0	Prod	Decl	14.4	Mixed	–	.00
Carpenter et al. (1998)	24	12.0	Prod	Imp	24.0	Expres	–	.08
Mundy and Gomes (1998)	24	15.8	Com	Decl	19.0	Mixed	.32 (15.8)	.60
Markus, Mundy, Morales, Delgado, and Yale (2000)	21	15.0	Com	Decl	24.0	Expres	–	.21
Morales et al. (2000)	22	15.0	Com	Decl	30.0	Mixed	.50	.62
Rowe (2000)	45	14.0	Prod	Gen	14.0	Expres	.64	–
Franco and Gagliano (2001)	32	33.0	Prod	Decl	33.0	Expres	.72	–
Delgado et al. (2002)	47	15.0	Comp	Decl	24.0	Expres	–	.55
Fasolo and d'Odorico (2002)	44	20.0	Prod	Decl	30.0	Recep	.49	.78
Blake et al. (2003)	12	9.8	Prod	Gen	12.0	Mixed	–	.00
Mundy, Fox, and Card (2003)	29	16.0	Comp	Decl	24.0	Expres	–	.30
Perucchini and Plescia (2005)	50	11.0	Prod	Decl	20.0	Expres	–	.26
Rodrigo et al. (2006)	8	24.0	Prod	Gen	24.0	Expres	.51	–
Locke (2007)	9	16.5	Prod	Gen	16.5	Expres	.82	–
Mundy et al. (2007)	72	13.5	Com	Decl	24.0	Expres	–	.14
Aureli, Perucchini, and Palazzo (2008)	18	12.0	Prod	Imp	17.0	Expres	–	.24
Colonnesei et al. (2008)	35	13.5	Prod	Imp	39.0	Recep	–	–.06
Brooks and Meltzoff (2008)	32	10.5	Prod	Decl	17.0	Expres	–	.52
Rowe and Goldin-Meadow (2008)	50	14.0	Prod	Gen	54.0	Expres	.61 (14.0)	.47

Notes: Mod = modality; Mot = motive; Conc = concurrent; Long = longitudinal; Prod = production, Com = comprehension; Decl = declarative; Imp = imperative; Gen = general; Expres = expressive, Recep = receptive.

^a Age of measurement.

cases the motive of pointing was coded as general. Pointing modality was coded according to the distinction between production and comprehension. When studies measured both modalities, the data on production were used for analysis. This was based on the assumption that the active use of the pointing gesture is more strongly related to language. When looking at the modes of measurement, thirteen studies measured the pointing gesture through observation, one study examined pointing by means of a questionnaire, and three studies applied a combination of questionnaire and observation measurement.

Next, age of measurement, modality and measurement method were coded for language. In case of multiple language measurements over time, information derived from the last assessment was used in our analysis. When studies reported concurrent correlations between pointing and language at different data waves, the mean effect size was calculated for analysis.

Language was coded as expressive or receptive. Expressive language was measured using the co-occurrence of vocalizations, the number of words mastered by the child or the emergence of the first referential words. Similarly, the mode of measurement for receptive language varied among studies. Language comprehension level was assessed through observation or by means of parent reports. Six studies employed both receptive and expressive language measurement. These studies were coded as mixed in the moderator analysis (see Table 1). The studies were coded by two independent raters. The moderators were coded by the third and first authors of this paper, with a mean Cohen's Kappa of .85 for all moderators.

Effect size calculation

Effect sizes were computed on the basis of correlations, means and standard deviations, percentages, and t -, F -, χ^2 -, p -values or odds ratios. The outcomes of the studies were transformed into Pearson's product-moment correlation coefficient r . After calculating the effect size for each single study, combined mean effect sizes were calculated and moderator analyses were conducted, using SPSS macros (Hox, 2002), based on the fixed effect model instead of the random effect model in order to obtain sufficient statistical power, which seemed imperative given the relatively small number of studies included in this meta-analytic study. The effect sizes were weighted for sample size. Significance testing in fixed effects models is based on the total number of participants in the meta-analysis, but generalization is limited to other participants that might have been included in the same studies of the meta-analysis. In random effects models, significance testing is based on the total number of studies in the meta-analysis, and results can be generalized to the population of studies from which the current set of studies was drawn (Rosenthal, 1995).

We also computed the statistical significance of the effect sizes and their confidence intervals. Outlying effect sizes were identified on the basis of z values larger than 3.3 or smaller than -3.3 (Tabachnick & Fidell, 2001). Homogeneity analyses were evaluated using the Q_{within} (Q_w) statistic (Hedges & Olkin, 1985), setting the significance level at $p < .05$, to determine whether sets of studies were homogeneous, that is, to what extent effect sizes were constant across studies. In case of heterogeneity there are differences among effect sizes that have some source other than subject-level sampling error. These differences may be associated with different study characteristics (Lipsey & Wilson, 2001, pp. 115–119). When the hypothesis of homogeneity was rejected, both categorical and continuous moderators were introduced and tested individually to help explain heterogeneity among the effect sizes.

Publication bias

A common problem in meta-analysis is that unpublished studies often lie unused in file drawers because of non-significant findings, whereas published studies are more likely to have achieved statistical significance (Rosenthal, 1995). Thus, the studies included in any meta-analysis do not form a random sample of all studies conducted on the subject. To inspect whether such possible publication bias exists, it is possible to calculate the fail-safe number, which is the minimum number of additional studies with non-significant results that is needed to decrease significant meta-analytic results to non-significance (Durlak & Lipsey, 1991). Meta-analytic findings are considered to be robust if the fail-safe

number exceeds the critical value obtained with Rosenthal's (1995) formula of $5 * k + 10$: k is the number of studies included in the meta-analysis.

Results

Two meta-analyses were conducted in order to examine separately concurrent and longitudinal relations between pointing and language. By doing so, we could use the data of the five studies which reported both concurrent and longitudinal data. No outlying effect sizes were identified. In interpreting the magnitude of the combined effect sizes, generally accepted conventions formulated by Cohen (1988) were used. Effect sizes of $r \leq .10$, $r = .25$, and $r = \geq .40$ were considered as indices of small, medium, and large effects (Lipsey & Wilson, 2001). It is important to note that significant associations between pointing and language development were reported as early as age 11 months.

The concurrent relation between pointing and language

In the meta-analysis of studies examining the concurrent relation between pointing and language development, 12 studies were included, involving 319 children. We found a large combined effect size of $r = .52$ ($z = 8.80$, $p < .001$), indicating that pointing was strongly related to language development in these studies. The fail-safe number was 331, which is above Rosenthal's (1995) critical value of 70 studies ($12 * 5 + 10$), which indicates that a file-drawer effect is unlikely. The test of homogeneity revealed the set of effect sizes to be homogeneous – $Q_w(9) 15.53$, ns – which indicates that the combined effect size for the relation between pointing and language development can be considered representative of this collection of studies. Therefore, no further analyses of the moderators were conducted.

The longitudinal relation between pointing and language

In the meta-analysis of the longitudinal studies, 18 studies were included, involving 580 children. A medium-to-large combined effect size was found, $r = .35$ ($z = 7.99$, $p < .001$), indicating that pointing was also strongly related to language development in the longitudinal studies. The fail-safe number was 407, which is larger than Rosenthal's critical value of 100 studies ($18 * 5 + 10$). As homogeneity analysis yielded a significant result – $Q(17) = 28.76$, $p < .05$ – meaning that there was a significant variability in effect sizes between studies, we conducted categorical and continuous moderator analyses in order to detect possible factors affecting the longitudinal relation between pointing and language development.

The following moderators were subject to analysis: publication status, impact factor, pointing modality, pointing motive, interaction of pointing motive by modality, assessment method of both pointing and language measurement, language modality, mean age of the participants during pointing and language assessment, time span between pointing and language assessment, country, and socio-economic status.

Table 2 presents the ANOVA's for categorical moderators of longitudinal associations.

The Q_{between} statistic was used to test the significance of categorical moderators, whereas the Q_{within} statistic was used to test the homogeneity of subsets of studies, that is, variation between studies within separate categories. For instance, the significant Q_{within} statistic of 27.81 in the moderator analysis of the assessment method of pointing shows that there is significant variability in the studies using observational measures.

It can be derived from Table 2 that pointing motive was the only significant categorical predictor of the longitudinal relation between pointing and language development: $Q(2,15) = 7.41$, $p < .05$. Whereas declarative and general pointing were significantly and strongly related to language development (both $r = .39$), imperative pointing was not significantly related to language development ($r = .04$). The interaction between pointing modality and motive just failed to reach significance ($p = .06$), and therefore should be considered as a trend. The effect sizes were large when comprehension or production measures were used to assess declarative pointing ($r = .42$ and $r = .38$, respectively)

Table 2

ANOVAs for moderator variables (fixed effect model) for longitudinal studies.

Moderator variables	Number of respondents	Number of studies	Effect size, <i>r</i> (fixed effects)	95% Confidence interval	Q statistic between studies	Q statistics within studies
Overall	580	18	.35***	.26–.43		28.76 ⁺
Publication status					0.38	
Published (journal)	462	14	.36***	.27–.46		27.58 ⁺
Unpublished	118	4	.30***	.10–.49		0.81
Country					1.06	
USA	346	10	.39***	.28–.50		9.93
Other	234	8	.29***	.16–.43		17.77 ⁺
SES					3.59	
Low to middle	52	2	.13	–.16–.42		0.84
Middle to high	373	11	.30***	.19–.40		13.75
High	49	2	.53***	.23–.83		0.21
Modality					0.33	
Production	340	11	.33***	.22–.44		21.33 ⁺
Comprehension	240	7	.38***	.25–.51		7.10
Motive					7.41 ⁺	
Declarative	393	11	.39***	.29–.50		18.29
General	110	4	.39***	.19–.59		2.32
Imperative	77	3	.04	–.20–.28		0.74
Modality * motive					7.56 ⁺	
Production * declarative	153	4	.42***	.26–.59		11.04 ⁺
Comprehension * declarative	240	7	.38***	.25–.51		7.10
Production * general	110	4	.39***	.19–.59		2.32
Production * imperative	77	3	.04	–.20–.28		0.74
Assessment method pointing					0.01	
Observation	507	16	.35***	.26–.44		27.81 ⁺
Questionnaire	73	2	.34***	.10–.58		0.95
Assessment method language					0.95	
Observation	229	7	.40***	.27–.54		9.57
Questionnaire	351	11	.31***	.20–.42		18.24
Language					0.47	
Expressive	348	9	.35***	.24–.46		9.28
Receptive	79	2	.41***	.18–.64		12.68***
Both	153	7	.31***	.14–.48		6.33
Age groups					7.96 ⁺	
Under 12 months	146	5	.25**	.08–.43		4.19
From 12 to 15 months	294	8	.29***	.17–.41		12.71
Above 15 months	140	5	.57***	.39–.74		3.90

⁺ $p < .10$.^{*} $p < .05$.^{**} $p < .01$.^{***} $p < .001$.

and when production measures were used to assess general pointing ($r = .39$), but small and non-significant when production measures were used to assess imperative pointing ($r = .04$).

Table 3 presents the results for the continuous moderators. The association between pointing and language development was moderated by the continuous moderator “age at the time of pointing assessment”, yielding a large standardized regression coefficient of $b = .59$, which indicated that the relation between pointing and language development became stronger with age. In order to further investigate the effect of age, three age groups for pointing measurement were formed in the longitudinal studies: under 12 months, before the emergence of the communicative pointing gesture and the emergence of language; from 12 to 15 months, during the development of intentional communication and the beginning of language use; and above 15 months, when the infant’s socio-cognitive abilities and the use of language is more developed. A significant result was found, with a larger effect size when pointing gesture was measured after 15 months (see Table 2).

Table 3

Continuous moderator analysis (fixed effect model) for longitudinal studies.

Moderator variables	<i>K</i>	<i>N</i>	<i>Beta</i>	<i>t</i>	<i>p</i>
Year of publication	18	580	–.11	–.60	.53
Impact factor	14	462	.05	.27	.79
Percentage male	17	556	.12	.64	.52
Age pointing	18	580	.59	3.15	.00
Age language	18	580	.16	.86	.39
Time span	18	580	–.02	–.10	.92

Discussion

The present meta-analytic study found support for a strong relation between the pointing gesture, emerging during infancy, and language development. This result confirms the hypothesis that the pointing gesture, as a joint-attentional behavior, is the first form of referential and intentional communication that is associated with language development, in other words, the “royal road to language” (Butterworth, 2003). In particular, the results of 25 studies carried out in the last 30 years have shown a concurrent relation as well as a longitudinal relation between pointing and language. The concurrent relation provides evidence that the pointing gesture is a way to communicate that integrates and supports language. The longitudinal relation indicates that the more children understand and use the pointing gesture in an early stadium the higher their level of language ability will be at a later age. In other words, as already pointed out by Goldin-Meadow (2007), the pointing gesture not only pre-dates language, but is also prospectively associated with the development of language. In addition, the longitudinal relation between the pointing gesture and language appears to be influenced by the age at the time of pointing assessment and the modality of the gesture.

The effect of motive

As expected, larger effect sizes were found when general pointing and declarative pointing were investigated instead of imperative pointing. This result supports the theoretical arguments (Bates et al., 1979; Camaioni, 1993) suggesting that declarative pointing and not imperative pointing is a first form of declaration, thus a first form of name giving, and the first way to use an external object/event in order to get another person's attention. However, the fact that the largest effect size was found when the general motive was examined also opens the possibility for other interpretations. It is important to note that the pointing gesture with a general motive was coded in three studies in which the pointing gesture was observed during natural observation at home. It is possible that the pointing gesture observed in those naturalistic studies represented different motives that may also be associated with later language development. For example, Tomasello et al. (2007) have recently proposed to distinguish two types of declarative pointing: expressive pointing, in order to let the recipient feel a certain attitude or emotion, and informative pointing, in order to let the recipient know something that the infant thinks the recipient will find useful or interesting. More important, Tomasello et al. (2007) raise the question whether we can simplify the pointing motive into fewer categories, such as imperative and declarative pointing. In sum, we argue that the pointing gesture, produced with different kinds of motives eliciting socio-communicative interactions, may be related to language development.

The effect of age

An important moderator of the relation between pointing and language proved to be the age at which the pointing gesture was measured. It was found that the relation between pointing and language development was stronger when pointing was measured at an older age. In other words, with increasing age the production and understanding of the pointing gesture becomes more related and integrated with the use of language. The strongest association was found between the ages of 15

and 20 months, when social-cognitive and social motivational skills are further developed, and when infants start to produce the first sentences, including vocabulary explosion. It should be noted, however, that significant associations between pointing and language development were obtained as early as 10–11 months. This age coincides with the onset age of communicative pointing (Camaioni et al., 2004), but the infants are not yet able to say their first real words. In sum, already before the end of the first year of life the pointing gesture is a sensitive predictor of language, and its relation with language increases during the whole second year of life.

The effect of modality

Interestingly, both production and comprehension of the pointing gesture proved to be equally strongly related to language development, which confirms the causal relation between joint attention and the development of language (Baldwin, 1991; Brooks & Meltzoff, 2005; Delgado et al., 2002; Mundy et al., 2007; Tomasello & Farrar, 1986). In sum, children who are better able to recognize the connection between the action of pointing and the target object are later on also better in word comprehension and production. As already mentioned, the understanding of the pointing gesture is an act of joint attention. It might therefore be argued that following the pointing gesture in order to disambiguate the referent facilitates the learning of new words. Because of the small number of studies, we were not able to determine whether a relation exists between the comprehension of pointing and receptive language as well as the production of pointing and expressive language. This issue should be addressed in future research.

Cross-sectional vs. longitudinal relations

The longitudinal relation between pointing and the later use of language provides empirical support for the assumption that the pointing gesture is a first way to intentionally communicate in a referential way that precedes the onset of language (Brooks & Meltzoff, 2005; Camaioni, 1993; Delgado et al., Mundy et al., 2007). In other words, children with a stronger communicative ability could be able to show a better production and comprehension of the pointing gesture first, and a more advanced linguistic level later. However, children who point more frequently elicit also more verbal answers in other people, which could promote their language development (Dobrich & Scarborough, 1984; Kishimoto et al., 2007; Petitto, 1988). A plausible conclusion is that the relation between the pointing gesture and later language ability is a combined result of individual and environmental factors. In sum, the pointing gesture is the first form of non-linguistic communication and, at the same time, a behavior that helps other people to better understand and stimulate infants' language.

Environmental factors

Notably, the longitudinal relation between pointing gesture and language was not influenced by the participants' characteristics, such as country and socioeconomic background. It is therefore plausible to infer that the society and the educational-social level of the parents did not have an effect on the relation between pointing and language development. However, we cannot rule out the possibility that environmental factors that have not been included in our meta-analysis, such as more specific information about the educational level of the parents, number of siblings, and day-care attendance, may have exerted an influence. Moreover, the environment may have a clear effect only when all the communicative gestures are examined in combination and not only the pointing gesture. For example, Rowe and Goldin-Meadow (2008, 2009) recently found that SES was positively associated with child and parent production of communicative gestures when the child was 14 months old, and with child vocabulary skills at 54 months, which proved to be mediated by children's gesture use at 14 months. It is important to notice that the sample distribution of these two studies was representative of English-speaking families in the city of Chicago area in terms of ethnicity and income. This means that also low SES was represented in the sample distribution. In contrast, the majority of the studies included in the present meta-analysis included middle to high SES samples, only one low SES sample (Rowe, 2000), and four studies did not report any information on SES.

Limitations and future directions

The present meta-analytic study has some limitations and suggestions for future research. Despite the fact that relations between pointing and early language development have received the interest of researchers for 30 years (Bates et al., 1979), the number of studies that were fit for the purpose of our meta-analytic study was rather small. This can be partly explained by the instruments that were used, which generally measured pointing together with other joint attention variables (Goldin-Meadow & Butcher, 2003; Iverson & Goldin-Meadow, 2005; Iverson et al., 2008; Rowe, Ozcaliskan, & Goldin-Meadow, 2008).

We also met a considerable heterogeneity between studies in the definition of the pointing gesture. In some studies the pointing gesture was defined as a combination of the extension of the index finger and hand, whereas in some other studies the pointing gesture was only defined as the extension of the index finger, and in some studies pointing was coded as the extension of a finger or the hand. Similarly, it was not possible in this meta-analysis to consider the type of language in terms of word types (verbs; nouns) or language use in terms of speech acts (defectiveness, questions, statement). In sum, we still need systematic longitudinal research examining the relation between pointing gesture and language development in which the main structural and functional characteristics of both the abilities are taken into consideration.

Finally, future research should examine in more detail which environmental factors moderate the relation between the production and the comprehension of the pointing gesture and language. One aspect that has been receiving attention only recently is parents' social and economic status (Rowe & Goldin-Meadow, 2008, 2009). Another aspect is the intercultural difference. In fact, almost all the studies were conducted in western countries (USA, England, Italy and Spain). Only one study was conducted in Japan (Blake, Osborne, Cabral, & Gluck, 2003) reporting no relation between pointing and language. Other relevant environmental factors are the communicative style of the parents, birth order (Westerlund & Lagerberg, 2008), and the number of siblings (Bornstein, Leach, & Haynes, 2004), which seem to play key roles in communication and language development. A strong effect of these environmental moderators could support the socially mediated theory of Petitto, supporting the assumption that infants produce and understand the pointing gesture better when specific environmental situations are met.

Conclusion

To our knowledge, this is the first meta-analytic study of the relation between the pointing gesture and the emergence of language, showing a strong concurrent and a longitudinal relation between pointing and language development. The studies conducted in the last 30 years show that both comprehension and production are related to language development and that this relation is stronger when pointing is produced with a declarative or general motive. These results support in particular the referential and the socio-cognitive theoretical approaches explaining the relation between pointing and language development. Less support was found for the socially-mediated approach, since there was no moderating effect for environmental factors. However, this result should be interpreted with caution because of the lack of available data in the literature. It is important to note that the pointing gesture both in production and comprehension is also one of the first indicators of children's understanding of others as intentional (i.e. mental) agents (Barresi & Moore, 1996; Camaioni et al., 2004; Colonnese et al., 2008; Tomasello et al., 2007; Wellman, 1990, 1993). Therefore, pointing is a unique milestone in children's linguistic and social development, already in their "in-fans" time.

Acknowledgments

The authors wish to thank Susan Goldin-Meadow, Meredith Rowe, Paola Perucchini, Malinda Carpenter, and Fabia Franco for providing us additional data and detailed descriptions of their data and methods.

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