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THE REORGANIZATION OF COMMUNICATIVE BEHAVIORS AROUND THE ONSET OF THE VOCABULARY SPURT

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ABSTRACT: *This study investigated the reorganization of communicative behaviors during the vocabulary spurt to explore whether the closely linked relationship between language, gesture, and facial affect is altered during a period of significant growth and transition in communication. Eighteen typically developing infants were videotaped with a primary caregiver at home one month before, at, and one month after the onset of the vocabulary spurt. The frequency with which communicative behaviors appeared in coordination increased significantly after the vocabulary spurt. While words were increasingly integrated into coordinations, gestures were the most frequently appearing behaviors in coordinated bouts and were the most likely behavior to initiate asynchronous bouts. Finally, developmentally earlier forms of communication continued to be produced throughout the observation period but the degree to which these behaviors appeared in coordinated bouts decreased after the onset of the spurt. Findings underscore the importance of examining the communicative system as a whole and using a milestone-based approach to studying developmental change.*

KEY WORDS: *Vocabulary spurt - Communication development - Transition - Gesture - Speech - Affect.*

Introduction

Long before infants begin to speak, they communicate nonverbally through a broad array of behaviors such as facial expressions, eye gaze, gestures, and prelinguistic sounds (Trevarthen & Hubley 1978); and they continue to utilize these preverbal forms of communication even as their communicative repertoires expand to include words (Bates 1976; Bates, Benigni, Bretherton, Camaioni & Volterra 1979). Over the course of the first two years, infants' communication becomes more varied and complex (Bates *et alii* 1979; Wetherby, Cain, Yonclas & Walker 1988). This is due at least in part to the emergence of the ability to coordinate multiple communicative behaviors into a single, seamless act (e.g., pointing at a toy and looking at a caregiver while smiling and vocalizing), a crowning achievement of early communicative development (e.g., Crais, Watson & Baranek 2009; Stone, Ousley, Yoder, Hogan & Hepburn 1997).

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The frequency with which infants coordinate multiple communicative behaviors across different modalities and the complexity of these cooordinations increase over the first two years (Bates 1976; Carpenter, Nagell & Tomasello 1988; Crais, Douglas & Campbell 2004). It is of note that the emergence and refinement of this ability occurs even as individual communicative behaviors (e.g., gestures, language) undergo significant developmental change (Bates *et alii* 1979; Desroches, Morisette & Ricard 1995; Wetherby *et alii* 1988). However, we know relatively little about how such change impacts the participation of individual communicative behaviors in coordination with behaviors from other modalities (e.g., gesture, facial affect).

Moments of significant developmental change or transition provide a unique opportunity to explore the overall organization of a behavioral system – in this case, the communicative system – and specifically, to examine how change in one behavioral component of the system impacts its coordination with other component behaviors (Gershkoff-Stowe & Thelen 2004; Iverson & Thelen 1999; Thelen & Smith 1994). Perhaps one of the best known and most widely studied transitions in communicative development is the vocabulary spurt, a period of rapid and dramatic increase in productive language. In the present study, we explore whether and how the significant period of growth in spoken language that occurs at the vocabulary spurt influences the coordination of language with developmentally earlier and well-established communicative behaviors from other modalities (e.g., gestures, affect).

Communicative Coordinations

There is ample evidence that communicative behaviors appear in coordination with one another from very early in development. By 3 months of age, infants coordinate facial expressions (smiles and frowns) with prelinguistic vocalizations at greater than chance levels (Yale, Messinger, Cobo-Lewis, Oller & Eilers 1999; Yale, Messinger, Cobo-Lewis & Delgado 2003). By 12 months, when infants begin to use communicative gestures, the repertoire of behaviors that appear in coordination with one another expands: for example, positive facial expressions frequently accompany pointing and showing gestures (Adamson & Bakeman 1985; Mundy, Kasari & Sigman 1992). The frequency of gestures and vocalizations produced alone also decreases in favor of gesture-vocalization combinations, which increase until they outnumber isolated gestures and vocalizations by 15 months (Carpenter *et alii* 1998; Wetherby *et alii* 1988).

Once infants begin to produce words, there is evidence that developmentally-prior communicative behaviors (i.e., facial affect, gesture) do not disappear, but rather continue to play an important role in infants' communicative repertoires. Thus, for example, in their longitudinal study, Bloom and colleagues (Bloom, Beckwith, Capatides & Hafitz 1988) reported that although frequency of word production increased substantially once infants began to produce words, frequency of affective displays remained relatively unchanged during this time. Thus, the affect and vocal modalities continue to act as complementary systems of expression as children begin to acquire spoken language. A similar relationship has been described for gesture and language. Prior to the emergence of two-word combinations, children begin to combine single gestures with single words (e.g., pointing

at a cup while saying "mommy"); the gestures and words in coordinated communications are both semantically coherent (conveying different but related pieces of information about the referent) and temporally synchronous with one another (Butcher & Goldin-Meadow 2000; Pizzuto, Capobianco & Devescovi 2005).

The evidence just reviewed points to close, time-linked relationships between the facial, manual, and vocal modalities, underscoring the integrated nature of the developing communicative system. One limitation of these studies, however, is that they have generally not considered the temporal organization of more than two modes of communicative expression and their mutual influence. That is, although individual communicative behaviors are viewed as components of a system, they have typically been studied in isolation or in relation to only one other communicative behavior (e.g., gestures with speech). Here we examine facial affect, gestures, words, and non-word vocalizations and their intercoordinations to provide a more complete picture of the frequency with which infants coordinate communicative behaviors and the composition of bouts of coordinated behaviors.

The Vocabulary Spurt

In their first few years of life, children undergo a number of developmental transitions in which new skills emerge and are gradually integrated into an existing skill set. One such transition in the area of language development that has captured researchers' interest for decades is the vocabulary spurt. Typically occurring at about 16 to 18 months, the vocabulary spurt involves a sudden, rapid increase in children's productive vocabularies, with vocabulary size often doubling within a month's time (e.g., Bloom 1973; Dromi 1987; Goldfield & Reznick 1990). Although there is disagreement regarding its underlying mechanisms (e.g., McMurray 2007), there is wide-spread recognition of the vocabulary spurt as a milestone of linguistic development (e.g., Bloom & Capatides 1987; Choi & Gopnik 1995; Gershkoff-Stowe & Smith 1997) and as a marker of developmental change (e.g., Fischer, Pipp & Bullock 1984; Lifter & Bloom 1989).

Although the vocabulary spurt is considered a time of impressive cognitive growth and developmental achievement, there is also evidence that it is a time of temporary disruption in language use. Gershkoff-Stowe (2001, 2002) describes the period surrounding the vocabulary spurt as a time when children are especially susceptible to error, and in particular, naming errors. These naming errors tend to peak with the onset of accelerated vocabulary growth and, in Gershkoff-Stowe's view, are most likely due to momentary failures in accessing the correct word rather than lack of word knowledge (Gershkoff-Stowe 2001; Gershkoff-Stowe & Smith 1997). In fact, Gershkoff-Stowe (2002) found that as individual words were practiced in production, they became stronger and more resistant to interference from lexical competitors. We build on this work in the current study by exploring whether and how this temporary disruption in language affects the production and coordination of words with other communicative behaviors, namely gesture and affect.

Thus, the overarching goal of the present study was to investigate the interplay between facial affective expressions, gestures, words, and non-word vocalizations and the ways in which their relationships may be modified during a major communicative transition. We expected to find evidence of links between all three modalities (as demonstrated by the temporal coordination of component behaviors)

during the time surrounding the vocabulary spurt; but we also anticipated that rapid advancement in language would impact these links in different ways.

Method

Participants

The initial sample consisted of 20 typically-developing, healthy infants and their primary caregivers (mostly mothers). Infants and caregivers were observed at home twice a month from 2 to 19 months of age as part of a larger longitudinal study of infant vocal-motor coordination (e.g., Iverson, Hall, Nickel & Wozniak 2007). Observations were scheduled to occur within a week of each infant's monthly birthday anniversary and at the midpoint between birthday anniversaries. Dyads were recruited from a small Midwestern city and a large mid-Atlantic city through published birth announcements and word of mouth. Eligible families were contacted by letter and follow-up phone call. Informed consent was obtained from parents upon enrollment. All infant participants were from full-term, uncomplicated pregnancies with normal deliveries and came from monolingual, English-speaking homes. To be included in the sample for the present study, infants must have had an observable vocabulary spurt (see below) prior to completion of the larger study.

Two infants were excluded from the initial sample due to sickness or malfunction in sound equipment. The final sample consisted of 18 infants (6 males and 12 females). Seven infants were firstborn and two were receiving at least 24 hours per week of child care at the time of study enrollment. Parents of participating infants were generally well-educated; all mothers and most fathers had completed at least some college or had a college degree.

Identifying the Vocabulary Spurt

Parents completed the MacArthur-Bates Communicative Development Inventory (CDI; Fenson *et alii* 1993), a widely-used measure of early communicative development, at regular two-week intervals from 8 to 19 months. Parent report is commonly utilized in studies of early language development and data suggest that parents are fairly good informants of their children's language development (e.g., Bates, Bretherton & Synder 1988; Goldfield & Reznick 1990). Indeed, the CDI has excellent internal consistency, test-retest reliability, and concurrent validity with tester-administered measures (Fenson *et alii* 1994). Between the 8 and 16 month sessions, the Words and Gestures Form of the CDI (CDI-WG) was administered to parents. Beginning at the 16-month observation, the Words and Sentences Form of the CDI (CDI-WS) was employed.[1] To determine the age at which infants achieved the vocabulary spurt, the total CDI expressive language score (i.e., items that the child said) was computed for all sessions from 8 months forward.

The most common method for identifying the point at which a child has under-

[1] At the time of data collection, the CDI-WG form was only standardized to age 16 months and so a switch to the CDI-WS was necessary at that point. However, there is no statistically significant difference in median scores between the CDI-WG and CDI-WS at 16 months of age in a large sample of typically-developing children (P. Dale, personal communication, September 26, 2009).

gone a vocabulary spurt is the threshold approach, in which a given number of new words is acquired within a specified time period (Ganger & Brent 2004). Following the most conservative criteria, we defined the vocabulary spurt as the first observation at which the number of words produced (as reported by parents on the CDI) increased by at least 10 in a given 2-week period *and* after the infant had acquired a minimum of 20 different words.

Using this procedure, the mean age at vocabulary spurt in this study was 16.22 months (range = 14 to 18 months). Three of the 18 children reached criteria for a vocabulary spurt at 16 months of age based on the CDI. All 3 children also exhibited a marked increase in the number of words produced spontaneously during the videotaped observation session from the pre-spurt session to the spurt-session (i.e., an average increase of 43 words); therefore, it is unlikely that the mean age at vocabulary spurt is a product of the transition from the CDI-WG to the CDI-WS at the 16 month observation.[1] Consistent with previous investigations (e.g., Bloom 1973; Dromi 1987), the average size of infants' vocabularies at spurt onset was about 50 words (mean = 48.89 words; range = 37 to 69 words). Although a minimum cumulative vocabulary of 20 words was required, none of the infants demonstrated an increase of 10 words in 2 weeks prior to achieving the base criterion.

Observational Data

As described above, all participants were followed bimonthly from 2 to 19 months of age. For the present study, we focused on three observations from the period in which infants achieved the vocabulary spurt: 1) that occurring one month prior to the onset of the vocabulary spurt (pre-spurt session); 2) that coinciding with the onset of the vocabulary spurt (spurt session); and 3) that occurring one month following the onset of the vocabulary spurt (post-spurt session).

Infants were videotaped at home with the same primary caregiver for approximately 45 minutes. For all infants, the first and final 15 minutes of the session consisted of unstructured, naturalistic observation. Caregivers were asked to continue their normal activities during this time; no attempt was made to structure this portion of the session. These activities may have included play with the infant, cleaning or other daily household activities, feeding, or conversation with the experimenter. During the middle 15 minutes, caregivers were seated on the floor with the infant, and infants were videotaped interacting with the caregiver and playing with favorite toys. To enhance the audio component of the recordings, infants wore a small wireless microphone clipped to a cloth vest worn over their clothing during the session. To allow for warm-up, the initial 15-minute naturalistic segment was not coded; the data reported here were obtained from the middle semi-structured play and the final naturalistic play periods.

[1] However, to address the possibility that parents may have been tempted to endorse a larger number of words on the CDI-WS because it is longer than the CDI-WG, we calculated the percentage of words selected on each form as a reliability check. In fact, the percentage of words selected shows a similar increase over time ($M_{\text{pre-spurt}} = 5.22$, $SD = 1.67$; $M_{\text{spurt}} = 8.84$, $SD = 3.08$; $M_{\text{post-spurt}} = 13.04$, $SD = 6.00$).

Coding

Coding was completed by one primary observer (the first author) and three secondary observers blind to the study's hypotheses. All spontaneous (i.e., not explicitly elicited by an adult) and communicative utterances produced by infants during the 30-minute session were coded continuously from the videotape, with onset and offset times identified for each behavior. Utterances consisted of gestures alone, facial affect expressions alone, words alone, non-word vocalizations alone, or any combination of these behaviors produced together (i.e., in coordination). To facilitate analysis of the relative timing of communicative behaviors, video coding was completed using a time-linked, computer-based video interface system (The Observer Video-Pro, Noldus Information Technologies).

Gestures were coded in terms of standard deictic and representational categories (e.g., Capirci, Iverson, Pizzuto & Volterra 1996; Iverson & Goldin-Meadow 2005). *Facial affect expressions* were coded categorically as either *positive*, *negative*, *surprise,* or *neutral*. For the purpose of this paper, all gestures and facial affective expressions were collapsed across categories for subsequent data analyses. Words and non-word vocalizations were coded in a manner consistent with previous work examining the gesture-speech relationship in infants and young children (e.g., Butcher & Goldin-Meadow 2000). *Words* involved consistent use of a sound pattern (either an English word such as "dog" or an idiosyncratic sound such as "bah" for bottle) to refer to a specific referent on multiple occasions or in different contexts. Words that were purely imitative (i.e., words repeated immediately after being spoken by another person) were not coded. All uninterpretable strings of speech sounds were coded as *non-word vocalizations*. Non-word vocalizations included vowel strings (e.g., "eeaa"), reduplicated babbling (e.g., "gaga"), or variegated babbling (e.g., "bama").

In addition to coding individual vocal, gestural, and affective behaviors (i.e., those produced in isolation), instances in which communicative behaviors co-occurred in time were coded as *coordinated bouts*. Communicative behaviors were considered coordinated when two (or more) behaviors overlapped temporally with one another (e.g., gesture + facial affect expression + vocal utterance; vocal utterance + gesture; facial affect expression + gesture). Coordinated bouts were further classified according to whether they were synchronous (i.e., the first communicative behavior was produced within .3 seconds of the second) or asynchronous.

Reliability

To assess inter-coder reliability, all coders independently coded 16 ten-minute segments randomly chosen from observations of different infants at different ages (4 from the pre-spurt session, 8 from the spurt session, and 4 from the post-spurt session). Using this procedure, mean inter-coder agreement was 92% (range = 83-98%) for identifying vocal utterances; 89% (range = 82-100%) for identifying gestures; 79% (range = 74-100%) for identifying facial affect; and 82% for identifying coordinated bouts (range = 67-100%). Mean inter-coder agreement was 87% ($\kappa = 0.78$; range = 0.58-0.96; Cohen 1960). Disagreements were resolved by joint viewing of the behavior(s) in question and discussion.

Results

This study was designed to explore the production of gestures, non-word vocalizations, words, facial affect, and the content and temporal organization of communicative coordinations at the time of the vocabulary spurt. Data from observations prior to, at, and following the onset of the vocabulary spurt were utilized without regard to infant age at the time of milestone achievement. Data were screened for outliers (i.e., values greater than two standard deviations above or below the mean), and these were replaced with a value one larger (or smaller) than the next most extreme score in the distribution (Tabachnick & Fidell 1996). All proportional variables were arcsine transformed prior to conducting statistical analyses. One-way repeated measures analyses of variance (ANOVAs) with planned contrasts between adjacent ages were used to examine changes from pre-spurt to spurt to post-spurt sessions.

Preliminary Analyses

Preliminary analyses were performed to assess potential effects of gender, birth order and age on overall communicative frequency and to verify the occurrence of the vocabulary spurt. Gender, birth order, and age effects were examined by analyzing the total number of communicative acts (i.e., the number of communicative behaviors produced alone plus the number of coordinated bouts) at each of the three (pre-spurt, spurt, post-spurt) sessions and averaging across sessions to create a stable measure of infant communicativeness. An independent samples *t* test showed no effects of gender, $t\ (16) = -.307$, *ns,* or birth order, $t\ (16) = .242$, *ns*. Pearson's correlations revealed a nonsignificant association between infant age and communicativeness, $r = .365$, *ns*. Thus, all subsequent analyses were carried out without regard to these variables.

Analyses of the vocabulary spurt focused on the overall spontaneous production of words during the pre-spurt, spurt, and post-spurt observation sessions. A repeated measures ANOVA revealed a significant increase in the number of words produced over the three time points ($M_{\text{pre-spurt}} = 15.28$, $SD = 11.72$; $M_{\text{spurt}} = 36.89$, $SD = 22.50$; $M_{\text{post-spurt}} = 44.78$, $SD = 22.69$), $F\ (2, 34) = 12.73$, $p < .001$, $\eta^2 = .428$, with planned contrasts indicating that the source of the effect was in the significantly higher number of words produced at the spurt relative to the pre-spurt session, $F\ (1, 17) = 14.90$, $p = .001$, $\eta^2 = .467$. Inspection of the individual data revealed that this pattern was apparent in all but two infants.

Communication Patterns during the Vocabulary Spurt

Production of communicative behaviors. We begin by presenting data on the mean proportions of the various communicative behaviors produced by infants during the time surrounding the vocabulary spurt (i.e., the total number of words, non-word vocalizations, gestures, or affect respectively divided by the total number of communicative behaviors). Means and standard deviations for each type of communicative behavior are presented in Table 1. Inspection of these proportions indicated that at all three observations, the majority of expressions were non-word vocalizations, a tendency that remained relatively unchanged over time,

F (2, 34) = 2.12, p = .136. Words initially comprised 10% of all behaviors produced, but this proportion almost doubled in size after the onset of the vocabulary spurt. A repeated measures ANOVA confirmed this overall difference, F (2, 34) = 7.93, p = .001, η^2 = .318, with planned contrasts indicating that the source of the effect was present in the significant increase from the pre-spurt to the spurt session, F (1, 17) = 12.58, p = .002, η^2 = .425. Approximately 20% of all infant communications were gestures, a value that remained relatively stable over time, F (2, 34) = 0.54, p = .590. Facial affective expressions were least frequent; they appeared in less than 10% of all communications produced at the pre-spurt and spurt sessions and decreased slightly at the spurt session, a pattern that approached significance, F (2, 34) = 2.74, p = .079, η^2 = .139.

TABLE 1. *Mean Proportion, Standard Deviation, and Range of Communicative Behaviors Produced at Each Time Point*

	Observation								
	Pre-spurt			Spurt			Post-spurt		
Communicative Behaviors	*M*	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Non-word Vocalizations	0.60	0.11	0.44-0.81	0.55	0.13	0.34-0.79	0.54	0.11	0.35-0.75
Words	0.10	0.07	0.01-0.27	0.18	0.08	0.04-0.30	0.20	0.09	0.06-0.35
Gestures	0.20	0.08	0.06-0.36	0.17	0.08	0.05-0.28	0.19	0.08	0.05-0.31
Facial Affect	0.10	0.07	0.01-0.21	0.10	0.04	0.02-0.18	0.07	0.03	0.01-0.12

Note. n = 18; Data were collected from 30-minute observation sessions; range reflects minimum to maximum values.

Coordination of communicative behaviors. The next set of analyses examined the frequency and composition of coordinated bouts during the vocabulary spurt, focusing specifically on the relationships between facial affective expressions and words and gestures and words respectively. Because the opportunity to produce coordinated bouts was held constant across participants (i.e., all infants were observed for 30 minutes at each time point), we examined the total number of coordinated bouts produced at each session.

With regard to frequency, all of the infants produced coordinated bouts at each session at a rate of about 1 per minute ($M_{\text{pre-spurt}}$ = 19.44, SD = 11.17; M_{spurt} = 19.22, SD = 9.55; $M_{\text{post-spurt}}$ = 29.22, SD = 14.12). A repeated-measures ANOVA revealed significant change over sessions, F (2, 34) = 5.94, p = .006. Planned contrasts indicated no significant difference in number of communicative coordinations between the pre-spurt and spurt sessions, F (1, 17) = .01, p = .946; however, coordinations increased significantly from the spurt to the post-spurt session, F (1, 17) = 11.91, p = .003.

With regard to composition, TABLE 2 presents the mean proportions of coordinated bouts that involved gestures, non-word vocalizations, words, or facial affect. As is apparent in the table, approximately 90% of all coordinated bouts involved a gestural expression. A repeated measures ANOVA indicated that the proportion of coordinations involving gesture did not vary significantly across the three observations, F (2, 34) = 1.16, *ns*. Although non-word vocalizations were also frequently involved in coordinated bouts, they tended to appear less often at and following

the onset of the vocabulary spurt, $F(2, 34) = 3.21$, $p = .053$, $\eta^2 = .159$. Finally, words and facial affect expressions occurred in bouts least often and with similar frequency (i.e., approximately 15%). However, the proportion of bouts including words increased across all sessions, $F(2, 34) = 6.52$, $p = .004$, $\eta^2 = .277$, with planned contrasts indicating significant change from the spurt to the post-spurt session, $F(1, 17) = 6.07$, $p = .025$. In contrast, the proportion of bouts involving facial affect peaked at the vocabulary spurt session and then declined, $F(2, 34) = 4.09$, $p = .026$, $\eta^2 = .194$. Planned contrasts revealed a significant increase from the pre-spurt to the spurt session, $F(1, 17) = 6.42$, $p = .021$, $\eta^2 = .274$, and a nearly significant decrease from the spurt to the post-spurt session, $F(1, 17) = 3.58$, $p = .076$, $\eta^2 = .174$.

TABLE 2. *Mean Proportion of Coordinated Bouts Involving Gestures, Non-word vocalizations, Words, and Facial Affect*

	Observation								
	Pre-spurt			Spurt			Post-spurt		
Behaviors	*M*	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Gestures	0.90	0.11	0.67-1.00	0.84	0.16	0.55-1.00	0.91	0.08	0.78-1.00
Non-word Vocalizations	0.81	0.18	0.28-1.00	0.70	0.24	0.14-1.00	0.70	0.14	0.37-1.00
Words	0.15	0.14	0.00-0.41	0.20	0.15	0.00-0.43	0.31	0.14	0.17-0.55
Facial Affect	0.15	0.11	0.00-0.33	0.29	0.19	0.00-0.57	0.17	0.14	0.00-0.48

Note. n = 18; Data were collected from 30-minute observation sessions; range reflects minimum to maximum values.

The above results illustrate differences between gesture and affect in terms of *overall* occurrence in coordination with other communicative behaviors. Bouts involving gestures remained frequent throughout the observation period, while bouts involving affect showed a clear peak at the spurt session with a subsequent decline. In light of Gershkoff-Stowe's (2001, 2002) suggestion that the vocabulary spurt is a time when words are a particularly fragile communicative behavior, we next asked whether words were more likely to co-occur with gesture vs. facial affect during the period surrounding the vocabulary spurt. For this analysis, we identified all coordinated bouts that contained words, and computed the proportion of bouts with words and gestures and the proportion of bouts with words and affective expressions respectively for each infant at the pre-spurt, spurt, and post-spurt sessions. Gestures were significantly more likely to occur with words in coordinated bouts than were affective expressions at the pre-spurt ($M_{gestures} = .72$, $SD = .39$; $M_{affect} = .12$, $SD = .26$), $t(13) = 3.50$, $p = .004$, spurt ($M_{gestures} = .70$, $SD = .36$; $M_{affect} = .11$, $SD = .28$), $t(15) = 3.79$, $p = .002$, and post-spurt sessions ($M_{gestures} = .77$, $SD = .20$; $M_{affect} = .11$, $SD = .15$), $t(17) = 7.08$, $p = .000$.

Finally, we examined the timing and patterning of behaviors appearing in coordinated bouts by identifying those in which communicative behaviors were produced simultaneously (e.g., infant begins to point and vocalizes at the same time) and those that were asynchronous, or comprised of overlapping behaviors in which there was a clear initiating behavior (e.g., infant points to an interesting toy,

pauses, and then turns to smile at her caregiver). Although there was a tendency for coordinated bouts to become more synchronous, $F(2, 34) = 3.07$, $p = .060$, $\eta^2 = .153$, the majority of bouts were asynchronous ($M_{\text{pre-spurt}} = .58$, $SD = .15$; $M_{\text{spurt}} = .54$, $SD = .16$; $M_{\text{post-spurt}} = .47$, $SD = .12$; see Table 3).

Therefore, for all asynchronous bouts, we identified the communicative behavior that initiated the bout, and classified bouts according to the initiating behavior (e.g., word, non-word vocalization, gesture, facial affect expression). These data are presented in TABLE 3. As can be seen, the majority of asynchronous bouts were initiated by a gesture, while words were least likely to initiate asynchronous bouts. It was also relatively uncommon for non-word vocalizations and facial affect to initiate asynchronous bouts. Additionally, while there were no significant changes in the proportion of bouts initiated by a non-word vocalization, gesture, or facial affect expression across sessions, words became more likely over time to initiate asynchronous bouts, $F(2, 34) = 3.62$, $p = .038$, $\eta^2 = .175$. Planned contrasts indicated that the source of this effect lay in the difference between the pre-spurt and post-spurt sessions, $F(1, 17) = 5.93$, $p = .026$, $\eta^2 = .259$.

TABLE 3. *Descriptive Information for Asynchronous Coordinated Bouts and Communicative Behaviors Initiating Asynchronous Bouts.*

	Observation								
	Pre-spurt			Spurt			Post-spurt		
Behaviors	*M*	*SD*	*Range*	*M*	*SD*	*Range*	*M*	*SD*	*Range*
Proportion of Asynchronous Bouts	0.58	0.15	0.38-0.81	0.54	0.16	0.32-0.83	0.47	0.12	0.20-0.62
Gestures	0.68	0.21	0.29-1.00	0.65	0.27	0.20-1.00	0.57	0.23	0.00-0.89
Words	0.03	0.06	0.00-0.18	0.06	0.09	0.00-0.30	0.13	0.24	0.00-1.00
Non-word Vocalizations	0.14	0.16	0.00-0.52	0.12	0.12	0.00-0.40	0.17	0.17	0.00-0.67
Facial Affect	0.15	0.13	0.00-0.40	0.17	0.19	0.00-0.60	0.13	0.17	0.00-0.60

Note. n = 18; Data were collected from 30-minute observation sessions; range reflects minimum to maximum values.

In sum, infants produced words with increasing frequency during the period of observation, with a sharp increase in the number of words specifically at the vocabulary spurt. Furthermore, words appeared to be increasingly integrated into coordinated bouts with other communicative behaviors. Gestures remained a prominent form of communication around the time of the vocabulary spurt and were the most frequently appearing behavior in coordinated bouts. Gestures were more likely to occur in coordination with words than were affective expressions and were also highly likely to initiate coordinated bouts. Finally, even as vocabulary was rapidly increasing, infants continued to utilize developmentally earlier forms of communication (e.g., non-word vocalizations, facial affect expressions); however, the degree to which these behaviors appeared in coordinated bouts decreased after the onset of the spurt.

Discussion

This research was designed to examine the ways in which the onset of the vocabulary spurt, a major communicative milestone, impacts the organization of the communicative system. We asked whether the closely linked relationship between gesture, affect, and language is altered as the linguistic system undergoes a period of significant growth. There were two major goals. The first was to provide a general picture of infants' production and coordination of facial affective expressions, gestures, non-word vocalizations, and words at the time surrounding the vocabulary spurt. The second was to examine whether differing relationships between language and other communicative behaviors would be observable during this transition.

This study complements prior work demonstrating that the temporal organization of communicative behaviors is a robust feature of infant behavior (e.g., D'Odorico, Cassibba & Salerni 1997; Yale *et alii* 1999, 2003). All of the infants in this study combined behaviors from multiple modalities to deliver a communicative message, and they did so frequently (at a rate of approximately 1 per minute). We found evidence for the increasing integration of words in coordination with other communicative behaviors, with coordinated bouts involving words becoming more frequent after the onset of the vocabulary spurt. Most importantly, as more dominant or "effective" means of communication (i.e., language) began to emerge, earlier behavioral forms did not disappear.

It may be that during linguistic transitions, one behavior in particular serves as an "organizer" for communication. In early infancy, when communication primarily takes place within the context of face-to-face situations, facial affective expressions appear to dominate social interchange (e.g., Adamson & Bakeman 1985). With the emergence of intentional communication, gestures come to the forefront in social interactions (Bates 1976; Bates *et alii* 1979) and expressions involving facial affect begin to decrease (though they do not completely vanish; Adamson & Bakeman 1985). Although we did not test this idea directly, the fact that the vast majority of coordinated bouts (approximately 90 percent) involved a gesture suggests that gestures play an important role in organizing communicative coordinations during the vocabulary spurt.

Two findings provide further support for this view. First, the majority of asynchronous bouts were initiated by a gesture. It is possible that gestures may influence, or "pull in," other communicative behaviors. This idea parallels the dynamic systems notion of entrainment (Iverson & Thelen 1999), in which sufficient activation in one component of a system pulls in or entrains the activity of a complementary component. Older, more established behaviors are considered the best candidates for entrainment. When children enter the period of the vocabulary spurt, gestures are a highly stable component of the communicative system, having been the preferred mode of communication since the emergence of first words (e.g., Bates *et alii* 1979). Thus, they may have the greatest potential for entraining other behaviors. Second, words were more likely to be coordinated with gestures than with facial affective expressions, suggesting that affect becomes a less integral part of communicative coordinations in later infancy. The scarcity of affective expressions during communicative utterances involving speech is consistent with the line of work by Bloom and colleagues indicating that the expression of affect may

even play a hindering role in the development of language (Bloom, Beckwith & Capatides 1987; Bloom & Capatides 1987).

The importance of gesture's role in the development of intentional communication has been widely acknowledged in previous studies. While there is some indication that gesture facilitates the development of language and may play a supportive role in linguistic transitions (e.g., Iverson & Goldin-Meadow 2005), many studies have also demonstrated that gesture's role changes with development (e.g., Iverson, Capirci & Caselli 1994, Capirci *et alii* 1996; see also Capirci & Volterra 2008). Findings from the present study add to these accounts and support a developmental scenario in which gestures begin as the primary form of intentional communication, then assume a communicative position that is relatively equivalent to language, and finally shift to a new role as a secondary support system integrated with language (Butcher & Goldin-Meadow 2000; Iverson *et alii* 1994).

The onset of the vocabulary spurt was also associated with changes in the composition of coordinated bouts. Specifically, coordinations involving facial affect peaked at the vocabulary spurt session, while coordinations involving gestures were produced consistently throughout the observation period. These findings indicate that during times of transition, there may be a preference for well-established patterns of coordination (e.g., configurations involving gestures, affect, and non-word vocalizations), patterns that have been a part of infants' communicative repertoires for several months. Our data are consistent with the possibility that infants do not abandon more "primitive" forms of behavior as they acquire new skills, but rather continue to draw upon earlier developing skills at a time when new skills are emerging. Further empirical support for this interpretation comes from work in the area of motor development (e.g., Adolph 2000; Corbetta & Bojczyk 2002; Thelen & Ulrich 1991). For example, Corbetta and Bojczyk (2002) demonstrated that infants returned to two-handed reaching when they were learning to walk. Prior to the onset of walking, most infants were able to produce well-coordinated movement patterns that involved the extension of one arm in reaching for objects. When they began to walk, however, those infants increased their rate of two-handed reaching. Then, a few to several weeks later, as infants gained better balance control, they returned to unimanual reaching.

Taken together, our findings suggest that the vocabulary spurt is a time of considerable change that alters existing communication patterns. They are also consistent with previous research suggesting that the gestural, affective, and vocal modalities develop as complementary systems of expression. However, we found that the communicative role played by each modality changes over the course of development, thus highlighting the dynamic organization of the communicative system. While affect is an important component of communication in early infancy, gesture appears to come to the forefront later in infancy, with speech eventually becoming the predominant form of communication. Importantly, however, older behavioral forms do not disappear once more "effective" means of communication emerge; rather, they assume a different role.

Future work examining temporal patterns of multiple, diverse behaviors at other linguistic milestones (e.g., onset of the first word, the transition into two-word speech) will shed further light on the relevance of systemic disruption for change in communication and on general processes underlying development. The

milestone-based design employed here offers a unique approach to studying infant development by permitting the examination of changes in behavior as they specifically relate to the emergence of a new communicative skill. Overall, the findings reported here provide an example of the richness of the communicative repertoire of the older infant and underscore the fruitfulness of an integrated approach to the study of early communication.

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