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Research Article

Classification of Infant Vocalizations by Untrained Listeners

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Purpose: To better enable communication among researchers, clinicians, and caregivers, we aimed to assess how untrained listeners classify early infant vocalization types in comparison to terms currently used by researchers and clinicians.
Method: Listeners were caregivers with no prior formal education in speech and language development. A 1st group of listeners reported on clinician/researcher-classified vowel, squeal, growl, raspberry, whisper, laugh, and cry vocalizations obtained from archived video/audio recordings of 10 infants from 4 through 12 months of age. A list of commonly used terms was generated based on listener responses and the standard research terminology. A 2nd group of listeners was presented with the same vocalizations and asked to select terms from the list that they thought best described the sounds.
Results: Classifications of the vocalizations by listeners largely overlapped with published categorical descriptors and yielded additional insight into alternate terms commonly used. The biggest discrepancies were found for the vowel category.
Conclusion: Prior research has shown that caregivers are accurate in identifying canonical babbling, a major prelinguistic vocalization milestone occurring at about 6–7 months of age. This indicates that caregivers are also well attuned to even earlier emerging vocalization types. This supports the value of continuing basic and clinical research on the vocal types infants produce in the 1st months of life and on their potential diagnostic utility, and may also help improve communication between speech-language pathologists and families.

Children that are identified as having disorders by age 3 years are likely to face substantial difficulty throughout all aspects of life (e.g., including academic, employment, social, and psychological well-being; Bornstein, Harynes, & Painter, 1998; Braze, Tabor, Shankweiler, & Mencl, 2007; Catts, Adlof, & Ellis Weismer, 2006; Duff, Reen, Plunkett, & Nation, 2015; Gertner, Rice, & Hadley, 1994; Hart & Risley, 2003; McGregor, Oleson, Bahnsen, & Duff, 2013). Work toward reducing the effect of these potential lifelong deficits can begin if a child is identified as early as possible and placed in intervention services (American Speech-Language-Hearing Association, 2017; Hebbeler et al., 2007). Due to the heavy reliance on parent report during assessment of infant speech-language skills, it is necessary to determine if parents and caregivers[1] classify infant vocalizations in the same manner as those of professionals. Past research shows that caregiver ability to report on infant development is often a natural skill they possess, resulting in report that accurately represents their child's true abilities (Feldman et al., 2005; Heilmann, Ellis Weismer, Evans, & Hollar, 2005; Oller, Eilers, & Basinger, 2001). There is good evidence that caregivers can correctly identify the onset of canonical babbling (Oller et al., 2001), which typically occurs at about 6–7 months of age, but has been shown to be delayed or reduced in frequency for children with severe hearing loss, autism spectrum disorder (ASD), and other conditions (Belardi et al., 2017; Garrido, Watson, Carballo, Garcia-Retamero, & Crais, 2017; Oller & Eilers, 1988; Patten et al., 2014; Paul, Fuerst, Ramsay, Chawarska, & Klin, 2011). However, a

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[1]From this point on, the term *caregiver* will be used to refer to parents and any individual who provides primary caretaking for an infant (e.g., grandparent).

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challenge may present itself in bridging the gap between how trained professionals (e.g., speech-language pathologists) and untrained[2] caregivers classify other infant vocalization types, including the earlier emerging sounds that differ primarily in phonatory characteristics. Although some basic research has addressed the linguistic significance of these early emerging infant vocalization types (Oller et al., 2013) and other research has indicated that phonatory characteristics differ for children with ASD (Sheinkopf, Mundy, Oller, & Steffens, 2000), whether caregivers are well attuned to these phonation-based vocalization types and the words they use to describe them has not been formally studied.

The goal of this research is to develop a list of intuitive and representative terms for classification of these early-appearing infant vocalization types, to ensure correspondence between terms used by researchers/clinical professionals and those used by caregivers. We aim to enhance communication between researchers, clinicians, and caregivers and improve accurate interpretation of parent report. In turn, accurate interpretation may facilitate earlier identification of infants at risk for speech and/or language delay/disorder. The question of how untrained listeners categorize and describe vocalization types is also interesting from a basic science perspective, as it could expand theory on how infants/children learn to speak. Caregiver perception of infant vocalizations directly influences caregiver–infant interaction, and shapes the language learning environment (Gros-Louis, West, Goldstein, & King, 2006; Julien & Munson, 2012; Olson & Masur, 2012; Ramsdell-Hudock, Stuart, & Peterson, 2018). Through these exchanges, how caregivers perceive infant vocalizations has implications for the evolution of vocal communication via parental selection (Locke, 2006; Oller, Griebel, & Warlaumont, 2016).

Clinician and Researcher Classification of Infant Vocalizations

During research and assessment of infant vocal development, researchers, speech-language pathologists, and other trained professionals classify infant sounds in a variety of ways. Regardless of classification scheme, there are some accepted stages of development that are regularly used by professionals to describe vocalizations in the first year of life (Koopmans-van Beinum & van der Stelt, 1986; Oller, 1980; Stark, 1980), as summarized by Oller (2000). Furthermore, although these are referred to as stages, there is overlap from one period of development to the next and individual variation between children necessitates that the ages given are approximates.

From birth to around 2 months of age, infants produce vegetative sounds, quasivowels, and cries in the *phonation stage*. Vegetative sounds may be divided into grunts and sighs associated with activity, and clicks and other noises associated with feeding. Quasivowels are those brief periods of voicing (or phonation, as the name of the stage implies) produced with the vocal tract at rest. Given that the vocal tract is not postured, as is the case during production of mature speech sounds, quasivowels are sometimes contrasted with fully resonant (full) vowels.

From around 1 to 4 months of age, infants enter the *primitive articulation stage,* or the coo and goo stage of vocal development. In this stage, cooing or gooing sounds are produced during comfortable states. The productions are said to contain consonant-like and vowel-like segments. The consonants are not clearly articulated, and the vowels are, again, not fully resonant within the oral, nasal, and pharyngeal cavities. Here, also, a primitive syllable structure emerges with irregular timing in the opening and closure of the consonant- and vowel-like segments.

From around 3 to 8 months of age, infants produce vocal play in the *expansion stage* with extreme variations in loudness (e.g., yells and whispers) and pitch (e.g., squeals and growls). Other vocalization types said to emerge during this time include raspberries, frication noises, fully resonant nuclei (with more variety in tongue height and position for vowel production), and marginal babbling. Marginal babbling, although consisting of longer strings of segments with prolonged vowel- and consonant-like elements, remains immature in that the timing of transitions between segments is much more slow and incomplete than those produced by adults. Listeners are able to perceive the articulatory movement of the slow transitions between consonant- and vowel-like segments in marginal babbling, making the productions sound mushy and immature.

From around 5 to 10 months of age, infant vocalizations begin to take on the mature timing and articulatory features of adult speech in the *canonical stage*. Regular production of canonical syllables are the defining characteristic of this stage; these are vocalizations produced with clearly articulated and more constricted consonants, fully-resonant vowels, and quick (i.e., timely) transitions between consonants and vowels. With the production of crisp, clear, mature-sounding canonical syllables, we can no longer perceive the transition between consonant and vowel segments. Canonical syllables are often reduplicated (repeated consonant–vowel syllables), but become more and more variegated (a combination of a variety of different consonants and vowels in strings of syllables) with increasing age beyond 10 months. Also, beyond the canonical stage, intonation patterns in child productions become more adultlike and phonetic repertoires increase in variability beyond the stops, nasals, glides, and lax vowels typical of early productions.

In line with the stage model, Nathani, Ertmer, and Stark (2006) used the Stark Assessment and Evaluation of Vocal Development-Revised (SAEVD-R), a research-based tool, to categorize the various vocalizations infants

[2]We identify untrained listeners as those individuals with no previous education in linguistics, protophone terminology, speech-language pathology, child development, and/or music.

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produce in the first 20 months of life. Specifically, through the SAEVD-R, a number of vocalizations commonly produced in prelinguistic to early linguistic development are grouped into five levels. Vocal types included in the *reflexive level* (Level 1) from 0 to 2 months of age are cry and discomfort sounds, quasiresonant nuclei, and vegetative sounds (burps, sneezes, coughing, etc.). Vocal types included in the *control of phonation level* (Level 2) from 1 to 3 months of age are consonant-like sounds, fully resonant nuclei, and laughter. Vocal types included in the *expansion level* (Level 3) from 4 to 8 months of age are vowels, glides, ingressive sounds, squeals, and marginal babbling. Vocal types classified in the *canonical syllables level* (Level 4) from 6 to 10 months of age are consonant–vowel syllables, reduplicated and nonreduplicated sequences, closed syllables (ending in a consonant), and whispers. Finally, vocal types included in the *advanced forms level* (Level 5) from 10 to 18 months of age are diphthongs, jargon, and complex syllable shapes.

Oller's stage model and the SAEVD-R levels of development are generally accepted as standard benchmarks for evaluating progress. These models, along with others, present similar ages of emergence, numbers of levels, and vocalization types to reference. However, despite the similarities across models, there are differences in terminology and definitions that "hamper the portability of vocalization types and make comparisons across studies difficult" (Nathani et al., 2006, p. 2–3). Discrepancies in defining infant vocalizations by professionals can also create confusion in communication between clinicians and parents.

Purpose

Given the wide variety of classification schemes used by researchers and clinicians for tracking infant vocal development and the potential for additional variety in caregiver report, we felt it relevant to review terminology to enhance transparency across listeners. Our focus is on infant vocalizations that differ in phonation characteristics, among the earliest apparent prespeech variations. Herein, we report our findings of vocalizations from a cohort of 10 infants analyzed by 59 untrained listeners. Through this study, we specifically sought to identify terms caregivers use to describe infant vocalizations. The question was, "how do caregivers classify infant vocalizations across age ranges extemporaneously and when provided a pregenerated list of descriptive terms to choose from?" The rationale for this line of study was that, determination of specific terminology for discussion of prelinguistic productions will improve caregiver and clinician/researcher communication, facilitate early intervention through more efficient means of identifying atypical patterns earlier in age, and inform our basic understanding of what caregivers, who play an important role in infant communication development, perceive as variations in infant vocal productions.

Method

Infant Participants and Recording Procedures

Vocalizations for this study were obtained from archived data of 10 infants who were typically developing, video/audio-recorded monthly from 4 to 18 months of age in a study conducted by the first author at East Carolina University (some of this data set has been used for other research purposes, see Ramsdell-Hudock, Stuart, & Parham, 2018). Data collection began at 4 months, and continued through 18 months of infant age for all 10 infants. Inclusion criteria were normal pregnancies, no significant history of prenatal or perinatal problems, English as the primary language spoken in the home, ability to travel to the laboratory monthly, expectation of remaining in the area for 2 years following the start of participation in the study, and low risk of developmental disorder diagnosis. Infants considered at elevated risk were those who had experienced one or more of the following conditions prior to 7 months of age: pre- and/or perinatal problems; ear, nose, and throat problems; swallowing/sucking problems; and/or a family history of speech and/or language problems (Brady, Marguis, Fleming, & McLean, 2004; Girolametto, Weitzman, Wiigs, & Pearce, 1999; Goldstein & Schwade, 2008; McDuffie & Yoder, 2010). For the purposes of this project, we explored data from 4 through 12 months of infant age. Following previous approval from the University Medical Center Institutional Review Board at East Carolina University, caregivers voluntarily gave informed consent for participation in the study. Furthermore, exemption was obtained from the Human Subjects Committee at Idaho State University (where data were analyzed and this study was conducted), as the purpose of this study was covered in the original consent.

Three of the 10 infant participants were male, and seven were female. One female infant was African American, one male infant was Asian American (father of East Indian descent and mother of Vietnamese and Hawaiian descent), one male infant was Palestinian, and all others were White. One male infant was from a home where English and Arabic were spoken, and a second male infant was from a home where English, Indian, and Vietnamese were spoken. All infants had normal hearing; they all passed an automated auditory brainstem response newborn screening (ALGO 3 or ALGO 5 Newborn Hearing Screener System) to click stimuli presented at 35 dB nHL. In addition, full hearing evaluations including tympanometry, transient evoked otoacoustic emissions, and visual reinforcement audiometry were conducted at 6 and 18 months of age, with follow-up testing as needed for instances where results were abnormal (i.e., middle ear dysfunction) or testing was incomplete. One of the infants received bilateral myringotomy and pressure equalization tubes during enrollment in the study.

Infants and caregivers came to the lab at East Carolina University once a month for hour-long recordings. During recordings, caregivers were instructed to play with their infants and interact as they would typically do in a home

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setting. The lab was designed to simulate a natural environment, such as a nursery in a home; it included stuffed animals, toys, and various objects that would allow both parent and child to feel comfortable. This setting attempted to encourage natural interactions between caregivers and infants, to facilitate capture of a representative sample of the infant's vocal abilities.

The lab was equipped with both video and audio recording capabilities. For video data, the recording room contained eight Sony EVI-D70/W wall-mounted cameras with pan and tilt capabilities. Furthermore, three walls contained 3 × 4 ft mirrors to optimize camera angles in recordings. For audio data, the recording room was sound treated with floor-to-ceiling carpeted paneling on all walls. Additionally, an infant vest housed a high-fidelity wireless microphone to control mouth-to-microphone distance (Buder & Stoel-Gammon, 2002). A signal-to-noise ratio of up to 96 dB was made possible with 16-bit quantization, and with signals digitized at sampling rates of 44.1 or 48 kHz. All video and audio from the recording room were relayed to an adjacent control room. During recordings, laboratory staff would attempt to record two of the eight available camera angles, choosing those with (a) the best view of the infant's face and (b) the best view of the interaction between caregivers and infants.

Vocalization Stimuli

Infant utterance location and coding were conducted within a software environment (Action Analysis Coding and Training [AACT] software) that coordinates frame-accurate video and audio presentation with real-time acoustic displays in TF32 (AACT, 1996). Utterance location boundaries were used to determine video playback (via Windows Media Player) for vocal type coding in this study, also using AACT.

Onsets and offsets of infant vocalizations were located based upon a breath group criterion wherein each change in the perceived direction of airflow corresponded with a new utterance; each vocalization occurred on a single egressive breath (Oller & Lynch, 1992). Voiced ingressive utterances, vegetative and reflexive sounds, and vocalizations with significant vocal or noise (e.g., toy) overlay were not included. When locating utterances and placing boundaries, laboratory staff participated in at least 5 hr of training with the first author and followed a strict coding protocol (see Ramsdell-Hudock et al., 2018, for the procedure).

Once infant utterances were located, they were coded for vocal type. Laboratory staff assigned vocal type codes intuitively based on salient audible characteristics, the most prominent impression of each utterance was used to determine judgment, and as few listening opportunities as possible (no more than three) were used before assigning codes. Furthermore, to prevent bias from visual support, utterance coding was conducted without viewing video or TF32 spectrographic information (Milenkovic, 2001).

Utterance vocal type was coded as *vowel, growl, squeal, raspberry, whisper, laugh,* or *cry*. Modal pitch across infants was judged intuitively by laboratory staff upon listening to vocalizations produced by each infant, and vocal type was coded accordingly. Vowel was coded if an utterance was perceived as predominantly produced in modal phonation, in the mid pitch range of the infant. Growl was coded if the most salient pitch of the utterance was notably lower than the infant's modal phonation, or if the pitch of the utterance was in the normal range but the utterance was produced with very high tension. Squeal was coded if the utterance was notably higher in pitch than the infant's modal phonation. Raspberry was coded if the infant produced any sort of lip or tongue trill. Whisper was coded if the infant produced a voiceless utterance with audibly perceptible articulatory movement. Laugh was coded if laughing was the most salient characteristic of the utterance, and cry was coded if uncontrollable crying (more than fussing) was perceived as the most salient characteristic of the utterance. These categorizations were then used to make sure there was diversity of sound types, and the full range of sound types selected across infants and ages; however, the number of utterances produced during recordings varied significantly from infant to infant, as well as between the age groups. To the extent possible (given that some infants did not produce certain sound types at certain ages), one of each vocal type was randomly selected from each infant at each age for audio presentation to untrained listeners (the distribution of these sounds across infant ages is displayed in Table 1). The full set of infant vocalization stimuli is available at https://doi.org/10.6084/m9.figshare.7461989.v1.

Located and coded utterances were extracted from the original recordings, and each was saved as a unique audio file for playback to untrained listeners via Windows Media Player (term generation task) or iTunes (term identification task). The full set of infant vocalization stimuli is available online (Ramsdell-Hudock & Warlaumont, 2018).

Untrained Listeners and Task Procedures

Two consecutive studies with separate groups of adult participants were conducted, during which participants

Table 1. Number of infant utterance types presented to untrained listeners.

Infant utterance type	Total across ages	Infant age in months								
		4	5	6	7	8	9	10	11	12
Vowel	58	8	6	7	6	4	5	7	8	7
Squeal	36	4	4	2	5	7	5	0	3	6
Growl	34	5	3	3	4	4	3	5	3	4
Raspberry	9	1	1	1	0	2	0	1	3	0
Whisper	7	0	0	0	0	0	2	2	1	2
Cry	25	7	1	4	4	4	2	0	0	3
Laugh	23	2	0	3	3	3	1	3	4	4
Total	192	27	15	20	22	24	18	18	22	26

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listened to the selected vocalizations. Inclusion criteria for the untrained listeners consisted of individuals with children, having normal hearing, between 18 and 40 years of age, who were native speakers of American English, and having no prior education in linguistics, protophone terminology, speech-language pathology, child development, or music. Listeners were recruited via word of mouth; e-mail news and notes to faculty, staff, and students at Idaho State University; distribution of recruitment flyers surrounding the Idaho State University campus; and Facebook advertising. The "term generation" study was conducted to generate a list of terms frequently used by untrained listeners for describing infant vocalizations, and the "term identification" study was conducted to vet terms from this broad list, so as to identify particularly useful terms for describing infant vocalizations from the list. Accordingly, two groups of participants were recruited. All listeners were native speakers of General American English (per participant report), exhibited normal hearing (confirmed via hearing screenings conducted by the third and fourth authors), and wore noise cancelling over-ear headphones when listening to audio stimuli. Although each participant was determined to have met all inclusion criteria, we specifically documented participant gender, age, and parenting/caregiver experience, and obtained informed consent prior to listener participation.

Term Generation

A total of 35 untrained listener participants (23 females and 12 males) were involved in generating terms associated with infant vocalizations. Participants ranged in age from 23 to 49 years and had between one and six biological children. Listeners were read a script to ensure consistency of instruction presentation, and then played the 192 vocalizations randomly via Microsoft Windows Media Player. They were prompted to respond to the probe, "What would you call this type of sound? Please answer in one to three words." To avoid bias, listeners were not provided with any examples. The fourth author recorded participant responses, which were explored for themes and patterns within and across reports, from which a list of frequently occurring responses was generated.

Term Identification

A total of 24 untrained listener participants (20 females and four males) were involved in identifying terms associated with infant vocalizations. Participants ranged in age from 23 to 39 years and had between one and four biological children. Again, listeners were read a script to ensure consistency of instruction presentation, and their gender, age, and parenting/caregiver experience were recorded. Terms on the list were presented to participants in a random order. Questions asked by participants before the start of the study included, "What does 'pitch' mean?" "Do I point to it or say it?" and "Do I have a time limit on how long it takes me to select one?" A definition was not provided for "pitch," and participants were instructed to use their best judgment and interpret each of the terms on the list on their own. Listeners were then randomly presented the same set of vocalizations (via iTunes) played for the "term generation" task and asked to verbally state their selections off the list. The order of terms on the list was random (e.g., not alphabetized), and four different random orders were presented to the listeners via a print-out, which the listeners could refer to throughout the experiment. The third author recorded participant responses, which were once again explored for themes and patterns within and across reports and compared to existing academic terminology used to describe prelinguistic infant vocalizations.

Results

Throughout the results and discussion, descriptive terms provided by listeners will be referred to as responses, labels, or tags. Themes from listener responses are as follows. Data are summarized from the term generation task in Table 2, and from the term identification task in Table 3.

Term Generation Task

When untrained listeners were presented with *vowel* stimuli, "coo," "talk," and "happy" (or some derivative of these tags, such as "cooing") were the most frequently elicited labels. In total, these three responses accounted for 41.2% of all of the labels provided for *vowel* stimuli. Moreover, the pattern of labels generated for *vowel* stimuli was largely consistent across infant age. "Coo" was the most frequently occurring response at every infant age except 7 months ("talk" was tagged 0.9% more often) and 11 months ("happy" was tagged 0.4% more often). Some other labels elicited for *vowel* stimuli included "tired," "content," "babble," "noise," and "sigh." The actual label "vowel" only appeared once across all listener responses to *vowel* stimuli.

The stimuli coded as *squeal* were most often labeled as "squeal," "happy," and some form of "high" (high pitch, high squeal, high yell, high noise, etc.). In total, these three responses accounted for 49.5% of all of the labels provided for *squeal* stimuli. "Excited," "coo," "pitch," and "squeak" were also common responses to *squeal* stimuli. "Squeal" was the most frequently occurring response at every infant age (except for 10 months where no *squeal* stimuli were presented to listeners). Accordingly, the term "squeal" appears to be mutually understood across trained and untrained listeners alike.

When the untrained listeners were presented with *growl* stimuli, "grunt," "growl," and "play" were the three highest yielded responses. This pattern of labels was largely consistent across infant age. "Grunt" was the most frequently occurring response at every infant age except 6 months, where "play" was tagged 8.5% more often and "growl" was tagged 4.7% more often. Some other labels generated for *growl* stimuli included "happy," "talk," "frustrated," "coo," "tired," "noise," and "cry."

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Table 2. Frequencies (counts) for each vocalization type of the top responses obtained from untrained listeners (caregivers) in the term generation task.

Vocalization type (total no. of terms generated across ages for vocalization type)	Untrained listener response	Total across all ages	Infant age in months								
			4	5	6	7	8	9	10	11	12
Vowel (2,030)	Coo	334	42	41	37	38	28	28	49	35	36
	Talk	271	36	22	34	40	21	20	37	31	30
	Happy	231	24	30	25	17	18	17	32	36	32
	Total	836	102	93	96	95	67	65	118	102	98
Squeal (1,260)	Squeal	337	33	31	22	39	67	45		37	63
	Happy	215	24	20	11	19	40	35		26	40
	High	72	10	5	4	12	13	11		7	10
	Total	624	67	56	37	70	120	91		70	113
Growl (1,190)	Grunt	203	19	19	5	34	26	10	30	34	26
	Growl	110	13	5	9	16	12	5	22	9	19
	Play	98	9	5	14	12	13	7	19	6	13
	Total	411	41	29	28	62	51	22	71	49	58
Raspberry (315)	Raspberry	40	3	4	2		8		6	17	0
	Spit	42	2	2	4		9		10	15	0
	Bubble	23	3	4	2		5		3	6	0
	Total	105	8	10	8		22		19	38	0
Whisper (245)	Whisper	43						19	14	3	7
	Talk	40						9	10	6	15
	Breath	21						13	3	1	4
	Total	104						41	27	10	26
Cry (875)	Cry	312	90	12	47	51	55	21			36
	Sad	131	32	4	17	31	23	13			11
	Upset	72	17	4	13	12	9	6			11
	Total	515	139	20	77	94	87	40			58
Laugh (805)	Laugh	271	25		32	25	43	18	22	39	67
	Happy	130	13		13	17	17	9	11	20	30
	Giggle	129	7		19	15	20	7	17	22	22
	Total	530	45		64	57	80	34	50	81	119

Note. Empty cells correspond with ages where no stimuli for the specific vocal type were presented to listeners.

The actual label "growl" appeared second most frequently to "grunt," suggesting it as a strong contender for describing low pitch/harsh quality infant vocalizations by untrained listeners.

Raspberry stimuli most frequently generated the labels "raspberry," "spit," and "bubble" (or some derivative of these tags, e.g., "spitting"). In total, these three responses accounted for 33.3% of all of the labels provided for *raspberry* stimuli. The pattern of labels generated for *raspberry* stimuli was largely consistent across all infant ages except 7 months, where "spit" and "bubble" were each tagged 2.9% more often, and 11 months, where "spit" was tagged 1.9% more often. Some other labels elicited for-*raspberry* stimuli included "play," "blow," "grunt," "fart," and "coo."

Whisper stimuli were presented to untrained listeners from only 9 to 12 months of infant age, as examples of whispers could not be found in the recordings from infants at 4 through 8 months of age. When untrained listeners were presented with *whisper* stimuli, "whisper," "talk," and "breath" (or some derivative of these tags, e.g., "talking" or "breathing") were the most frequently generated labels. In total, these three responses accounted for 42.5% of all of the labels generated for *whisper* stimuli. Other common responses included "babble," "coo," "quiet," "play," "noise," "mama," "soft," "sigh," "happy," and "content."

When untrained listeners were presented with *cry* stimuli, "cry," "sad," and "upset" (or some derivative of these tags, e.g., "crying") were the most frequently elicited labels. In total, these three responses accounted for 58.9% of all of the labels provided for *cry* stimuli. "Cry" was the most frequently occurring response at every infant age (except for 10 and 11 months where no *cry* stimuli were presented to listeners). Accordingly, the term "cry" appears to be mutually understood across trained and untrained listeners alike. Other tags elicited in response to *cry* stimuli included "tired," "mad," "hurt," "angry," "hungry," "frustrated," "unhappy," and "coo."

Laugh stimuli most frequently generated the labels "laugh," "happy," and "giggle" (or some derivative of these tags, such as "laughing"). In total, these three responses accounted for 65.1% of all of the labels provided for *laugh* stimuli. As with squeal and cry, the term "laugh" appears to be mutually understood across trained and untrained listeners alike. "Laugh" was the most frequently occurring response at every infant age (except for 5 months where no *laugh* stimuli were presented to listeners). Some other labels elicited for *laugh* stimuli included "coo," "play," and "chuckle."

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Table 3. Frequencies (counts) for each vocalization type from untrained listeners (caregivers) in the term identification task.

Listener term identification	Researcher determined vocalization type							
	Cry	Growl	Laugh	Raspberry	Squeal	Vowel	Whisper	Total
Angry	17	11	0	0	16	0	0	44
Babble	0	36	3	2	15	117	12	185
Blow	0	6	0	21	1	0	0	28
Breath	0	14	1	0	0	5	15	35
Bubble	0	4	0	36	0	1	0	41
Chuckle	6	2	36	0	0	1	0	45
Content	0	22	3	1	7	133	4	170
Coo	0	14	0	5	14	137	2	172
Cry	***89***	6	4	0	16	10	0	125
Excited	4	32	9	0	64	27	0	136
Fart	0	5	1	31	0	1	0	38
Frustrated	50	34	1	0	58	24	0	167
Giggle	6	2	103	0	4	2	0	117
Growl	1	***83***	0	0	0	1	0	85
Grunt	2	190	15	0	3	35	0	245
Happy	4	27	32	1	39	65	2	170
High	0	0	0	0	13	2	1	16
Hungry	22	8	3	0	5	20	0	58
Hurt	36	2	0	0	2	1	0	41
Laugh	4	2	***87***	0	3	3	0	99
Mad	23	6	0	0	12	0	0	41
Mama	2	0	0	0	0	2	1	5
Noise	3	22	3	1	19	103	10	161
Pitch	1	0	0	0	24	3	0	28
Play	2	38	6	0	18	35	2	101
Quiet	0	2	0	0	0	7	15	24
Raspberry	0	2	0	***59***	0	0	0	61
Sad	34	6	3	0	8	17	0	68
Sigh	0	6	0	0	6	52	6	70
Soft	0	1	0	0	0	25	8	34
Spit	0	4	0	35	0	2	1	42
Squeak	0	0	0	0	62	1	0	63
Squeal	2	2	0	0	***243***	5	0	252
Talk	5	47	0	0	20	219	31	322
Tired	18	17	4	0	17	55	0	111
Unhappy	74	12	2	0	22	39	0	149
Upset	118	19	8	0	33	12	0	190
Vowel	1	2	0	0	0	***9***	1	13
Whisper	0	0	0	0	0	0	***33***	33
[a]Error	4	0	0	0	0	5	0	9
TOTAL	528	686	324	192	744	1176	144	

Note. Numbers presented in bold and italics represent a direct correspondence between listener term identification and vocalization type (e.g., the number of times "cry" was used to label *cries*).

[a]*Error* refers to technical difficulties in audio presentation, when the vocal stimuli did not play (for unknown reasons) when presented to the listener.

The most frequently generated terms to describe each unique infant vocalization (given clinician/researcher classification of vowel, squeal, growl, raspberry, whisper, cry, and laugh) were included on a list presented to untrained listeners in the "term identification" task. The list included the following 39 terms: squeak, growl, grunt, play, frustrated, cry, raspberry, spit, bubble, blow, fart, whisper, breath, quiet, mama, soft, sad, upset, mad, hurt, angry, hungry, unhappy, laugh, giggle, chuckle, vowel, coo, talk, happy, tired, content, babble, noise, sigh, squeal, high, excited, and pitch. This list was presented to listeners in the "term identification" task in print in four random orders, and reviewed with each participant before beginning the study.

Term Identification Task

When listeners viewed the list of words from the "term generation" task, and selected terms they felt best described presented vocalizations, some overlap was observed between untrained caregivers' labeling of sounds when compared to terms used by clinicians and researchers to describe infant vocalizations. Specifically, when looking only at the clinician/researcher-classified vocalization types (cries, growls, laughs, raspberries, squeals, vowels, and whispers) and how often the untrained listeners used these exact terms in labeling said sounds, there was a high degree of match. For example, given options of cry, growl, laugh, raspberry, squeal, vowel, and whisper, clinician/

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researcher-classified *cries* were labeled "cry" by the untrained listeners most frequently, *growls* as "growl," *laughs* as "laugh," and so on, as demonstrated by numbers that have been highlighted via bolding and italics in Table 3.

When examining the most frequently used labels by caregivers across all response options (as opposed to across only clinician/researcher-classified vocal types), differences between listener responses and the researcher-determined terms were present. In fact, there was correspondence only 6.3% of the time. *Cries* were labeled by listeners most often as "upset" (22% of the time), "cry" (17%), and "unhappy" (14%). *Growls* were described by caregivers as "grunt" (in 28% of presentations), "growl" (12%), and "talk" (7%). *Laughs* were labeled as "giggle" (32%), "laughs" (27%), and "chuckle" (11%). *Raspberries* were labeled as "raspberry" (31%), "bubble" (19%), and "spit" (18%). *Squeals* were labeled as "squeal" (33%), "excited" (9%), and "squeak" (8%). *Vowels* were labeled "talk" (19%), "coo" (12%), and "content" (11%). *Whispers* were labeled as "whispers" (23% of the time), "talk" (22%), and "quiet" and "breath" (each 10%).

The terms "talk," "squeal," "grunt," "upset," "babble," "coo," and "content" were used most frequently throughout the study. "Talk" was used 8% of the time, "squeal" 7% of the time, "grunt" 6% of the time, "upset" 5% of the time, "babble" 5% of the time, "coo" 5% of the time, and "content" in 4% of trials. Of the most frequently used terms, "talk," "babble," "coo," and "content" were all mostly descriptions provided by the untrained listeners to label clinician/researcher-classified *vowels*. Given that *vowels* were presented more than any other vocalization type in this study (49 of the total 192 utterances), this may explain the reason for frequency of these labels. "Squeal" was most often used to label clinician/researcher-classified *squeal* stimuli, and "grunts" were used most often to label clinician/researcher-classified *growl* stimuli. As previously stated, "upset" was used to describe *cry* stimuli.

All of the terms on the term generation list were selected by listeners at least once throughout the term identification task. Of the available choices, "mama," "vowel," and "high" were the three terms used least frequently—each of them used less than 1% of the time. "Mama" was used in 0.13% of opportunities to label *cry, vowel,* and *whisper* vocalization types. "Vowel" was used to describe *cry, growl, vowel,* and *whisper* vocalizations in only 0.34% of trials. "High" was used to label *squeals, vowels,* and *whispers* 0.42% of the time.

Discussion

In an attempt to enhance communication between researchers, clinicians, and caregivers, the purpose of this study was to determine how untrained caregivers describe clinician/researcher-classified *vowel, growl, raspberry, squeal, cry,* and *laugh* vocalizations produced by infants from 4 to 12 months of age. Findings indicated that, although caregivers may not use the same terms that clinicians/researchers use upon first instinct, when they do use these terms, they are using them in a similar manner to clinicians/researchers. Additionally, it appears that untrained listeners prefer to label vocalizations by attempting to interpret the meaning or emotion behind each presented sound. For example, *cry* stimuli were most often classified by caregivers as "upset," "unhappy," and "frustrated." It is important to recognize that while assigning emotional meaning to utterances, the top-provided responses for *cry* carry a negative connotation, which is consistent with how *cry* vocalizations are interpreted across settings. Several participants stated that they wished they could combine two terms off the term generation list for their response (e.g., "hungry cry" or "tired cry"). Others stated that a supplemental video footage would be helpful because they "couldn't tell if the sound was happy or sad without seeing the infant's face." Similar trends were observed in response to *squeal* stimuli, labeled as "excited" or "frustrated." *Whispers, raspberries, growls,* and *laughs* received more concrete, action-type descriptors. For example, *whisper* stimuli were often labeled "whisper" or "talk;" *raspberry* stimuli were labeled "spit," "blow," or "fart;" *growl* stimuli were labeled "grunt," "growl," or "talk;" and *laugh* stimuli were labeled "giggle," "laugh," or "chuckle." *Vowel* stimuli received a combination of emotion- and action-type labels by untrained listeners, such as "talk," "coo," and "content."

The most common words used per vocal type were "upset" for *cries,* "grunt" for *growls,* "giggle" for *laughs,* "raspberry" for *raspberries,* "squeal" for *squeals,* "talk" for *vowels,* and "whisper" for *whispers*. Although all labels provided by caregivers were not the same as the clinician/researcher-classified terms, the terminology offered by the caregivers was similar. For example, the terms "upset" and "cry" are not the same, but they are similar to one another and represent comparable behavioral states. This was also the case for the terms "grunt" and "growl," as well as "giggle" and "laugh." Overall, although the terms provided by the untrained listeners differed slightly from clinician/researcher classification, we can conclude that caregivers are using labels that have the same (or similar) meanings to the clinician/researcher-classified words.

One of the most interesting findings of this study is in relation to vowels. Of infant vocalizations sound types presented to listeners, vowels made up 30% of the stimuli; the 10 infants from this study produced substantially more *vowels* when compared to other vocal types. Although vowels were the most dominant vocal type presented to listeners, clinician/researcher-classified "vowel" was chosen as the descriptor by untrained listeners in only nine, or less than 1%, of those presentations. *Vowels* were classified by untrained listeners with the most variability across sound types. For example, vowels were described using 35 different labels from the presented list of terms, whereas vocal types such as *raspberries* and *whispers* were described using only 10 and 16 different labels respectively. This demonstrates a discrepancy between clinician/researcher use of the term *vowel* and the way caregivers label *vowels*. This is a critical discrepancy to consider because the term *vowel* is

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used widely in the field of speech-language pathology by clinicians and researchers alike. In contrast, untrained listeners classified *vowels* most often as "talk," "coo," and "content."

Perhaps the discrepancy between caregiver and clinician/researcher-classified *vowel* stimuli highlights a historical trend in the field of speech-language pathology. Although the term *vowel* is used widely by clinicians and researchers, acquisition of vowels is an area of phonemic development that has been historically neglected (Davis & MacNeilage, 1990). Vowel-like sounds are among the earliest produced because the ability to phonate is a skill infants begin to acquire at birth, long before learning to articulate precise supraglottal vocal tract movements for consonant productions (Oller, 2000). The speech production characteristics (articulatory features) of vowels are more difficult to describe than the articulation of consonants given the relative lack of constriction of the vocal tract for vowel production. There is limited to no contact between the articulators during vowel production. Accordingly, vowels and consonants have different systems for describing their articulatory features. Moreover, there is inadequate sampling of vowels on standardized tests (Pollock, 1991). Still, vowels cannot be neglected, particularly since they dominate early productions.

In this study, we followed prior research methodology for classifying infant phonation types; *vowel* (sometimes also termed "vocant") was used to characterize all sounds produced with normal phonation (not unusually high pitched or in loft register, and not unusually low pitched or rough in vocal quality), regardless of whether or not supraglottal vocal tract articulations (including consonant constrictions) occurred. In the sample of *vowel* stimuli, there were vowels that included consonant-like articulation, although many did not. It may be that within the *vowel* category, untrained caregivers naturally reacted to the types of supraglottal vocal tract articulation present. Perhaps "talk" was used to describe sounds that included combinations of vowel- and consonant-like articulations, whereas "coo" and "content" were used to describe more primitive vocalizations that did not contain adultlike consonants. Still, even vowel-only sounds were not described as "vowels" by listeners, but instead they were described with other terms such as "coo" and "content," which indicates that "vowel" is not a term that untrained caregivers feel natural using.

As infants develop more speech production capabilities (the ability to fully articulate consonants and produce timely transitions between consonants and vowels in canonical syllables, etc.), it is important to note that less language growth is seen in children with more vowel-like babbling. Moreover, ASD has been associated with proportionally more atypical phonation (Sheinkopf et al., 2000). Clearly, it will be imperative to identify a way for clinicians/researchers to communicate with caregivers about vowels versus consonants and about different phonatory qualities, to effectively identify children in need of intervention at earlier ages. The present research suggests that using the term "vowel" without providing a clear and accessible definition and/or examples might be problematic when communicating with caregivers.

Given the labels most often generated/identified by untrained listeners to describe each vocal type, and the similarity of the labels to clinician/researcher-classified terms, we, as researchers and clinicians, can consider how best to communicate with caregivers about infant vocalizations. It is appropriate to refer to *cry* vocalizations with untrained listeners as "cries." Although *cries* were most often labeled by parents as "upset," the semantic proximity of the terms "cry" and "upset" is not likely to result in miscommunication between clinicians and caregivers. Likewise, it is appropriate to refer to *growl* vocalizations with untrained listeners as "growls," given its similarity to the most frequently used caregiver term "grunt." The term "growl" is deemed more transparent than "grunt," because use of the term "grunt" could result in confusion between "growl grunts" and "vegetative grunts." *Laugh* vocalizations can be referred to as "laughs," again, given its semantic proximity to the most frequent untrained listener label of *laughs* as "giggle." Many individuals use the terms "giggle" and "laugh" interchangeably. *Raspberry* vocalizations were most often classified by untrained listeners as "raspberry," and therefore, "raspberry" is the best term to describe this vocal type. Similarly, *squeal* and *whisper* vocalizations were labeled by caregivers most often as "squeal" and "whisper," respectively, and therefore, "squeal" and "whisper" are the most fitting terms to use when communicating about *squeals* and *whispers*.

Vowel sound types, which had the most variety in terms of descriptors offered by untrained listeners, may best be referred to as "coo" sounds. Although "talk" was the most frequently used term to describe *vowel* sounds, using "talk" in discussing *vowel* productions with caregivers could result in miscommunication because "talk" was also regularly used to describe other vocal types ("talk" was tagged 322 times by untrained listeners to describe five different vocal types, including *cries, growls, squeals, vowels,* and *whispers*). "Coo" was the second most frequently used label to classify *vowel* productions. However, given the issues surrounding classification of *vowel* stimuli presented above, clinicians and researchers need to realize the potential for confusion when discussing commonly occurring vowel-like vocalizations in infancy, and may want to be ready to probe using a variety of related terms, such as those generated/identified in this study ("babble," "coo," "noise," etc.). It may also be appropriate to describe and provide examples of vowel sounds when talking with parents to enhance understanding and avoid miscommunication.

Clinical Implications

The results of this study tell us that clinicians, researchers, and caregivers are generally describing infant vocalizations in the same manner. Although some differences were observed, we can conclude that the terms

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caregivers offer most often hold the same meaning as clinician/researcher-generated terms. Since we know that caregivers are using the clinician/researcher-classified words appropriately when they do use them, we can accurately probe parents and provide multiple-choice options during the assessment process if needed, and expect to get accurate descriptions of their baby's vocalizations in response. Now, we know that untrained listeners prefer to label some sound types more emotionally rather than by the type of sound produced, and can use this information to increase accuracy in both assessment and treatment. For example, if a caregiver describes an infant utterance as "upset" or "unhappy," we can ask more clarifying questions to determine if the infant exhibited a *cry* vocalization. Or if a caregiver describes a sound as "excited," we can clarify whether the term "squeal" would also apply.

We do not know whether the onset and frequency of these precanonical sound source–focused vocalization types will be as useful as the onset and frequency of canonical syllables are for early identification of infants at risk for speech-language development difficulties. However, our finding that these precanonical infant vocalization types are readily identifiable by caregivers suggests that they are of communicative importance and justifies continued future clinical (and basic) research on these sounds.

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