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UNIVERSITY OF CALIFORNIA, MERCED

Learning about Objects from Interpersonal Verbal and Emotional Communication

A dissertation submitted in partial fulfillment of the requirements
for the degree of Doctor of Philosophy

in

Psychological Sciences

By

Lukas D. Lopez

Committee in charge:
Professor Eric A. Walle, Chair
Professor Rose M. Scott
Professor Heather Bortfeld

2021

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The Dissertation of Lukas D. Lopez is approved, and it is acceptable in quality and form
for publication on microfilm and electronically:

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2021

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- Lopez, L. D.**, Walle, E. A., Pretzer, G. M., & Warlaumont, A. S. (2020). Adult responses to infant prelinguistic vocalizations are associated with infant vocabulary: A home observation study. *PLoS one*, *15*, e0242232. [5-year IF = 2.740]
- Walle, E. A. & **Lopez, L. D.** (2020). Emotion Recognition & Understanding. In J. B. Benson (Ed.), *Encyclopedia of Infant and Early Childhood Development*. Elsevier: New York, NY.
- Lopez, L. D.**, Moorman, K., Schneider, S., Baker, M. N., Holbrook, C. (2019). Morality is relative: Anger, disgust and aggression as contingent responses to sibling versus stranger harm. *Emotion*. [5-year IF = 4.197]
- Pretzer, G. M., **Lopez, L. D.**, Walle, E. A., & Warlaumont, A. S. (2019). Infant-adult vocal interaction dynamics depend on infant vocal type, child-directedness of adult speech, and timeframe. *Infant Behavior and Development*, *57*, 101325. [5-year IF = 1.889]
- Reschke, P. J., Walle, E. A., Knothe, J. M., & **Lopez, L. D.** (2019). The influence of context on distinct facial expressions of disgust. *Emotion*, *19*, 365-370. [5-year IF = 4.197]
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Lopez, L. D., Reschke, P. J., Knothe, J. M., & Walle, E. A. (2017). Postural communication of emotion: perception of distinct poses for five discrete emotions. *Frontiers in Psychology*, 8, 710. [5-year IF = 2.129]

MANUSCRIPTS UNDER REVIEW/REVISION

Lopez, L. D., & Walle, E. A. (invited revision). Caregiver encouragement to act on objects is related with crawling infants' receptive language. *Developmental Psychology*. [5-year IF = 4.798]

Lopez, L. D., & Walle, E. A. (invited revision). Infants use emotion to infer intentionality from non-random sampling events. *Cognition and Emotion*. [5-year IF = 2.473]

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Lopez, L. D., & Walle, E. A. (in prep). Learning about objects in infancy: The role of emotional communication.

Lopez, L. D., & Walle, E. A. (in prep). Pedagogy in emotions: Towards discrete affective social learning.

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RESEARCH IN PROGRESS

- Appraisals, discrete emotions, and moral judgements
- The role of pedagogical cues and discrete emotions in cultural learning
- Infant use of statistical information and emotional communication to infer intentions
- Infant use of discrete emotions for word learning
- Infant directed speech pragmatics in naturalistic home interactions
- The effect of face, posture, and context on emotional recognition

DATASETS

Warlaumont, A. S., Pretzer, G. M., Walle, E. A., Mendoza, S., & **Lopez, L. D.**, (2016). Warlaumont homebank corpus.

ORGANIZED CONFERENCE SYMPOSIA

Lopez, L. D. & Walle, E. A. (2018, July). The dyadic nature of learning: Contingent parent responses influence infant attention and language. Biennial Meeting of the International Congress on Infant Studies in Philadelphia, Pennsylvania.

CONFERENCE TALKS

Lopez, L. D. & Walle, E. A. (2021, April). Push it! Encouraging crawling infants to act on objects relates to increased receptive vocabulary. Paper presented at the Society of Research in Child Development Biennial Conference.

Lopez, L. D., Walle, E. A., & Campos J. J. (2020, July). The association of infant locomotor status and caregiver action directives with infant vocabulary. Paper presented at the International Congress of Infant Studies, Glasgow, Scotland. (Conference canceled).

Lopez, L. D. & Walle, E. A. (2019, July). Infant appreciation of emotion when attributing preferences from non-random sampling events. Paper presented at the International Society for Research on Emotion Conference, Amsterdam, Netherlands.

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Reschke, P. J., Knothe, J. M., **Lopez, L. D.**, & Walle, E. A. (2018, April). The influence of context on distinct facial expressions of disgust. Poster presented at the Society for Affective Science, Los Angeles, CA.

Reschke, P. J., Walle, E. A., Knothe, J. M., & **Lopez, L. D.** (2017, July). Putting 'context' in context: The effects of body posture and emotion scene on adult categorization of disgust facial expressions. Paper presented at the International Society for Research on Emotion Conference, St. Louis, Missouri.

Walle, E. A., **Lopez, L. D.**, Johal, J., Pretzer, G. M., & Warlaumont, A. S. (2017,

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Walle, E. A., Campos, J. J., **Lopez, L. D.**, Johal, J., Reschke, P. J., & Knothe, J. M. (2016, May). Crawling and walking infants' gaze following: Relations with parent-infant joint engagement. Paper presented at the Biennial Meeting of the International Congress on Infant Studies, New Orleans, Louisiana.

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Lopez, L. D. & Walle, E. A. (2021, April). Eww, you want that one? Toddlers use emotion to infer intentionality from non-random sampling events. Poster presented at the Society of Research in Child Development Biennial Conference.

Castillo, A., **Lopez, L. D.**, Gilger, J. (2020, January). Exploring socio-emotional differences between monolingual and bilingual children with Autism Spectrum Disorders. Poster presented at the University of California Center for Research on Special Education, Disabilities, and Developmental Risk (SPEDDR) conference, Los Angeles, CA.

Lopez, L. D., Reschke, P. J., Knothe, J. M., & Walle, E. A. (2017, July). Postural communication of emotion: Validation of distinct poses for five discrete emotions. Poster presented at the International Society for Research on Emotion Conference, St. Louis, Missouri.

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- Lopez, L. D., (2019). Emotions teach too: Discrete emotions affect preference attributions and attention. Talk presented at the UC Merced Psychological Sciences Colloquium Series, Merced, CA.
- Lopez, L. D., (2018). Crawling and walking infants' home language environments. Talk presented at the UC Merced Psychological Sciences Colloquium Series, Merced, CA.
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Abstract

Interpersonal communication provides information about objects in the environment. Usually studied in the context of word learning, social-attentional cues and word-to-world timing contingencies during infants' object engagement facilitate learning the words for referents. However, the role of emotional communication in such processes is understudied. This dissertation presents three studies that assess the impact of caregivers' verbal and emotional communication on infants' word and object learning. Study 1 examined the effect of caregivers' verbal pragmatics on 13-month-old crawling and walking infants' word learning. The results indicated that caregivers' verbal encouragement to act on objects related with crawling infants' word learning. Study 2 investigated the role of emotions on 2-year-olds' inferences of intentionality from non-random sampling events. Findings indicated that 2-year-olds inferred that an agent could intentionally select a preferred or undesired object from a sample as a function of the discrete emotion expressed. Study 3 examined the influence of discrete emotions on 2-year-olds' word learning and attention to objects. Results suggested that discrete emotions may not affect word-object learning but could influence young learners' attention to objects and agents. Taken together, these findings demonstrate that interpersonal verbal and emotional communication affects learning about objects early in development.

Chapter 1

Verbal and emotional communication provides information about specific objects in the environment. This is crucial when considering that the world presents young learners with innumerable objects and possible words for objects daily. Extracting referential intent (i.e., the object an agent is referring to) from this abundance of statistical information has been a perennial hurdle for word-object learning (Quine, 1960). Yet, recent theoretical advancements have shown that referential intent is clarified by social-attentional cues and word-to-world timing contingencies during object engagement (Gleitman & Trueswell, 2020). Although emotions are powerful social-attentional cues that signal individuals' significant relationships with the environment (Walle & Lopez, 2020), the role of emotions in such interpersonal processes remains understudied. Chapter 1 discusses the role of emotional communication in processes that facilitate determining referential intent and learning about objects. Specifically, I consider how emotions are at the core of the dyadic exchanges that underlie the following of social cues in infancy. Then, I discuss the similarities between caregivers' contingent verbal and emotional responses to infants' actions. Finally, I hypothesize how discrete emotions, and their corresponding distinct action tendencies (Frijda, 1986), may alter infants' learning about objects.

Early Emotion Contingencies Scaffold Social-Attentional Cuing

Emotions are integral for infants' use of social-attentional cues, such as gaze following and attention sharing, which are well known predictors of word learning (Brook & Meltzoff, 2008; Tomasello, 1988). Emerging at the end of the first year of life, the ability to follow social-attentional cues bridge the two sources of information infants need for linking words to objects: object perception and contingent caregiver verbal feedback. In fact, gaze following is a natural cue to referential intent since it allows infants to follow caregivers' attention to specific objects in the environment (Triesch et al., 2006). Moreover, shared attention episodes have been considered 'hotspots' for word-object learning because they allow caregivers' to direct infants' attention toward relevant objects and object properties while providing corresponding verbal labels contingent upon infants' attention (Bigelow et al., 2004). Consequently, gaze following and attention sharing promote infants' word-object learning by clarifying referential intent.

Emotional exchanges are foundational for gaze following and attention sharing. It is well known that by 2 months of age infants have a strong preference for contingent face-to-face interactions with caregivers (Trevarthen, 1979). Before infants are linguistically competent, these dyadic 'protoconversations' are rooted in contingent exchanges of emotional expressions and infants will emotionally protest if contingencies are broken (Trevarthen, 1979). Tomasello (2005) describes these emotion laden protoconversations as a fundamental prerequisite for gaze following and attention sharing. He explains that these early emotional exchanges develop into infants' "checking-in" or referring to the caregiver's attentional state when acting on the environment, which is a necessary component of utilizing social-attentional cues (Tomasello, 2005). Accordingly, early dyadic emotional exchanges underpin infants following social-attentional cues, which promote word-object learning.

When considering infants' early visual tendencies, emotion exchanges may tether infants back to caregivers' social-attentional cues during object exploration. Taking the

ego-centric view of 3-month-old infants has shown that they are drawn to visually rewarding salient objects (Triesch et al., 2006; Deak et al., 2014). Once infants become more adept at handling objects at 6 months of age, they decouple their sensory-motor modalities allowing them to attend to objects that they handle themselves as well as those manipulated by the caregiver (de Barbaro et al., 2016). Certainly, visuo-haptic decoupling, wherein infants can visually and physically engage with different objects, is a prerequisite for utilizing social-attentional cues. However, if infants are merely drawn to salient objects, then why do they check-in with the caregiver at all? It could be that caregivers' attention is a cue for the presence of a salient object (Triesch et al., 2006), but the answer is likely related to infants' emotional bonding with caregivers. Indeed, attachment between infant-caregiver dyads is indexed by infants' checking-in behaviors while exploring the environment (Ainsworth, 1979) and the act of checking-in is central to the construct of social referencing, wherein infants use caregivers' emotions to disambiguate the significance of a referent and modify their behavior accordingly (Walle, Reschke, & Knothe, 2017). Therefore, aside from early emotion exchanges being foundational for using social-attentional cues, they also act as a base for receiving contingent responses during infants' object engagement.

Infant Ability Drives Contingent Verbal and Emotional Responses

Infants' sensory-motor abilities prompt contingent caregiver verbal and emotional feedback, which is crucial for learning about objects. Infants' visuo-haptic engagement with objects at 9 months of age predicts future language outcomes, over and above sharing attention with objects and caregivers (Pereira et al., 2014; Slone et al., 2019; Yu et al., 2019). Yet, contingent caregiver verbal responses are necessary. Caregiver naming instances that are contingent upon infants' object-directed actions promote sustained visuo-haptic object engagement and maximize the likelihood of infants learning the word for the object (Gleitman & Trueswell, 2020; McQuillan et al., 2019; Suanda et al., 2019). This is because caregivers' verbal responses that occur when infants are engaged with an object create a tight temporal coupling, or word-to-world timing, between the word and referent (Gleitman & Trueswell, 2020). As infants age and their abilities develop, they begin to elicit these optimal word-to-world coupled verbal responses from caregivers with their object-directed vocalizations (Goldstein et al., 2010) and actions (Chang et al., 2016). For instance, when infants begin to walk, they initiate more object-directed actions (Karasik et al., 2011), receive more contingent object-directed verbal feedback (Karasik et al., 2014), and correspondingly know more words than their same-age crawling peers (Walle & Campos, 2014). Hence, infants' sensory-motor abilities naturally spur the contingencies necessary to learn words and about objects.

Infants' sensory-motor development also results in an increased propensity of emotional responses from caregivers. The transition to crawling has been considered the 'cradle' of social referencing since it is only after the onset of crawling that infants typically seek out emotional signals to disambiguate distal referents (Campos et al., 2000). Likewise, infants also receive more prohibitions accompanied with negative emotions after crawling and walking onsets due to their increased ability to act on prohibited objects (Biringen et al., 1995; Campos et al., 2000). This initiates a cycle wherein infants increasingly socially refer to caregivers before acting on objects in anticipation of a negative emotion prohibition and will emotionally protest themselves

upon receiving a prohibition (Biringen et al., 1995; Campos et al., 2000). Because deciphering referential intent involves associating a word or action with an object, emotional responses to infants' object-directed actions may lead to increased referential clarity. For example, consider an infant who has never encountered dog food. Upon grabbing dog food, their caregiver may contingently respond with a negative emotion prohibition and a verbal label such as, "no touching dog food!". Because the contingent response occurs tightly coupled with the infant's visuo-haptic engagement with the dog food, the infant is likely to learn the word-to-world matching for dog food. However, the role of the accompanied emotional response for word learning is less known. Since emotions arise from individuals' significant relationships with the environment, they may increase infants' memory of valuable word-object associations. Similarly, infants may associate their object-directed action with the subsequent emotional response they received. For instance, if the infant were to socially refer to the caregiver before acting on dog food again in the future, it may be because of the association between touching dog food and receiving a negative emotional response from the caregiver. Thus, contingent emotional responses may help to clarify referential intent and learning about objects.

Discrete Emotions Effect on Determining Referential Intent

The process of inferring referential intent and associating objects with words and emotional responses likely depends on the discrete emotion originally expressed. This is because emotions motivate distinct action tendencies (Frijda, 1986) and emotion to action links manifest in caregivers' prohibitions. Caregivers report expressing fear when vocally and physically prohibiting infants from engaging with dangerous stimuli (Dahl & Campos, 2013), in line with the function of fear to avoid aversive threats (Cosmides & Tooby, 2000). Conversely, caregivers' anger corresponds with physical restraint and verbal reasoning to deter their infant's unwanted behaviors (Dahl & Campos, 2013), congruent with anger's function of enforcing values (Cosmides & Tooby, 2000) and the tendency for angry prohibitions to result in a 'testing of wills' between infants and caregivers (Biringen et al., 1995). This functional distinction can also be observed in infants' behavioral responses and attention allocation when socially referring to fear and anger expressions, as well. Fear prompts object avoidance (Camras & Sachs, 1991; de Rosnay et al., 2003; Klinnert et al., 1986; Mumme & Fernald, 2003; Walle, Reschke, Camras, et al., 2017) and increases infants' attention to the threatening referent (Hoehl, 2014; LoBue & Rakison, 2013). Anger, on the other hand, results in object avoidance only in the presence of the angry adult (Repacholi & Meltzoff, 2007; Repacholi et al., 2016; Repacholi et al., 2008) and increases infants' attention to the adult (Hoehl, 2014). These results suggest that infants link discrete emotions with caregivers' likely responses to their object-directed actions. For instance, infants may increase their attention to objects that were previously prohibited with fear to monitor the aversive referent but increase their social referencing to caregivers before acting on objects previously prohibited with anger in anticipation of caregivers' next angry intervention.

Further support of infants linking their object-directed actions to caregivers' emotional responses can be seen in their behavioral responses and attentional allocation when socially referring to disgust and sadness (see Walle & Campos, 2012 for a summary). Like fear, disgust elicits object avoidance (Hornik et al., 1987; Schieler et al.,

2018; Walle et al., 2017) and increases infants' attention to aversive stimuli (LoBue & Rakison, 2013). Yet, unlike seeking security to avoid fear inducing referents, disgust elicits increased information seeking (Walle, Reschke, Camras, et al., 2017) and visual examination of the stimulus in infants (Repacholi, 1998). These findings are consistent with the functional distinction between fear, which motivates rapid responses to avoid common threats, and disgust, which elicits the calculated avoidance of contaminated referents (Cosmides & Tooby, 2000). On the other hand, like anger, sadness increases infants' attention to the adult (Zahn-Waxler et al., 1992). However, unlike responding to anger by monitoring the adult to anticipate their next direct intervention (e.g., Repacholi & Meltzoff, 2007), sadness prompts infants' prosocial responses to alleviate caregiver distress (Zahn-Waxler et al., 1992). Taken together, infants link discrete emotions to caregivers' functional responses. Anger and sadness evoke more attention and actions towards caregivers so infants can anticipate the next angry intervention and alleviate distress, respectively. Meanwhile, fear and disgust elicit more attention and actions in relation to the referent so infants can monitor and comprehend the threat. These results suggest that infants attend to the *most* significant aspect of the environment associated with caregivers' functional and contingent discrete emotion reactions.

Whether the influence of discrete emotions on infants' attention, behaviors, and anticipation of caregivers' interventions affects their understanding of referential intent and word-object learning is an empirical question worthy of further investigation. Emotions may generally enhance referential intent inferences and word learning because they signal individuals' significant relations with referents in the environment. Yet, discrete emotions shift infants' attention and behaviors to referents based on the *most* significant environmental entity in each context, i.e., caregivers in anger and sadness contexts and referents in fear and disgust contexts (see Knothe & Walle, 2019). It is possible that the increased significance placed on referents from fear and disgust emotional communication compared to the emphasis on caregivers for anger and sadness emotional communication influences referential intent inferences and word learning. Chapter 3 and Chapter 4 provide preliminary tests of this hypothesis.

Current Studies

This dissertation presents three studies that assessed the impact of caregivers' verbal and emotional communication on infants' understanding of referential intent and word learning. Chapter 2 assessed how caregivers' encouragement to act on objects related with crawling and walking infants' language development. Chapter 3 investigated whether infants inferred intentionality from an adult's non-random sampling selections that corresponded with discrete emotion communication. Chapter 4 examined whether discrete emotions affected infants' visual attention to objects and agents and subsequent word-object learning. Together, these studies expand our knowledge of the impact of verbal and emotional communication on infants' understanding of referential intent and word learning.

Chapter 2

Chapter Abstract

This study assessed how caregivers' verbal behaviors related to crawling and walking infants' object-directed actions associated with their word learning. We present findings from day-long home audio recordings (Study 1) and laboratory observations (Study 2) of same-aged crawling and walking infants to explore how caregiver language, specifically action directives that encourage infants' independent actions on objects (i.e., outside of joint attention episodes), were associated with parent reported infant vocabulary size. Findings in both studies indicated that caregiver action directives were associated with crawling, but not walking, infants' receptive vocabulary sizes. Specifically, action directives related to infant object manipulations associated with higher receptive vocabulary scores for crawling infants, but the same pattern was not evinced in walking infants. Taken together, these studies demonstrate that caregiver social engagement specific to infant motoric constraints relates with infant language learning.

Introduction

The transition from crawling to walking in infancy initiates a developmental cascade that corresponds with changes across various developmental domains (Adolph & Robinson, 2013). A host of emerging literature has demonstrated that numerous aspects of infant-caregiver social interactions are affected by infant locomotor ability. The infant-caregiver dyad's physical positioning, ability to share and direct attention, and the language environment have all been associated with changes in infant locomotor development (Franchak et al., 2018; Karasik et al., 2014), and multiple studies have shown that parents report increases in infant receptive vocabulary size following the acquisition of walking independent of age and culture (He et al., 2016, Walle & Campos, 2014; West et al., 2017). Observational research also indicates that walking infants interact with more objects in their environment and are more likely to receive encouragement from caregivers to manipulate handled objects in comparison to crawlers (Karasik et al., 2011; Karasik et al., 2014). Since caregiver verbal feedback occurring when infants are engaged with objects has been shown to predict infant receptive vocabulary (Pereira et al., 2014), it is crucial to examine how caregiver speech related to object engagement contributes to crawling and walking infants' vocabulary. However, existing research has not yet assessed this question. The present study assessed how caregiver verbal input was related to same aged crawling and walking infants' attention, manipulation of objects, and receptive vocabulary size.

Infant Locomotion and Social Interaction

The onset of walking greatly changes the infant's social world. The ability to walk qualitatively increases infants' visual field, enabling the monitoring of distal objects and caregivers (Kretch et al., 2014). This perceptual advantage allows walking infants to better follow adult attention cues to objects and events in the environment (Franchak et al., 2011). Indeed, parents report more joint attention episodes with walking infants (Walle, 2016) and walking infants outperform same-aged crawling infants in following adult gaze (Walle et al., under revision). Walking also facilitates infants' ability to guide parent attention to referential objects (Karsik et al., 2011). Upright locomotion frees the hands, allowing walking infants to more easily access distal objects and bring them to

their caregiver in the form of mobile bids (Karasik et al., 2014). Such mobile bids for attention facilitate walking infants' driving of social interactions with their caregiver.

On the other hand, crawling infants can alleviate their perceptual disadvantage by eliciting caregiver attention from stationary positions (Franchak et al., 2018; Kretch et al., 2014). For example, although crawlers have more constrained visual fields than their walking counterparts while locomoting, they can bring objects and caregivers into their field of view by assuming sitting postures (Kretch et al., 2014). Utilizing sitting postures also allows crawling infants to more easily bid for caregiver attention. Specifically, unlike the increased mobile bids shown by walking infants, crawling infants are more likely to bid from a stationary position with proximal objects (Karasik et al., 2014).

Nonetheless, a successful infant bid, regardless of how it is preformed, necessitates a response from the caregiver in order to optimize language learning opportunities. Sensitive parenting behaviors that follow in on infant attentional focus and do not restrict infant actions are associated with infant cognitive and language outcomes (Carpenter et al., 1998; Landry et al., 1997). Thus, caregivers who are sensitive to their infant's motor abilities and modify their behaviors accordingly can scaffold their infant's development in other domains. However, it is unknown whether caregiver verbal input that is sensitive to infant locomotor abilities can propel infants' language outcomes.

Infant Locomotion and Caregiver Language

Prior research has found that walking infants hear less or similar amounts of adult verbal input in the home environment (Walle & Warlaumont, 2015) and lab settings (Walle & Campos, 2014) as same-aged crawling infants. However, these studies also found that caregiver language directed to walking infants was positively associated with their receptive vocabulary, a pattern not shown for crawling infants (Walle & Campos, 2014; Walle & Warlaumont, 2015). These findings suggest that the sheer *quantity* of adult verbal input may not be the best indicator of infant language outcomes. Rather, the nature of the verbal input that crawling and walking infants receive may be of greater importance.

Indeed, the nature of caregiver infant-directed speech (IDS) changes with infant age, progressing from primarily affirmations to an increased number of questions and descriptions after the infant's first birthday (Tamis-LeMonda et al., 2001). Interestingly, the end of the first year of life is also when infants typically begin to walk (Bayley, 1969) and receive differentiated responses based on their locomotor status (Adolph & Tamis-LeMonda, 2014). Karasik et al. (2014) found that caregivers were twice as likely to provide a verbal response to walking infant bids compared to those made by crawling infants. Moreover, of those responses, caregivers used more action directives (e.g., bring it here) to walking infants than to crawling infants as a function of the infant's increased use of mobile bids. These findings make intuitive sense given that action directives were coded as utterances that "encouraged infants' actions with the object or on the object" (p. 391, Karasik et al., 2014) and walking infants could presumably perform more object actions given their mobility. However, it remains to be studied whether the amount of caregiver action directives directed to crawling and walking infants are consistent for distinct subtypes of action directives, such as those relating to object manipulation or those used to orient the infant's attention and movement (e.g., look at this, come here), as

well as how such action directives differentially relate to crawling and walking infant language outcomes.

Although caregiver action directives have typically been associated with infant compliance and negative developmental outcomes (e.g., Hughes et al., 1998; Reddy et al., 2012), this caregiver verbal behavior can serve a variety of functions depending on the social and environmental context. Indeed, whereas intrusive action directives often request infant attention or movement away from objects and to the caregiver, sensitive action directives can actually promote the infant's ongoing actions on objects and thus facilitate learning (Deak et al., 2008; Lloyd & Masur, 2014). For instance, sensitive action directives elicited from infant object initiations promoted future language outcomes over those that redirected infant attention and movement (Lloyd & Masur, 2014; Newland et al., 2001). Hence, caregiver action directives can serve different functions that are associated with infant learning outcomes. However, how caregiver action directives relate with receptive language outcomes in crawling and walking infants remains understudied.

Current Study

This investigation examined various types of IDS (see Tamis-LaMonda et al., 2001) in two distinct samples of caregivers and their 13-month-old infants. In line with previous research (e.g., Karasik et al., 2014; Walle & Campos, 2014), we focused on 13-month-old infants because approximately half of each sample had begun walking while the other half were still crawling. Of particular interest was how caregiver action directives were associated with crawling and walking infant receptive vocabulary. Study 1 included day-long audio recordings of infant-caregiver interactions in the home environment. Study 2 used video observations of infant-caregiver dyads during a naturalistic freeplay session in the lab.

Our analyses were guided by 3 main hypotheses. First, in line with previous research (Karasik et al., 2004), we predicted that walking infants would receive more action directives than crawling infants in both Study 1 and in Study 2. Second, we hypothesized that action directives would be more impactful for crawling infants than walking infants. Specifically, since walking infants already receive more action directives (Karasik et al., 2014), encounter more objects in their environment (Karasik et al., 2011), and have higher receptive vocabulary scores (Walle & Campos, 2014), we predicted that action directives to crawling infants would compensate for their diminished object-directed feedback and be positively associated with their receptive vocabulary. Third, since action directives elicited from infants' independent object initiations promoted future language outcomes (Lloyd & Masur, 2014; Newland et al., 2001), we predicted that action directives during infants' independent object-directed actions, i.e., when the dyad was not already jointly engaged, would be specifically associated with crawling infants' receptive vocabulary. Because this hypothesis relies on the physical presence of objects and infant-caregiver attentional states, this hypothesis was only assessed in Study 2.

Study 1

Methods

Participants. A total of 48 infants were included in Study 1. An a priori power analysis determined that 48 subjects would provide power of .68 to detect a moderate effect size using a regression model with up to 6 predictors. Crawling infants ($n = 23$, 7 female; $M_{age} = 12.70$ months, $SD = 0.62$ months) had an average of 4.71 months ($SD = 2.15$ months) of crawling experience. Walking infants ($n = 25$, 13 female; $M_{age} = 12.81$ months, $SD = 0.50$ months) had an average of 6.30 months of crawling experience ($SD = 1.53$ months) and 1.98 months of walking experience ($SD = 1.36$ months). Crawling and walking infants did not significantly differ in age, $t(46) = -0.65$, $p = .52$. Infants were recruited from the California San Joaquin Valley from primarily English-speaking households (i.e., caregivers reported that English was spoken to the infant at least 50% of the day). Families had an average household income of \$61,000 ($SD = \$40,000$), the majority of caregivers either had a high school ($n = 15$) or college degree ($n = 16$), and the average family had 4 to 5 members ($M = 4.58$, Range = 3-9). Twenty-three caregivers reported their ethnicity as Caucasian, 18 as Latino, 3 as Asian, and 2 as Black. All infants were born full-term and had no prior diagnosis of developmental disorders or hearing impairment.

An additional 17 dyads were excluded from the sample because the primary language spoken in the home was Spanish (i.e., > 50% of the time, according to the caregiver estimates) and 30 were excluded because the recording did not meet specified requirements (see Sample selection for recording criteria). English language exposure did not differ between walking ($M = 95.28\%$, Range = 60-100%) and crawling ($M = 90.52\%$, Range = 60-100%) infants, $t(69) = -1.44$, $p = .16$.

Procedure. All procedures were approved by the Institutional Review Board at the University of California Merced. Samples selection procedures and IDS coding procedures were derived from a larger study (see Lopez et al., 2020 for more details). Each family received the study materials by postal mail or personal delivery to their home. The materials included a LENA recording device, a LENA vest to hold the recorder, and a set of questionnaires, including a demographic form, locomotor questionnaire, and the MacArthur-Bates Developmental Inventory: Words and Gestures (Fenson et al., 1994). Adults were instructed to put the vest on the infant, place the recorder inside, and record a typical day (e.g., no parties or special trips) of the child's language environment. The LENA device recorded up to 16 hours of audio and captured all infant vocalizations, nearby adult vocalizations, and other nearby environmental noises.

Locomotor questionnaire. Caregivers completed a locomotor questionnaire to indicate when their infant had achieved specific locomotor milestones. Walking onset was defined on the questionnaire as the date when the infant was able to bipedally locomote 10 feet without falling or needing support (Adolph et al., 2003). Previous research indicates high validity of parent reporting of infant motor milestones (see Bodnarchuk and Eaton, 2004).

MacArthur-Bates Long Form Vocabulary Checklist: Level I. Parents completed the English version of the MacArthur-Bates Long Form Vocabulary Checklist: Level I (MCDI) (Fenson et al., 1994). The MCDI is a 396-item checklist on which parents are instructed to mark words that their infant "understands" or "understands and says."

Parents were instructed to mark words that their infant “understands” or “understands and says” in another language as well. Reliability and validity for the MCDI is well documented (see Fenson et al., 2000) and has been shown to be comparable to in-lab evaluations (Bergelson & Swingley, 2015).

Sample selection. Caregivers were required to record 10-hours within a single day to help ensure that the samples were drawn from a range of contexts that the infant experienced over the course of one day. Recordings that were less than the 10-hour requirement were excluded.

The remaining audio recordings were first processed using the LENA Pro software (LENA; LENA Research Foundation, Boulder, Colorado, United States). LENA’s Automatic Data Extractor (ADEX) relies on the software’s sound source labels that identify the source of vocalizations (target infant, adult, other child, and overlap) and an internal clock to determine the number of infant vocalizations, adult vocalizations, and conversational turns (i.e., infant and adult vocalizations contingent upon one another within 5 s intervals) within 5-minute intervals. This automated processing was used to identify the 3 most voluble infant (i.e., containing the highest number of infant vocalizations) and 3 most voluble interactive (i.e., containing the highest number of conversational turns between the infant and caregiver) 5-minute segments from the infant’s recording. Each of the 6 segments were required to be separated by at least 15 minutes to ensure that the audio was selected from different times throughout the day (average of 1 sample replaced per infant). Further, an identifiable primary caregiver needed to be present (4 samples replaced overall) and English needed to be spoken for the majority of the segment (8 samples replaced overall) in order for a given segment to be included for coding.

IDS coding. A total of 30 minutes (six 5-minute samples) was hand-coded for each participant. For each 5-minute sample, adult vocalizations were marked by 5 primary coders using ELAN software (Wittenburg, et al., 2006). Reliability coding of infant and adult vocalization types was assessed using a random sample of 30% of participants coded by the first author, who was blind to the original coding.

Vocalizations made by the caregiver were first coded as either *infant-directed*, *other-directed* (i.e., speaking to another person who is not the target infant; ODS), or *unknown*. Research assistants were presented with examples of IDS versus ODS in training. Features typical of IDS were highlighted, such as elongated pitch, increased volume due to proximity to the recorder, and semantic information such as the addressing the infant by name. It has also been shown that utterance direction is most reliably coded by human coders (Bergelson et al., 2019). Caregiver direction codes demonstrated substantially great inter-rater agreement (percent agreement = 90.18%; $k = .80$; Landis and Koch, 1977). Next, the coders used a coding scheme based on Tamis-LaMonda et al. (2001) to categorize the *type* of each IDS caregiver vocalization (see Table 1). However, action directive subtypes were not coded in Study 1 because of the audio recorded nature of the observation. Any remaining Spanish IDS utterances in a given segment were coded by a Spanish speaking primary coder. These codes demonstrated substantial inter-rater agreement (percent agreement = 86.11%; $k = .64$ (Landis and Koch, 1977).

Table 1
IDS Type Codes

<i>Caregiver IDS types</i>	<i>Definition</i>	<i>Example</i>
Naming	Providing a label for an object	“That’s a ball”
Description	Explaining features of an object	“It’s big and red”
Question	Asking the infant a question	“Do you want down?”
Action Directive	Telling the infant to do something	“Give me that one”
Object related	Encouraging infant actions on an object	“Push it”
Attention related	Requesting infant attention	“Look here”
Movement related	Telling the infant to move oneself	“Come here”
Prohibition	Inhibiting the infant from acting	“Don’t touch that”
Imitation	Repeating an infant utterance	Saying “Ball” when the infant says, “Ba”
Affirmation/Other	Praising the infant or any other kind of language	“That’s a good job”

Results

Although we were most interested in action directives, we considered all of the various *IDS types* that caregivers used most prevalently in walking and crawling infants’ language environments. Analyses first compared crawling and walking infants’ receptive vocabulary size, total amount of IDS, and frequency of each IDS type. Next, we examined the correlations of the IDS codes with crawling and walking infants’ receptive vocabulary size. Lastly, hierarchical multiple regressions, guided by the correlational findings, tested associations of the IDS codes of interest and infant locomotor development with infant receptive vocabulary size. Each model controlled for the total number of IDS vocalizations, infant gender, and family socioeconomic status (i.e., a composite variable that added together caregivers’ ordinal score for income and education; SES) to ensure the findings were specific to the language environment.

Comparing crawling and walking infants’ receptive language and caregiver IDS. Crawling ($M = 99.39$, $SD = 70.55$) and walking ($M = 90.36$, $SD = 51.86$) infants’ receptive vocabulary scores did not significantly differ, $t(46) = 0.51$, $p = .61$. The total amount of IDS heard by crawling infants ($M = 120.45$, $SD = 67.59$) and walking infants ($M = 129.95$, $SD = 74.14$) also did not differ, $t(46) = -0.46$, $p = .65$. In line with previous

research, walking infants ($M = 13.29$, $SD = 12.75$) received more action directives from caregivers than crawling infants ($M = 6.83$, $SD = 6.20$), $t(46) = -2.17$, $p = .03$, 95% CI [-12.45, -0.47]. However, no differences were found between locomotor groups for amount of caregiver naming, descriptions, questions, prohibitions, imitations, and other IDS, $ps > .40$.

Locomotor status, IDS, and infant receptive vocabulary. Bivariate correlations examined associations of crawling and walking infants' receptive vocabulary size with frequency of caregiver IDS types. Caregiver action directives toward crawling infants was significantly correlated with crawling infants' receptive vocabulary size, $r(23) = .50$, $p = .01$, but not that of walking infants, $r(25) = -.12$, $p = .57$. No other significant correlations were present, $ps > .06$.

Hierarchical multiple regression further examined the above relations with infant receptive vocabulary (see Table 2). Step 1 included total IDS, SES, and infant gender as control variables, and Step 2 included locomotor status, action directives, and the Locomotor status x Action Directives interaction term. In Step 1, no significant effects were found for infant gender, $b = 1.46$, $p = .94$, caregiver socioeconomic status, $b = 5.69$, $p = .12$, or total amount of IDS, $b = 0.58$, $p = .47$. Interestingly, Step 2 indicated a significant main effect of caregiver action directives, $b = 66.21$, $p = .02$, CI [13.68, 118.74], as well as a significant Locomotor Status x Action Directives interaction, $b = -34.71$, $p = .02$, CI [-62.45, -6.98], but no main effect of infant locomotor status, $b = -20.99$, $p = .27$. Examination of the significant interaction and corresponding simple slopes revealed that crawling infants who received more caregiver action directives had larger receptive vocabularies, $p = .02$, but this effect was not present for walking infants, $p = .60$ (see Figure 1).

Table 2
*Multiple Regression with Infant Locomotor Status and Caregiver Action Directives
 Predicting Receptive Vocabulary*

	Receptive vocabulary	
	β	ΔR^2
Step 1		.08
SES	0.11	
Infant gender	0.01	
Total IDS	0.24	
Step 2		.13*
Infant locomotor status	-0.17	
Caregiver action directives	1.93*	
Infant Locomotor Status x Caregiver Action Directives	-1.86*	

Note. * = $p < .05$.

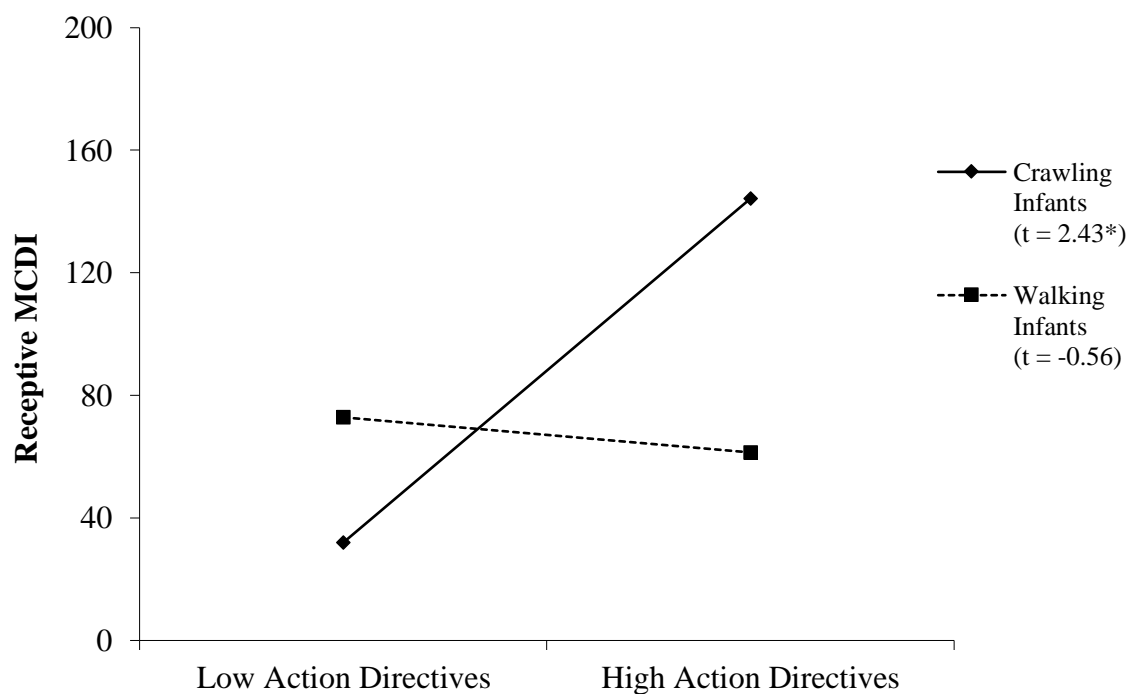


Figure 1. Infant receptive vocabulary for crawling and walking infants receiving low (-1 *SD* from the mean) and high (+1 *SD* from the mean) levels of action directives. Numbers in parentheses are unstandardized simple slopes. * = $p \leq .05$.

Discussion

The findings from Study 1 support and extend previous research. In line with our predictions, caregivers used more action directives with walking infants than crawling infants (Hypothesis 1), and novel to the present study, caregiver action directives were positively associated with crawling, but not walking, infants' receptive vocabulary size (Hypothesis 2). This finding may indicate that action directives that followed-in on crawling infant's object initiations were associated with infant receptive language (Lloyd & Masur, 2014; Newland et al., 2001). However, the nature of the audio recorded interactions in Study 1 limits our ability to make this determination. Thus, Study 2 utilized video recordings of infant-caregiver interactions to further explore these findings. Specifically, we tested our third hypothesis by examining whether caregiver action directives that followed-in on crawling infants' object-directed actions, i.e., occurring when the infant and caregiver were not jointly engaged, or those which were in coordination with caregiver attention, i.e., occurring when the dyad was jointly engaged, differentially predicted infant receptive language. The video observations also allowed us to categorize the distinct function of each action directive as related to infant object manipulation, infant attention, or infant physical movement.

Study 2

Methods

Participants. A total of 71 infants were included in Study 2. An a priori power analysis determined that 71 subjects would provide power of .74 to detect a moderate effect size using a regression model with up to 10 predictors. Crawling infants ($n = 28$, 15 female; $M_{age} = 12.68$ months, $SD = 0.36$ months) had an average of 3.50 months ($SD = 1.74$ months) of crawling experience. Walking infants ($n = 43$, 24 female; $M_{age} = 12.73$ months, $SD = 0.33$ months) had an average of 5.17 months of crawling experience ($SD = 1.46$ months) and 1.68 months of walking experience ($SD = 1.00$ months). Crawling and walking infants did not significantly differ in age, $t(69) = -0.61$, $p = .54$. Infants were recruited from families of the San Francisco Bay Area. Families had an average household income of \$100,000 ($SD = \$40,000$), a majority of caregivers had a college degree (range = some high school to graduate degree), and the average family had 3 to 4 members ($M = 4.58$, Range = 2-7). Caregiver reported ethnicity demonstrated that 53 caregivers identified as Caucasian, 10 as Asian, 4 as Latino, and 4 as Black. All infants were born full-term and had no prior diagnosis of developmental disorders or hearing impairment.

An additional 19 dyads were excluded from the sample because of experimenter error ($n = 7$), the caregiver spoke a language other than English ($n = 6$), they were missing MCDI data ($n = 4$), or multiple caregivers were present in the naturalistic observation ($n = 2$). English language exposure did not differ between walking ($M = 89.05\%$, Range = 60-100%) and crawling ($M = 91.93\%$, Range = 60-100%) infants, $t(69) = 0.85$, $p = .39$.

Procedures. The procedures were administered in the following set order: walking assessment, naturalistic observation, MacArthur-Bates Long Form Vocabulary Checklist: Level I (Fenson et al., 1994). All procedures were approved by the University of California Berkeley Committee for the Protection of Human Subjects.

Locomotor Assessment. A walking assessment based on the procedures used by Walle and Campos (2014) determined the locomotor status of each infant. Infants had one minute to cross a distance of 3m to the parent. Infants needed to successfully walk unsupported to the parent without falling on at least two of three trials to be classified as walking. Interrater agreement for the walking assessment was 100%.

Naturalistic Observation. Each infant-caregiver dyad was observed in a 5-minute naturalistic freeplay session. The observational space was approximately 10m x 10m, and contained a toy basket and other age-appropriate items (e.g., a shape sorter, pull toys, puppets). Parents were instructed to play normally with the infant. The experimenter began timing the 5 minutes after leaving the room. A remote live feed of the observation space allowed the researcher to monitor the dyad and intervene if necessary, though this never occurred.

Caregivers typically sat on the floor next to or behind the infant and engaged the infant with toys from the toy basket. Three high-definition video camcorders captured the freeplay space. One camera was hidden in front of the dyad above the toy basket to capture the majority of the interaction. The second and third cameras were located behind the dyad to capture movement in the room by the infant or parent. Audio from the

observations was recorded from the camcorders. Each observation was coded by a primary coder naïve to the hypotheses, and reliability was assessed by a secondary coder who reviewed 25% of the observations. The dyadic interaction was coded for the following:

Joint attention. A trained research assistant coded the frequency and duration of parent-infant social engagement. Based on variables described in Bakeman & Adamson (1984), joint attention (JA) was defined as the infant actively coordinating his/her visual attention with the caregiver and an object. The coding did not assess whether infant attention was coordinated to smaller object parts or was coordinated with infant reaching behaviors. Rather, the goal of the JA coding was to assess whether infants were receiving caregiver verbal input while acting alone or in visual coordination with the caregiver. A JA episode was identified when the infant and caregiver coordinated attention to an object for 3 seconds, with the onset of the episode beginning when the coordinated attention initially occurred. If the parent and infant became uncoordinated in their JA for longer than 3 seconds, the period ended, with the offset time occurring when the dyad first disengaged. Interrater reliability of JA coding was excellent ($r = .96$; $M_{\text{difference}} = 2.84$ seconds).

IDS coding. A trained research assistant applied the coding scheme from Study 1 to assess IDS types to the naturalistic observation. This scheme then further categorized caregiver action directives into mutually exclusive subtypes based on whether they referred to (see Table 1): infant object manipulations (as in Karasik et al., 2014; e.g., “put it here”), infant attention (similar to exploratory prompts in Tamis-Lamonda et al., 2002; e.g., “look here”), or infant physical movement (e.g., “come here”) (percent agreement = 90.62%; $k = .71$; Landis and Koch, 1977).

MacArthur-Bates Long Form Vocabulary Checklist: Level I. Parents completed the MacArthur-Bates Long Form Vocabulary Checklist: Level I (MCDI) (Fenson et al., 1994) after the freeplay session.

Results

As in Study 1, we first analyzed differences between crawling and walking infants’ receptive vocabularies and IDS input. Next, we examined correlations of these variables and whether the specific IDS types occurring inside or outside of JA correlated with receptive vocabulary. Finally, the correlational findings guided our use of hierarchical multiple regression to further explore whether the IDS codes of interest, the different subtypes of action directives occurring inside and outside of JA episodes, and infant locomotor status predicted infant receptive vocabulary size.

Receptive vocabulary and IDS type for crawling and walking infants. Table 3 provides a summary of the means and standard deviations of the IDS action directive codes. There were no differences in crawling ($M = 83.32$, $SD = 57.16$) and walking ($M = 91.84$, $SD = 53.55$) infants’ receptive vocabulary scores, $t(69) = -0.64$, $p = .53$. The frequency and duration of JA episodes as well as the total amount of IDS directed at crawling infants and walking infants in the 5-minute freeplay did not differ, $ps > .13$. Caregivers in the laboratory observation directed more action directives to both crawling ($M = 8.36$, $SD = 5.47$) and walking ($M = 8.47$, $SD = 6.33$) infants compared to caregivers in the home environment per 5-minute interval (Crawlers: $M = 1.15$, $SD = 0.91$; Walkers:

$M = 2.22$, $SD = 1.06$), which is in line with research finding that infants receive more dense language input in laboratory contexts (Tamis-LeMonda et al., 2017). Yet, the laboratory observation did not show differences in the total amount of action directives

Table 3

	Walking infants		Crawling infants	
	<i>M (SD)</i>	MCDI Correlation	<i>M (SD)</i>	MCDI Correlation
Action directives (Study 1)	13.29 (12.75)	-.12	6.83 (6.20)	.50*
Action directives (Study 2)	8.47 (6.33)	-.07	8.36 (5.47)	.44*
Action directives inside JA	3.65 (4.19)	.08	3.53 (4.13)	.02
Object related	1.98 (2.91)	.10	1.82 (2.96)	.09
Attention related	0.88 (1.33)	-.01	0.79 (0.96)	.11
Movement related	0.79 (1.35)	.04	0.93 (1.78)	-.14
Action directives outside JA	4.81 (4.08)	-.19	4.82 (3.78)	.61**
Object related	1.47 (2.10)	-.04	1.53 (2.01)	.58**
Attention related	1.93 (1.94)	-.01	2.61 (3.07)	.49**
Movement related	1.37 (1.99)	-.31*	0.71 (1.01)	-.38*

Means, Standard Deviations, and Correlations with Receptive Vocabulary of Action Directives and Action Directive Subtypes Occurring Inside and Outside of Joint Attention

Note: ** = $p < .001$, * = $p < .05$.

caregivers used towards infants who were crawling ($M = 8.36$, $SD = 5.47$) and walking ($M = 8.47$, $SD = 6.33$), $t(69) = -0.74$, $p = .94$, nor did caregivers differ in their use of actions directives to crawling and walking infants inside or outside of JA episodes, $ps > .91$. Likewise, no differences existed between the total number of object related, attention related, or physical movement related action directives directed to crawling and walking infants, nor the amount of these subtypes occurring inside or outside of JA., $ps > .11$. Additionally, there were no differences in caregiver use of the other IDS types (i.e., naming, descriptions, questions, prohibitions, imitations, other) toward crawling and walking infants generally, or inside or outside episodes of JA, $ps > .12$.

Associations with receptive vocabulary. As shown in Table 3, bivariate correlations indicated that caregiver action directives to crawling infants were significantly correlated with receptive vocabulary, $r(28) = .44$, $p = .02$. This correlation appeared to be driven by action directives occurring outside of JA episodes, $r(28) = .61$, $p = .001$, rather than action directives in JA, $r(28) = .02$, $p = .90$. In fact, none of the action directive subtypes occurring within JA episodes were correlated with crawling nor walking infant receptive vocabulary size, $ps > .22$.

Closer examination of the action directive subtypes occurring outside of JA episodes revealed that crawling infants' receptive vocabulary size was positively correlated with those related to objects, $r(28) = .58$, $p = .001$, and infant attention, $r(28) = .49$, $p = .01$. However, no such associations were present for walking infants, $ps > .22$ (see Table 3 for a summary of the means, standard deviations and correlations of these variables with receptive vocabulary). Interestingly, action directives outside of JA related to physical movement were negatively correlated with both walking, $r(43) = -.38$, $p = .04$, and crawling, $r(28) = -.31$, $p = .04$, infants' receptive vocabulary sizes. No other associations were present between the amount of IDS, naming, descriptions, questions, prohibitions, other IDS, or any of these variables occurring inside or outside of JA episodes with crawling and walking infant receptive vocabulary, $ps > .13$.

Next, hierarchical multiple regression was used to further examine the role of caregiver action directives outside of JA in predicting infant receptive vocabulary. Step 1 of the model included the total number of IDS vocalizations, SES, and infant gender as control variables, and Step 2 included locomotor status, action directives occurring outside of JA episodes, and the Locomotor Status x Action Directives Outside JA interaction term (see Table 4, Model 1: Step 2). Step 1 revealed no significant effects of infant gender, $b = 0.94$, $p = .95$, caregiver socioeconomic status, $b = -3.88$, $p = .18$, nor the total amount of IDS, $b = 0.04$, $p = .51$. Step 2 indicated a significant main effect of caregiver action directives outside of JA episodes, $b = 9.23$, $p = .01$, 95% CI [2.20, 16.26], as well as a significant Locomotor Status x Action Directives Outside JA interaction, $b = -11.99$, $p = .005$, 95% CI [-20.19, - 3.81], but no main effect of infant locomotor status, $b = 12.45$, $p = .36$. Examination of the interaction and simple slopes revealed that crawling infants who received more caregiver action directives outside of JA episodes had larger vocabulary sizes, $p = .02$, but this effect was not present for walking infants, $p = .56$ (see Figure 2).

Table 4
*Multiple Regression with Infant Locomotor Status and Caregiver Action Directive Types
 Predicting Receptive Vocabulary*

Control Variables	Receptive vocabulary	
	β	ΔR^2
Step 1		.03
SES	-0.18	
Infant gender	0.01	
Total IDS	0.09	
Model 1: Step 2		.11*
Infant locomotor status	0.11	
Action directives outside JA	0.62*	
Infant Locomotor Status x Action Directives Outside JA	-0.68**	
Model 2: Step 2		.11*
Infant locomotor status	0.17	
Action directives outside JA objects	0.08	
Action directives outside JA attention	0.13	
Action directives outside JA movement	-0.26*	
Model 2: Step 3		.13*
Infant Locomotor Status x Action Directives Outside JA Objects	-0.51*	
Infant Locomotor Status x Action Directives Outside JA Attention	-0.25	
Infant Locomotor Status x Action Directives Outside JA Movement	0.03	

Note: ** = $p < .001$, * = $p < .05$.

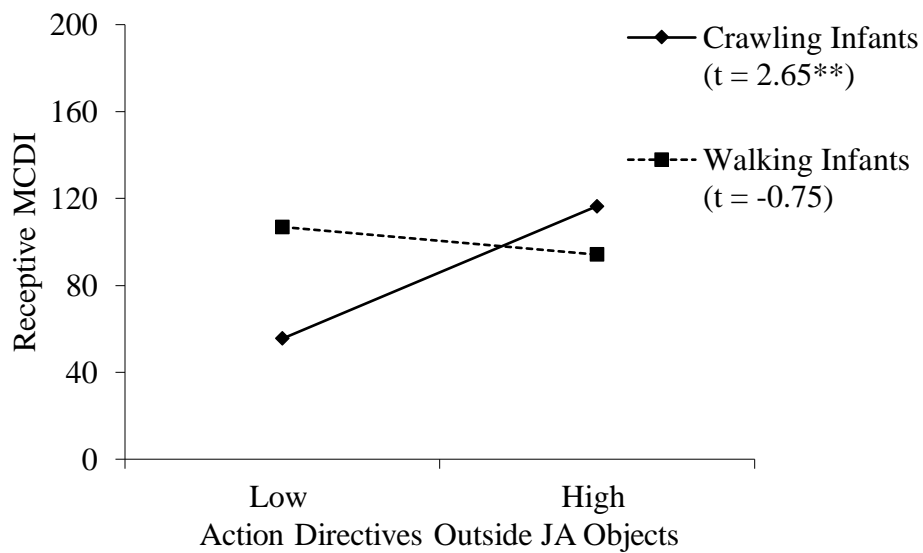
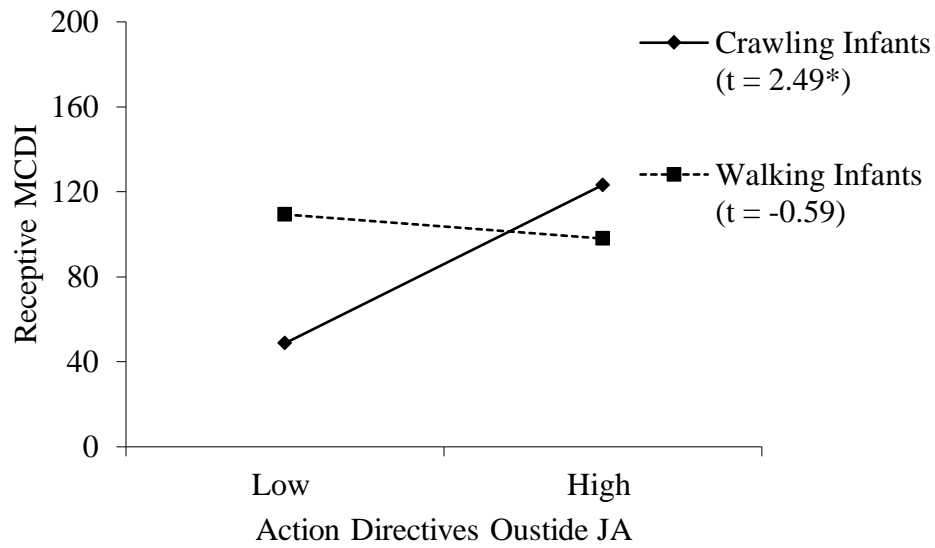


Figure 2. Predicted infant receptive vocabulary for crawling and walking infants receiving low (-1 *SD* from the mean) and high ($+1$ *SD* from the mean) levels of action directives outside joint attention and action directives related to objects outside of joint attention. Numbers in parentheses are unstandardized simple slopes. $*$ = $p \leq .05$, $**$ = $p \leq .01$

Finally, we examined the relation of action directives outside of JA related to objects, attention, and physical movement with crawling and walking infants' receptive vocabulary size. As before, Step 1 included total IDS, SES, and infant gender as control variables. Step 2 included locomotor status, action directives occurring outside of JA episodes related to objects, action directives outside of JA related to attention, and action directives outside of JA related to physical movement. Step 3 included the Locomotor status x Action Directives Outside JA Objects, Locomotor status x Action Directives Outside JA Attention, and Locomotor status x Action Directives Outside JA Movement interaction terms (see Table 4, Model 2: Step 2 and Step 3). Step 1 revealed no significant effects for infant gender, $b = 0.94$, $p = .95$, caregiver SES, $b = -3.88$, $p = .18$, or total amount of IDS, $b = 0.04$, $p = .51$. Step 2 indicated no significant main effects of locomotor status, $b = 19.11$, $p = .18$, nor action directives outside of JA related to objects, $b = 2.06$, $p = .57$, or attention $b = 3.15$, $p = .33$. However, a significant negative effect of movement related action directives outside of JA was present, $b = -10.69$, $p = .04$, 95% CI [-21.07, -0.31]. Step 3 revealed a significant Locomotor Status x Action Directives Outside JA Objects interaction, $b = -16.56$, $p = .03$, 95% CI [-31.43, -1.69], but the Locomotor Status x Action Directives Outside JA Attention interaction, $b = -9.10$, $p = .16$, and the Locomotor Status x Action Directives Outside JA Movement interaction, $b = 1.53$, $p = .91$, were not significant. Examination of the interactions and simple slopes revealed that crawling infants who received more caregiver action directives outside of JA episodes related to objects had larger vocabulary sizes, $p = .01$. No such associations were present for action directives related to attention or movement outside of JA and no associations were present for any of the subtypes for walking infants (see Figure 2).

Discussion

Study 2 replicated and extended some of the findings from Study 1. Departing from previous research and Study 1, Study 2 found that walking and crawling infants received similar amounts of action directives in the lab (Hypothesis 1). However, in line with the novel findings in Study 1, action directives were positively associated with only crawling infants' receptive vocabulary size (Hypothesis 2). Furthermore, Study 2 indicated that action directives that occurred during infants' independent object manipulations, i.e., those that were object directed and occurring outside of JA, accounted for the association with crawling infants' receptive vocabularies (Hypothesis 3). This supports the notion that action directives that encourage on infants' object directed actions facilitate receptive language increases.

General Discussion

The infant's ability to walk fundamentally changes the infant-caregiver social relationship and alters the language learning environment. Utilizing two distinct samples and observational methodologies, the present investigation suggests that caregiver action directives are more impactful for crawling infants compared to their walking counterparts. Study 1 replicated previous research (Karasik et al, 2014) and supported our first hypothesis that walking infants received more overall action directives in the naturalistic home environment (though, as elaborated upon below, this was not the case in Study 2). Interestingly, and in line with our second hypothesis, both Study 1 and Study 2 revealed that caregiver action directives were positively associated with crawling, but

not walking, infants' receptive vocabulary size. The replication of this novel finding across two distinct samples and observational contexts highlights the important role that action directives to crawling infants may play in bolstering their receptive language. Furthermore, Study 2 extended our understanding of how these action directives may facilitate infant vocabulary increases. Specifically, and in support of our third hypothesis, caregiver action directives that followed-in on infants' independent object manipulations when the dyad was not jointly engaged were positively associated with crawling infants' receptive vocabulary size.

While walking undeniably changes the infant's relationship with their environment, the present findings underscore the importance of infant-caregiver social interactions, particularly how caregivers can accommodate their infant's locomotor abilities to facilitate development. A host of recent research has examined the advantages bipedal locomotion affords walking infants, such as an increased number of stimuli in their visual field such that they have better access to adult gaze cues and distal objects (Franchak et al., 2011; Kretch et al., 2014) and superior physical access to objects in the environment (Karasik et al., 2011). As walking infants begin to drive the language environment by producing more object directed vocalizations and gestures (Clearfield, 2011), caregivers respond by physically following their infant around in upright postures themselves (Franchak et al., 2018) and using an increased number of action directives to their infant's mobile bids (Karasik et al., 2014). The caregiver of a crawling infant, however, needs to be adept at bringing the language environment to their infant and promoting their future independent actions. This may take the form of caregivers modifying their physical posture, such as sitting, to engage infants' gaze (Franchak et al., 2018), but can also manifest in caregiver IDS. Our findings indicate that utilizing action directives to promote infants' independent actions on objects in the language environment is a strategy uniquely associated with crawling infants' receptive language.

The Many Paths to Language Learning

Different mechanisms may facilitate language learning as a function of the infant's motoric development and corresponding social interactions with caregivers. Recent research has demonstrated that contingent responses to infants' object engagement play a central role in infant language learning (Pereira et al., 2014). To this end, walking infants have been found to encounter and manipulate more objects (Study 1; Karasik et al., 2011), receive more caregiver action directives (Karasik et al., 2014), and have higher parent reported receptive vocabularies (Walle & Campos, 2014). However, the present findings indicate that caregiver action directives that followed-in on infants' object directed actions associated with crawling, but not walking infant receptive vocabulary. This finding may support the notion that action directives have differentiated functions to crawling and walking infants. For instance, bipedal locomotion provides walking infants with the ability to perform more object directed actions, and a corresponding increase in caregiver action directives may be a natural byproduct. Therefore, action directives to walking infants may be indicative of infants' increased object directed actions (e.g., Karasik et al., 2014), but may not be as predictive of walking infants' receptive language outcomes as the infants' locomotor abilities themselves. From this line of reasoning, action directives to walking infants may be redundant with the infant's already present motoric capacity to perform independent

object directed actions. On the other hand, action directives that encourage infants' object-directed actions outside of JA may provide crawling infants the same type of verbal feedback to their object-directed actions as walking infants receive. Thus, action directives may be a type of verbal response that could begin to bridge the gap between crawling and walking infant receptive language (see He et al., 2015; Walle & Campos, 2014). A closer examination of Figure 2 supports this point, as crawling infants who received more object related action directives outside of JA had receptive vocabulary scores on par with their walking counterparts.

Of course, several alternate hypotheses (of which we elaborate on two) may also explain the link between action directives and crawling infant receptive vocabulary. First, action directives could more generally scaffold infant motoric development by promoting gross motor and attentional skills. However, if this were the case, we would expect to see similar associations between action directives that simply motivated infant movement more generally, which our results do not support. On the contrary, action directives that merely commanded infant movement were negatively correlated with both crawling and walking infant vocabulary. Previous research has indicated that action directives that command infant movement tend to be intrusive as they normally occur when infants are disengaged with toys and need to be redirected (Lloyd & Masur, 2014; Masur et al., 2014). This may explain why action directives related to physical movement were negatively correlated with vocabulary in the present study.

Moreover, the fact that the language assessments in these studies were taken concurrently do not support action directives as a positive antecedent to the developmental cascade of walking. The use of a concurrent language assessment also leaves the door open to a second alternative explanation: caregivers may provide more action directives and report higher receptive vocabulary scores if they perceive their crawling infant as motorically competent. Specifically, caregivers' perception of their crawling infant as more motorically advanced than their crawling peers could drive increased reports of receptive vocabulary and the use of more action directives to their infant. Although this cannot be ruled out, the lack of any meaningful correlation between caregiver action directives and infant locomotor experience in both studies may discourage this notion. Nonetheless, future research is needed to explore the downstream consequences action directives have on scaffolding crawling infant motoric development, object engagement, and language outcomes.

Further Considerations

In contextualizing our investigation with prior research, we wish to note both the discrepancies with prior studies and potential implications for future research. First, a growing body of research indicates that walking infants have larger receptive and productive vocabulary sizes (He et al., 2016; Walle & Campos, 2014; West et al., 2017). However, no significant difference between crawling and walking infants' receptive vocabulary sizes was observed. This may be because the present investigation did not require a sufficient amount of walking experience for classification of a walking infant. Prior research suggests that a sufficient amount of walking experience is necessary to observe the walking and language effect (see Walle, 2014). Second, although Study 1 found that walking infants received more action directives than crawling infants, neither the total number of action directives nor their subtypes differed between locomotor

groups in Study 2. This discrepancy may be due to constraints associated with the lab setting, as both Study 1 and Karasik et al. (2014) were conducted in the home. Group differences may also have emerged if we had only examined caregiver responses to infant bids. Third, although samples were derived from peak language segments in Study 1, a more holistic view of the day-long language environment may predict temporal associations between action directives and infants' actions on objects. Methodological techniques such as Recurrence Quantification Analysis and video observations from the home could be utilized to decipher the temporal relations between caregiver IDS and infant object directed actions.

Finally, the use of JA in the current study motivates future considerations regarding how infants and caregivers coordinate attention to objects. We did not find that walking infants had more JA episodes than crawling infants, although prior longitudinal work by Walle (2016) found that parents reported an increase in infant JA episodes across the transition from crawling to walking. The cross-sectional nature and limited observational context of the present investigation may have precluded replication of this finding. Thus, we encourage further direct observation of infants' JA behavior as they transition from crawling to walking. Specifically, a more fine-grained assessment of infant attentional allocation and physical handling of objects, perhaps by utilizing head-mounted eye trackers, would help clarify the role of caregiver action directives matching infants object-directed actions in real time.

These findings also have important implications for considering mechanisms that underlie language development. Infant language research has increasingly relied on the study of embodied and contingent interpersonal processes to illuminate how infants learn language (Yu, 2014). The current study adds to this growing body of literature, underscoring that infant social interactions are conditional on both the infant's motoric abilities and caregiver social behaviors that are sensitive to infant locomotor competency. Moreover, there is not necessarily a one size fits all parenting strategy to promote language development. Caregiving practices that accommodate the infant's capabilities and limitations are most beneficial. This approach may be particularly important for caregivers, educators, and practitioners interacting with children with special needs, such as children at risk for autism spectrum disorder who demonstrate motoric delays, decreased social skills, and impaired language development (West, 2019). Thus, we advocate that infant-caregiver interactions be construed as dynamic, embodied processes that shape the language learning environment.

Chapter 3

Chapter Abstract

This study examined 2-year-olds' inferences of intentionality from non-random sampling events and subsequent discrete emotion reactions. Infants observed an experimenter remove five objects from either the non-random minority (18%) or random majority (82%) of a sample and express either joy, disgust, or sadness after each selection. Two-year-olds inferred the experimenter's intentionality by giving her the object that she had previously selected when she expressed joy or disgust after non-random sampling events, but not when she expressed sadness or sampled at random. These findings demonstrate that infants use both statistical regularities and discrete emotion communication to infer an agent's referential intent. In particular, the present findings show that 2-year-olds infer that an agent can intentionally select a preferred *or* an undesired object from a sample as a function of the discrete emotion.

Introduction

Statistical inferences and emotional communication guide our interpretation of social intentions and referential intent. For instance, seeing a woman open a bag of trail mix and select out all of the raisins one at a time might lead one to assume that she has a preference for raisins. However, that assumption would change if you saw her preform the same act but express disgust after each raisin selection before continuing to enjoy the now raisin-less bag. These contrasting examples are plausible everyday scenarios of intentional selections that underscore the role of emotion when attributing preferences from non-random sampling events. Specifically, while it is expected that individuals act intentionally toward preferred objects (Woodward, 1998), it is also the case that agents can intentionally select undesirable objects out of a sample to achieve their goals, such as when someone cleans out the fridge, separates recycling from trash, or disposes of unwanted raisins. Here, we investigated whether 2-year-old infants use an agent's emotional communication (i.e., joy, disgust, sadness) to infer her intentionality from non-random sampling selections.

Cues for Inferring Intentionality and Goals

Consistency and efficiency. Humans have a penchant for taking an intentional stance when interpreting the behaviors of others (Dennett, 1987). Even young infants expect agents to act intentionally towards their goals through the principle of rationality – that agents will act consistently and efficiently in relation to their goals, desires, and beliefs (Baillargeon et al., 2016). For instance, 6-month-old infants expect that a consistently repeated object selection is intentional and indicates a preference for that object (Woodward, 1998) and that agents will use the most efficient means to reach their goal (Liu & Spelke, 2017). Moreover, the principles of consistency and efficiency can also work in tandem. If an agent has shown a consistent preference for an object, 16-month-old infants infer that she will perform an inefficient action to obtain that object later, even over a more easily accessible alternative (Scott & Baillargeon, 2013). For example, although it may have been most efficient to take whichever piece of trail mix that was at the top of the bag, the fact that the woman consistently chose raisins despite it being a less efficient action showcased her goal to obtain the raisins.

Statistical Regularity and Probability. Our detection of patterns in the environment stems from the human tendency to learn from statistical information. In

addition to using statistical regularities in the environment to learn about physical reasoning (Teglas et al., 2011), object labels (Smith & Yu, 2008), and causal relationships (Gopnik & Wellman, 2012), infants also learn about the desires and beliefs of agents from such information (Wellman et al., 2018). In a noteworthy study, Kushnir et al. (2010) found that 20-month-olds inferred agent preferences from non-random sampling events. Specifically, infants offered the object that the agent had previously selected more often when she had consistently selected the minority (18% present) object five times out of the sample, but not when she consistently selected the majority (82% present) object. Thus, infants inferred intentionality from the agent's selection of the minority object due to its consistent, yet inefficient, nature, whereas her selection of the majority object offered little information regarding intentionality because the selection could be expected by chance. This research indicates that infants can make inferences about intentionality based on sampling probabilities.

Emotional Communication. The role of discrete emotions in attributing intentionality from non-random sampling events has not been studied. In fact, Kushnir et al. (2010) controlled for affect by having the agent only express joy after making her selections. However, understanding others' emotions is inherently linked to deciphering their goals and intentions (Reschke, Walle, & Dukes, 2017). For example, 12-month-old infants expect joy and sadness to correspond to agent's goal achievement and goal failure, respectively (Reschke, Walle, Flom, et al., 2017), and young children can infer an agent's happiness and surprise reactions based on the probability of sampling event outcomes (Doan et al., 2018; 2019). However, less research has investigated how infants use discrete emotions to infer agent intentions. Fourteen-month-old infants do expect an agent to perform actions that correspond to their anger or joy expression (Hepach & Westerman, 2013) and a recent study by Reschke et al. (2020) found that 18-month-old infants can use an agent's expression of frustration to infer their intentions to complete an unfinished action. Thus, as with positive emotions, negative emotions can also communicate intentions and goals, as in the case of the woman selectively taking out all of the raisins so as to rid them from her snack. However, the above studies can speak only to how infants use emotion valence (i.e., positive vs. negative emotion), not how discrete emotions (e.g., joy vs. disgust vs. sadness) may differentially guide their inference of others' intentions and goals.

Current Study

This investigation examined 2-year-olds' use of discrete emotion communication to infer an agent's intentionality from statistical sampling events. Specifically, we manipulated which discrete emotion an agent expressed following her selection of either the majority (random sampling) or minority (non-random sampling) object. In addition to the agent expressing joy after each selection, which is common in such research, we also included trials in which she expressed disgust or sadness.

The study had 3 predictions. First, we expected that joy trials would replicate the findings from Kushnir et al. (2010) that infants would infer the agent's preference by giving her the target object (i.e., the object type she previously selected) more often in the non-random minority (18%) sampling condition compared to the random majority (82%) sampling condition. Second, we predicted a similar pattern of results would emerge in the disgust trials: infants would give the target object more often in disgust trials in the

minority (18%) sampling condition than in the majority (82%) sampling condition, so as to help decontaminate the sample. Although disgust functions to prompt avoidance of aversive foods and pathogens, it can also motivate the intentional removal of contaminated objects (Rozin & Fallon, 1987) – a concept understood in infancy (Brown & Harris, 2012). Our third prediction was that sadness, which infants understand is typically elicited by goal failure (Reschke, Walle, & Dukes, 2017), would be an irrational response to the agent picking the minority (non-random) object from the sample when she could have more easily picked the majority (random) object to achieve her goal. Thus, infants in this condition were expected to give the objects at chance in the minority condition.

Method

Participants

Forty-eight 2-year-olds ($M = 27.57$ months, Range = 23-31 months, $SD = 3.14$) participated in the study. A power analysis based on Kushnir et al. (2010) determined that 48 infants were needed to detect an effect size of 0.6 between conditions. Twenty-four infants (10 male, 14 female) were assigned to the non-random minority (18%) sampling condition and 24 (11 male, 13 female) were assigned to the random majority (82%) sampling condition. No differences across conditions were present for infant age, $t(46) = -0.79$, $p = .43$, or gender distribution, $X^2(1, 47) = 0.09$, $p = .77$. An additional 15 infants were excluded from the study due to not handing toys to the experimenter (10), experimenter error (2) or fussiness (3). All participants were recruited from the California San Joaquin Valley. The majority of parents had either a high school ($n = 17$) or college degree ($n = 15$), and the average household income was \$50,000 ($SD = \$40,000$).

Materials

Three sets of small bath toys were contained in clear plastic boxes (length = 10 7/8 in., width = 7 1/2 in., height = 6 3/8 in). Each set had a 31:7 ratio of ducks and frogs, fish and whales, or dolphins and crocodiles. The proportion of each toy type and presentation order of the toy sets were both counterbalanced. Each set also had a corresponding smaller box (length = 10 3/4 in., width = 6 7/8 in., height = 2 3/4 in) that contained 5 of each toy type from the larger set. The use of a single smaller container (as opposed to two containers in Kushnir et al., 2010) afforded infants the opportunity to decontaminate the sample, as was predicted in the disgust trials.

Procedure

All procedures were approved by the University of California Merced Institutional Review Board. The procedures mirrored those used in Study 2 of Kushnir et al. (2010), with minor adjustments made to allow multiple trials with varying emotion expressions. Infants were seated on their parent's lap at a table. Experimenter 1 (E1) stood on the opposite side of the table. Experimenter 2 (E2) stood behind a room dividing curtain out of sight of the infant. A warm-up phase consisted of a turn-taking game to allow infants to become comfortable sharing with the E1. The infant and E1 took turns passing back and forth a toy car, toy dinosaur, and toy horse. The first trial began after all toys had been successfully passed back to the E1.

After receiving the final warm-up toy, E1 stepped behind the curtain and out of sight from the infant. Then, E2 entered, set the first box of toys on the table, and took out one toy at a time from the box, labelled it, and let the infant handle it for a few seconds

before asking for it back. After the infant handled and returned both toy types, E2 returned to behind the curtain, and E1 reemerged across the table from the infant.

E1 then proceeded to take out 5 toys of the same type (e.g., all frogs) from the box, one at a time. The standing position of E1 allowed her to express each emotion through her face, voice, and posture upon each selection while alternating her gaze between the toy and the infant. The emotion expressions were communicated as follows (see Figure 1):

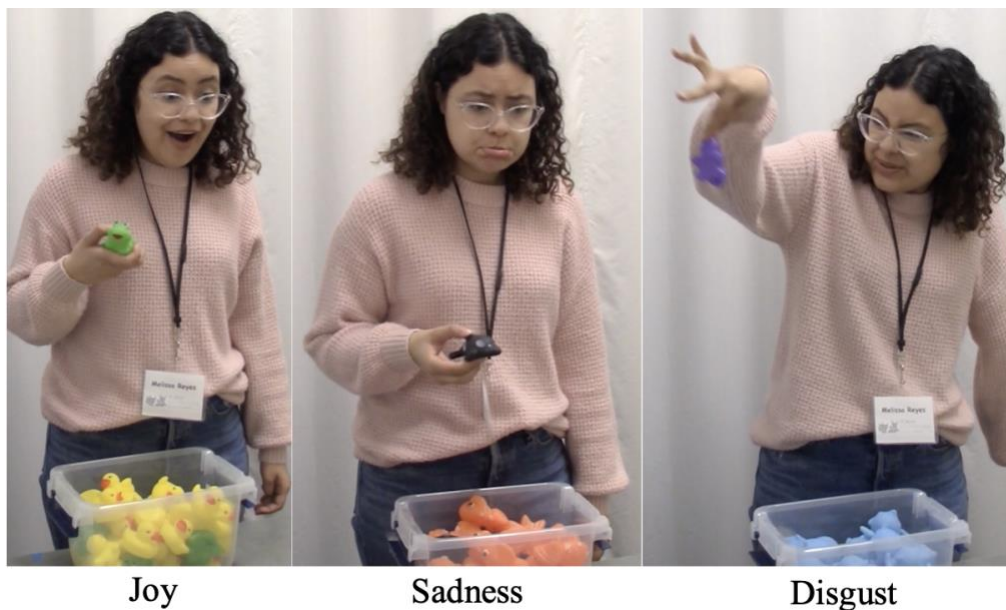


Figure 3. Exemplars of joy, sadness, and disgust expressions after each toy selection.

Joy. E1 raised her eyebrows, widened her eyes, and smiled with her teeth showing while maintaining an upright posture with a whole hand grip on her selected toy. She said in a high-pitched excited tone of voice, “Wow, I got a [frog].”

Disgust. E1 furrowed her brow, scrunched her nose, and curled her lip up while moving her head, but not torso, away from the toy she selected and held with a pincer grip. She said in an elongated tone with rough intonations, “Ew, yuck, I got a [frog].”

Sadness. E1 raised the interior of her eyebrows, had downward eyes, and pouted her lips while slouching her shoulders and holding the selected toy with a limp wrist. She said in a low, slightly whiny, tone, “Oh no, I got a [frog].”

After making all five selections, E1 left by going behind the curtain. Next, E2 came back out, removed the toy box by putting it behind the curtain, and placed the smaller box on the table out of the reach of the infant and left. Then, E1 returned, pushed the smaller box towards the infant and asked, “Can you help?” while extending her hand with open palm above the smaller box. The infant then had 10 seconds to give a toy to E1, which was timed by E2 behind the curtain. Infants had to offer a toy in at least 1 trial to be included in the analyses. Infants who did not hand any toys to E1 were evenly distributed across conditions (majority sampling condition = 6; minority sampling condition = 4). This exclusion criterion and the number of infants excluded were the

same as in Kushnir et al. (2010).

After infants shared a toy or the full time had elapsed, E1 went behind the curtain and E2 came out, removed all the toys from the trial, and began the next trial with a new toy set. Infants received the same selection criteria in a given condition (i.e., either minority 18% sampling or majority 82% sampling across trials) and participated in each of the 3 emotion conditions. The order of the emotion trials was randomized across all participants.

Coding

A trained research assistant naïve to the experimental condition coded the infants' first toy touched ("first touch") and first toy offered to the experimenter ("first offer") based on Kushnir et al. (2010). Reliability was assessed from 30% of the trials and interrater reliability demonstrated near perfect agreement for first touches (97.2%) and perfect agreement for first offers (100%).

A manipulation check ensured that the experimenter adequately communicated the emotion in a given trial. A trained researcher first selected which emotion was expressed for each trial and then rated the expression as: 0 = unacceptable, 1 = dull, or 2 = acceptable. Interrater reliability of emotion expression codes was near perfect (96.7%). Only trials with an emotion expression rated as acceptable (98% of trials) were included in the analyses.

Results

Infants' "first touch" and "first offer" responses across emotion and distribution conditions are presented in Table 1. Chi-square analyses were conducted separately for each emotion to determine whether infants differed between the minority and majority conditions for which toy (i.e., target or alternate) they first touched and first offered. The toy infants first touched ($p = .90$) and first offered ($p = .57$) did not correlate with the order in which the emotion trials were presented and first touches $X^2(2, 138) = 1.01, p = .61$ and first offers $X^2(2, 138) = 2.71, p = .26$ did not differ between trials. Since infants received each emotion trial in counterbalanced order in either the minority (18%) or the majority (82%) condition, all subsequent analyses were between-subjects.

Table 4

Infants' First Touches and First Offers Across Emotion Trials and Conditions

		18% condition		82% condition	
		First Touch	First Offer	First Touch	First Offer
Joy	Target	18	18	11	10
	Alternate	6	4	13	14
Disgust	Target	15	15	8	8
	Alternate	9	8	15	15
Sadness	Target	14	10	12	12
	Alternate	10	12	12	12

Note. Two infants did not offer either toy in the minority (18%) condition joy and sadness trials, 1 infant did not offer either toy in the minority (18%) condition disgust trial, and 1 infant did not offer either toy in the majority (82%) condition disgust trial.

First Object Touched

Joy. First touch responses were significantly different between distribution conditions when the experimenter expressed joy, $X^2(2, 48) = 4.27, p = .04$. Specifically, when joy was expressed, infants first touched the target object more often when the minority object was selected (75% of infants) than when the majority object was selected (46% of infants), replicating findings from Kushnir et al. (2010).

Disgust. Differences across distribution conditions of infants' first touch responses when the experimenter expressed disgust did not reach statistical significance, $X^2(2, 47) = 3.61, p = .06$.

Sadness. First touch responses did not differ across distribution conditions when the experimenter expressed sadness, $X^2(2, 48) = 0.34, p = .56$.

First Object Offered

Joy. Infants' first offer responses differed significantly between distribution conditions when the experimenter expressed joy, $X^2(2, 46) = 7.77, p = .005$. Specifically, when joy was expressed, infants in the minority sampling condition offered the target more often (75% of infants) than infants in the majority sampling condition (42% of infants).

Disgust. Likewise, infants' first offer responses significantly differed between distribution conditions when the experimenter expressed disgust, $X^2(2, 46) = 4.26, p = .04$. Infants offered the experimenter the target object more often in the minority sampling condition (65% of infants), but conversely infants in the majority sampling condition offered the alternate object more often when the experimenter expressed disgust (65% of infants).

Sadness. Infants' first offer responses did not differ when the experimenter expressed sadness, $X^2(2, 46) = 0.09, p = .76$. Specifically, infants were similarly likely to offer either toy in the minority (45% of infants offered the target) and majority (50% of infants) conditions.

Taken together, these results demonstrate that infants inferred intentionality from the selections when the experimenter repeatedly selected the minority toy and expressed joy or disgust, but not when she repeatedly selected the majority toy or when she expressed sadness in either condition (see figure 2).

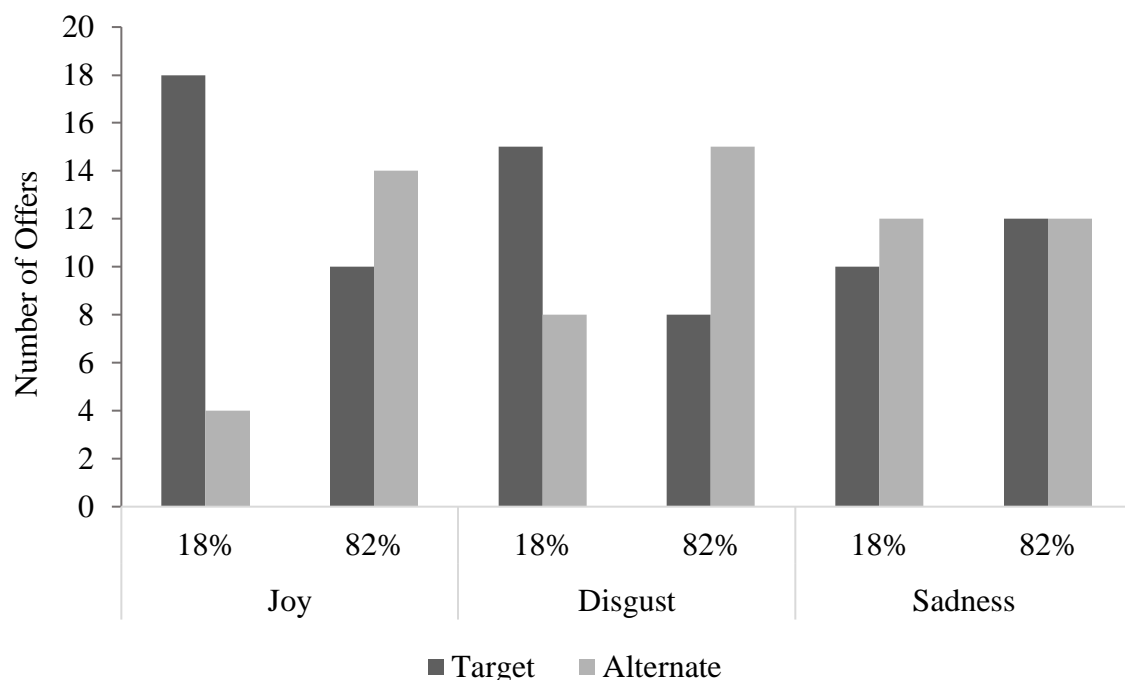


Figure 4. Frequency of infant offering the target or alternate toy across emotion conditions and sampling conditions.

Discussion

This study examined how 2-year-olds used discrete emotions to infer intentionality from statistical sampling events. Findings indicated that infants inferred an agent's intentional selection of an object when she expressed joy or disgust, but not sadness, after non-random sampling selections. To our knowledge, this is the first study to demonstrate that infants can infer intentionality from non-random sampling events in which an agent expresses a negative emotion after their selection. This novel finding complements a growing body of literature on infants' inferences from probabilistic sampling events and provides insights into how discrete emotions convey agent intention.

The results from the joy trials in our study bolster previous findings that infants infer agent preferences from non-random sampling events (Kushnir et al., 2010; Ma & Xu, 2011; Wellman et al., 2018). Specifically, in line with our first hypothesis, we found that 2-year-old infants first touched and offered the experimenter the target object when she expressed joy upon selecting minority (18%) objects out of the sample, but not when she expressed joy after selecting majority (82%) objects. Moreover, replication of prior findings in this joy condition provides added confidence to the validity of our procedures given the inclusion of the novel negative emotion trials.

Unique to the current study, and in support of our second hypothesis, 2-year-olds who observed the experimenter express disgust after her selection gave her the target object more often in the minority sampling condition than in the majority sampling condition. It is noteworthy that the pattern of results in the disgust trials mirrored those in the joy trials. This indicates that by two years of age, infants infer that an agent can intentionally select a preferred *or* an unpreferred object from a sample as a function of

the discrete emotion. Importantly, our findings distinguished between discrete negative emotions, namely disgust and sadness. Though sparse, some evidence suggests that infants may have some notion for differentiating their responses to these emotions. For example, upon observing an experimenter express joy or disgust toward the contents of two cups, infants were not surprised when she later reached into either cup to retrieve the contents (Vaish & Woodward, 2010). However, infants fail to attribute intentionality to an experimenter's action when she selected an object toward which she had previously expressed sadness (Patzwald et al., 2018). Our findings support such distinctions between discrete negative emotions. In particular, in line with our third hypothesis, infants only inferred that the agent was making intentional selections in the minority sampling conditions when she expressed disgust, but not sadness. This finding underscores that discrete emotions, even of the same valence, communicate distinct relational significance between agents and objects.

Future Directions

This study illuminates important avenues for further research examining the role of discrete emotion communication in statistical sampling events. Future work could investigate whether infants expect agents to intentionally select disgusting objects out of a sample as they do with preferred objects (e.g., Wellman et al., 2018). Further, it would be interesting to examine whether children infer that an agent should have calibrated negative reactions based on their probability of receiving aversive objects – as recently found with joy and surprise reactions to preferred objects (Doan et al., 2018; 2019). Additionally, the developmental trajectories of infants' ability to infer intentions from discrete emotions necessitates further examination. Although the participants in this study were somewhat older than those in Kushnir et al. (2010), infants' understanding of agent dis-preferences is thought to develop later than understanding of preferences (see Reschke, Walle, & Dukes, 2017) and our sample is more socioeconomically diverse compared to that used in prior research, making this replication and extension of previous findings particularly noteworthy.

Taken together, findings from the present study serve to motivate future investigations examining how the interplay of discrete emotions and statistical regularities in the environment interact to inform infants' understanding of the social world

Chapter 4

Chapter Abstract

This study assessed the influence of discrete emotion communication on 2-year-olds' visual attention to objects and word learning. Infants watched an experimenter label an unfamiliar object with a novel word while expressing either joy, sadness, or disgust. Infants received two emotion conditions and in test were asked to point to the object that matched the novel word. Infants' looking during the labeling trials was analyzed to examine differences between the duration infants looked at the object compared to the experimenter. Infants' looking and pointing to the target object during test was then assessed to determine if infants learned the word for the novel object. Interestingly, infants looked at the experimenter more than the object in the sadness condition, whereas looking to these elements was similar in the joy and disgust conditions. However, preliminary results demonstrated that infants learned the object labels in each emotion condition.

Introduction

Social and contextual cues are important for infants' understanding of referential intent (i.e., the object a person is referring to) and word learning. Emotions are a particularly powerful cue for appreciating referential intent and learning about objects (Baldwin & Moses, 1994). This is because emotions spotlight referents in the environment that have a significant relationship with the individual expressing the emotion (Walle & Lopez, 2020). However, the role of emotional communication in word-object learning is rarely studied (see Doan, 2010 for a review). Here, we examined how discrete emotion communication influenced infants' learning of novel words for unfamiliar objects.

Referential Intent and Word Learning

Word learning is facilitated by contextual information (Vlach & Sandhofer, 2011). One source of the context that has been shown to be especially impactful is social cues. In particular, the abilities to follow gaze and share attention with a social partner towards a referent have been long known predictors of word learning in infancy (Brook & Meltzoff, 2008; Tomasello, 1988). This is because gaze following and sharing attention both aid in conveying referential intent, which is central to word learning, by linking individuals' attention and words to specific objects in the environment. Specifically, following gaze and sharing attention allows caregivers to guide infants' attention to the most relevant objects while providing contingent object labels. This creates a tight temporal coupling, or word-to-world timing, between the word and object that clarifies referential intent and promotes word-object learning outcomes (Gleitman & Trueswell, 2020). However, few standardized word learning paradigms include contextual elements and social cues (see Golinkoff et al., 2013 for examples). In addition to including social cues of eye-gaze and gesture, the present study included a social cue that is less studied in traditional word learning paradigms: emotional communication.

The Role of Emotion in Word Learning

Multiple studies have demonstrated the ability for emotions to clarify referential intent for infants (see Baldwin & Moses, 1994 for a review). By the end of the first year of life, infants engage in social referencing (i.e., use an adult's emotions to disambiguate

the significance of a referent and modify their behavior accordingly; Walle, Reschke, & Knothe, 2017) to extract referential intent from emotional displays (Moses et al., 2001). At this same age, infants also expect discrete emotions to correspond to different object directed actions (Reschke et al., 2017; see Walle & Campos, 2012 for a review). Yet, the majority of research examining infant word learning from emotional communication has manipulated the prosody of speech streams. The role of emotion as a social cue that impacts understanding referential intent and word-object learning remains understudied.

The use of emotion in word learning paradigms has usually been relegated to only the vocal modality. It is well known that infants prefer infant-directed speech over other types of adult speech as early as 6 months of age (Singh, Morgan, & Best, 2002). Infant-directed speech has also been shown to facilitate infant learning of word-object pairs in rapid word learning paradigms over adult-directed speech (Ma et al., 2011). It has been hypothesized that the affect in the infant directed speech, being happy in nature, drives these findings. Indeed, as early as 7.5 months of age infants prefer adult speech containing positive affect over neutral adult speech (Singh et al., 2004) and 7- to 8-month-old infants who were exposed to variability in affective forms (i.e., words spoken in happy, neutral, sad, angry, and fearful affect) could recognize the word when it was presented in fluent speech varying across discrete emotions (Singh, 2008).

To my knowledge, only one study has assessed whether emotions communicated through multiple modalities facilitate the learning of word-object associations. A recent study found that both positive and negative emotions communicated facially and vocally resulted in 2-year-olds learning words for novel objects (Ma et al., 2019). Thus, infants have been shown to learn words from emotional speech and facial expressions, but findings failed to indicate that such word learning varied based on the valence or discrete emotion used in the presentation. However, none of the emotional expressions in these studies were presented as dynamic social cues, which have been shown to influence infants' understanding of referential intent and word learning. This presents a problem considering that word-object learning has increasingly been construed as dynamic and contingent process for young learners (Pereira et al., 2014). Further, it remains to be studied whether discrete emotions communicated dynamically through multiple modalities (i.e., facially, vocally, postural, and gesturally) differentially affect word-object learning in infancy.

Discrete Emotions and Word Learning. Discrete emotions may influence infants' word learning since they differential impact infants' attention to objects. By 7 months of age, infants have been shown to fixate on anger faces that gaze straight ahead and fear faces that are gazing towards an external referent (Hoehl, 2014). This may be due to what infants perceive as threatening. An angry individual is a potential threat, whereas a fearful individual signals the presence of an external threat (Cosmides & Tooby, 2000). In this way, infants may be attending to the most important element of the emotional context by looking at the adult in anger and using the gaze of the adult to locate an external threat in fear (see Knothe & Walle, 2017). Similarly, disgust signals an external threat while sadness communicates an individual's distress (Cosmide & Tooby, 2000; Zahn-Waxler et al., 1992). Accordingly, evidence shows that infants' preferentially attend to the adult in sadness and the referent of disgust. Disgust has even been shown to elicit more visual examination of the stimulus than fear (e.g., Repacholi, 1998; Walle,

Reschke, Camras, et al., 2017), as fear motivates rapid avoidance (Cosmides & Tooby, 2000). Conversely, sadness increases infants' attention to the caregiver and prompts prosocial responses to alleviate distress (Zahn-Waxler et al., 1992), unlike anger which motivates the avoidance of the adult (Walle, Reschke, Camras, et al., 2017). Taken together, anger and sadness may direct more infant attention to adults while fear and disgust may direct more attention to objects (Knothe & Walle, 2017).

This attentional difference could potentially impact infants' word-object learning because attention to an object while receiving a contingent label has been shown to promote word learning outcomes (Pereira et al., 2014). The present study compared disgust to sadness. These emotions were selected because they represent the adult-object attentional distinction but are lower in arousal, which could interfere with learning, than their emotional counterparts (Russell & Bullock, 1985).

Current Study

The present study utilized a version of the intermodal preferential looking paradigm (IPLP) to assess 2-year-olds word-object learning from an experimenter dynamically expressing a discrete emotion while labelling an unfamiliar object with a novel word. The IPLP has a long history of effectiveness as an assessment tool for studying infants' novel word-object learning (see Golinkoff et al., 2013). Because the current study included a pointing component in test, which is usually included in word learning paradigms with 2-year-olds, 24-month-old infants were recruited for this study.

Infants were shown a video of an experimenter labeling objects while communicating either joy, sadness, or disgust through the face, voice, posture, and gesture. Next, infants were presented with two objects and were asked to point to the object that matched the novel word. First, I hypothesized that infants would attend more to the experimenter when she labeled the object with sadness but attend more to the object when she labeled it with disgust. Second, I hypothesized that infants would be more likely to learn the words for objects presented with disgust over sadness. I made these hypotheses because disgust signals the presence of an aversive stimulus (Cosmides & Tooby, 2000) and prompts infants' attention to objects compared to sadness which increases infants' attention and behavioral responses to the adult expressing the emotion over the referential object (Zahn-Waxler et al., 1992). The joy condition was included as a baseline condition of IDS because infants have been known to learn words from speech with positive affect (Ma et al., 2011).

Methods

Participants

Due to the COVID-19 pandemic, recruitment was halted during the course of this study. Therefore, preliminary results are reported here that include 12 monolingual English speaking 2-year-olds ($M = 25.21$ months, $Range = 23-29$ months, $SD = 2.58$). Four infants were assigned to a condition in which they saw one object labeled with joy and one labeled with sadness, 4 were assigned to the joy and disgust object labelling condition, and 4 to the sadness and disgust object labeling condition. All participants were recruited from the California Central Valley. The majority of parents had either a high school diploma or equivalent ($n = 5$) or a college degree ($n = 7$) and the average household income was \$50,000 ($SD = \$40,000$).

Apparatus

Infants sat on their parent's lap at a table approximately 0.5 m across from a 1.40 m television monitor. Caregivers were instructed not to distract the infant and wore opaque sunglasses to ensure their visual behaviors did not influence the infant. Other individuals accompanying the family were directed to sit quietly in a separate room. An experimenter (E1) sat behind the infant and caregiver to ask the infant to point in test. A second experimenter sat behind the television to monitor the infant through a webcam and operate the stimuli. A webcam was placed out of sight directly in front of the infant to capture infant visual attention and pointing behaviors.

Stimuli

Labeling Trials. Labeling trials consisted of 17 second videos of a female experimenter labelling one of two novel objects with either the word “blick’ or “modi”. The experimenter was seated at a table with a white background behind her. The novel object was on the table and positioned slightly to the experimenter's right or left. The placement of the object, the word used to label the object, and the emotion were all counterbalanced. All audio was played through the television speakers and was controlled for duration and loudness.

The experimenter labeled the objects 6 times per trial using the following script: “Look here! It's a modi! See the modi. That's the modi. Look here is the modi. This is the modi. Modi.” While labeling, the experimenter pointed at the object and alternated her gaze from the infant to the object while expressing the following emotional expressions multimodally (see Figure 5):

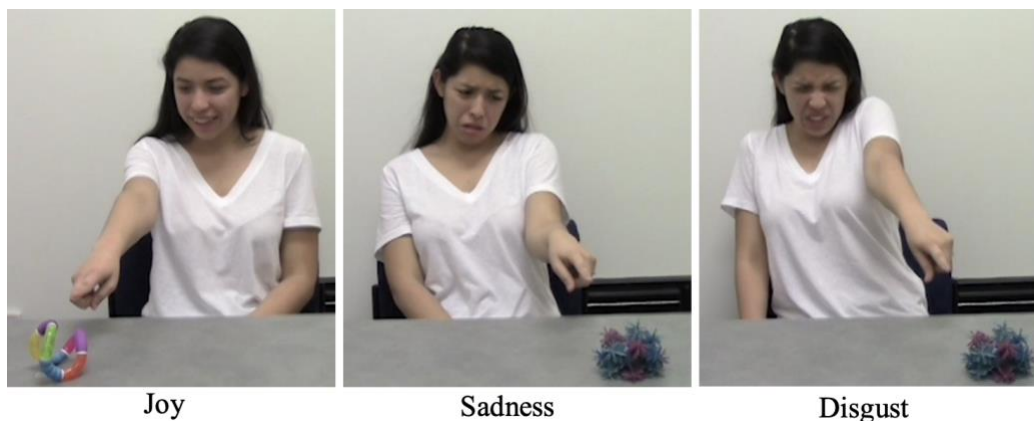


Figure 5. Exemplars of emotional expressions for joy, sadness, and disgust labelling stimuli.

Joy. The joy expression consisted of raised eyebrows, widened eyes, and a smile with teeth showing while labelling the object with a direct pointing gesture and a high-pitched excited tone of voice.

Sadness. In the sadness condition, the experimenter displayed of raised interior eyebrows, downward eyes, and pouted lips while labelling the object with slightly slouched shoulders, a pointing gesture with a limp wrist, and a slightly whiney tone of voice.

Disgust. The disgust display featured the experimenter with a furrowed brow, scrunched nose, and curled upper lip so that teeth were showing while labelling the object

with shoulders slightly back, a direct pointing gesture with a slightly crooked wrist to resemble a pincer grip, and an elongated rough tone of voice.

Test Trials. On test trials, infants were presented with images of the two novel objects on either side of the television monitor. Each image was the same size and presented on a black background (see Figure 2).



Figure 5. Test stimuli infants viewed on test trials.

Procedure

After the infant was seated on the parent's lap and the parent had put on the sunglasses, E1 took her seat behind the dyad and E2 began the video presentation which consisted of a warm up, labeling trials, and the test trials.

Warm Up. To familiarize infants with the preferential pointing procedures, a pointing warm up was conducted. First, a video clip was played of Kermit the Frog and Elmo each introducing themselves. Then, pictures of Kermit and Elmo were presented on each side of the television monitor and E1 asked the infant to first point to Kermit then Elmo. If the infant was reluctant to point, E1 demonstrated the pointing response for the infant and encouraged the infant to point in a similar manner.

Next, the infant viewed 4 warm up videos that were identical to the labeling trials but with familiar objects. A video played of the same female experimenter from the labeling trials. She labeled a book 6 times in one video and a ball 6 times another. In both video presentations she used infant-directed speech and expressed joy. Infants viewed each video (i.e., book and ball) twice in counterbalanced order. After viewing all 4 videos, a 4-second countdown played to fixate infants' attention to the television monitor for 4 warm up test trials. After the countdown, images of the book and ball were presented side by side. Infants participated in 4 warm up test trials (2 for book and 2 for ball) with the 4-second countdown occurring between each. E1 asked from behind the infant, "Book/ball! Where is the ball/book? Can you point to the ball/book?". The video went to the next trial after the infant pointed or 15 seconds had elapsed without an infant point.

Labeling Trials. The labeling stimuli were administered in the exact same manner as the warm up videos. Infants watched 4 videos consisting of 2 emotion labeling presentation stimuli (i.e., either joy and sadness, joy and disgust, or sadness and disgust). Each labeling stimulus played twice one after another (e.g., joy, sadness, joy, sadness). The stimuli that went first was counterbalanced. After viewing all 4 videos, a 4-second countdown played to fixate infants' attention to the television monitor for 4 test trials.

Test Trials. After the countdown, images of the objects labeled Blick and Modi were presented side by side. Infants participated in 4 test trials (2 for Blick and 2 for Modi) with the 4-second countdown occurring between each. E1 asked from behind the infant, "Blick/modi! Where is the blick/modi? Can you point to the blick/modi?" Again, the video went to the next trial after the infant pointed or 15 seconds had elapsed without an infant point. Two infants were excluded from looking and pointing analyses of the test trails for not pointing and looking away from the screen for the majority of the time.

Coding

Labeling Trials. Infant looking. For labeling trials, infants' total looking time to each location (experimenter, object, elsewhere) was coded frame-by-frame. Since each labeling trial was exactly 17 seconds, the window of coding infants' looking during labeling trials was consistent across participants. Inter-rater reliability coding was assessed by comparing the number frames that matched and the difference in looking durations between coders (percent agreement = 89.29%, $M_{diff} = 0.41$ seconds).

Test Trials. Infant looking. For each test trial, infants' total looking time to each location (correct object, incorrect object, elsewhere) was coded frame-by-frame. Each test trial ended after an infant point, and thus the window of coding infants' looking during test varied by their latency to point. Infants who did not point during a test trial were coded for the full 15 second window.

Infant pointing. For each test trial, a coder indicated to which object (correct or incorrect) the infant pointed. Inter-rater reliability was assessed by a second coder who coded infants' points to the objects from the webcam videos. Coding of infant pointing demonstrated perfect inter-rater reliability (100%). Two infants did not point in any test trials and were excluded from analyses of infant pointing.

Results

Labeling Trials

Infant Looking. All 12 infants attended to the stimuli the majority of the labeling trials. Specifically, infants looked at the screen 11.65 seconds on average ($SD = 1.54$ seconds, Range 9.25-14.32 seconds) out of the 17 second presentation (69% of the time on average).

Differences in infants' visual attention to the novel object compared to the experimenter during labeling trials was assessed using paired t -tests. Infants looked significantly more at the experimenter ($M = 9.16$ seconds) than the object ($M = 2.49$ seconds) during sadness labeling trials, $t(8) = 6.48$, $p < .001$. However, differences did not emerge for joy labeling trials between infants' duration looking at the experimenter ($M = 6.89$ seconds) versus object ($M = 4.83$ seconds), $t(8) = 1.79$, $p = .12$, nor disgust labeling trials between infants duration looking at the experimenter ($M = 6.36$ seconds) versus object ($M = 5.23$ seconds), $t(8) = 0.93$, $p = .38$. To further test these looking time differences between emotions, paired t -tests were used to compare the differential

looking scores (DLS) for infants duration looking to the experimenter compared to the object. The results determined that infants looked significantly more to the experimenter than to the object during sadness labeling trials compared to joy, $t(8) = 16.39, p = .004$ and disgust labeling trials, $t(8) = 3.89, p = .03$, but no differences emerged between the joy and disgust trials, $t(8) = 2.12, p = .10$ (see figure 3).

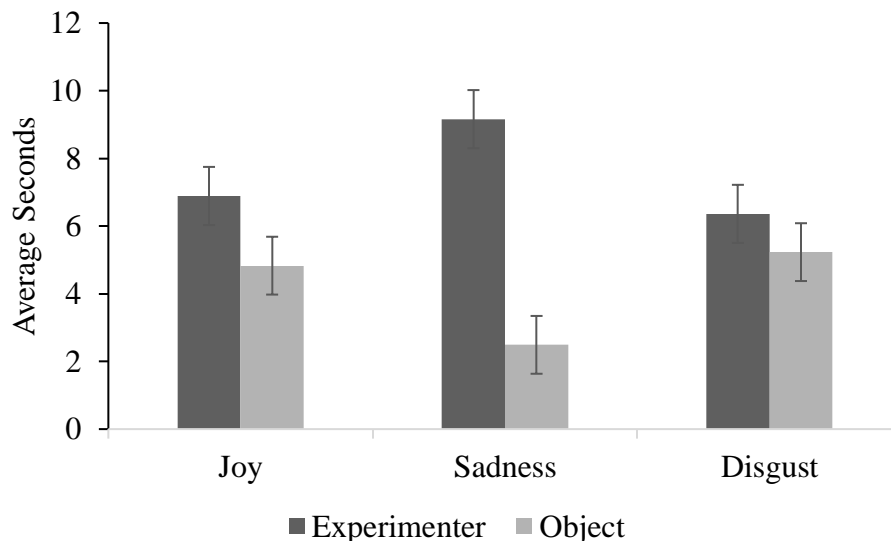


Figure 7. Infants' average looking time in seconds to the experimenter and object during labeling trials across emotion conditions. Error bars represent +/- 1 SD.

Test Trials

Ten out of the 12 infants were on task during test (99% of the time on average). The 2 off task infants were only on task 22% of the time and also did not point in the test trials, and were thus excluded from all analyses of the test trials.

Infant Looking. Infants looked at the objects before pointing for an average of 4.65 seconds ($SD = 2.27$ seconds; $M_{\text{joy}} = 3.77, SD = 1.91$ seconds; $M_{\text{sadness}} = 5.22, SD = 3.08$ seconds; $M_{\text{disgust}} = 4.98, SD = 1.81$ seconds). Of that time, infants looked at the target for an average of 2.73 seconds (59% of the time in test). Specifically, infants looked at the target labeled with joy for 1.99 seconds (53% of the time in test), sadness for 3.20 seconds (61% of the time in test), and disgust for 3.10 (62% of the time in test). Paired samples t -tests were used to compare the DLS that controlled for differences in trial duration. Results indicated that infants did not differ in their looking to the target between joy and sadness conditions, $t(10) = 0.20, p = .88$, joy and disgust conditions $t(10) = 1.83, p = .17$, or sadness and disgust conditions, $t(10) = 0.12, p = .91$.

Infant Pointing. Ten out of the 12 infants pointed in test. On average, infants took 4.65 seconds ($SD = 2.27$ seconds) to point on each test trial ($M_{\text{joy}} = 3.77, SD = 1.91$ seconds; $M_{\text{sadness}} = 5.22, SD = 3.08$ seconds; $M_{\text{disgust}} = 4.98, SD = 1.81$ seconds). Infants selected the correct stimulus for the word in test on 73% of total test trials. Specifically, infants selected the correct joy target 67% of the time, the correct sadness target 80% of the time, and the correct disgust target 73% of the time. Chi-square tests were conducted to determine whether infants differed in their selection of the correct vs. alternate object

between emotions. No significant differences were found between emotions, $X^2(3, 10) = 0.68, p = .71$, indicating that infants learned the novel label similarly across emotions.

Discussion

This study investigated the effect of discrete emotion communication on infants' attention and ability to learn words for novel objects. In line with our first hypothesis, findings from the labeling trials showed that infants attended more to the experimenter than the object during sadness labeling trials than during joy and disgust trials. However, in opposition to our second hypothesis, 2-year-olds learned novel word-object associations similarly when communicated with joy, sadness, and disgust. These preliminary results demonstrate that while emotions may influence infants' attention to adults' and objects, they may not impact infants' word-object learning. Nonetheless, these findings add to the limited literature on discrete emotions' role in communicating referential intent and promoting word learning.

The differences in the amount of time 2-year-olds looked to the experimenter's expression compared to the novel object during the labeling events correspond with previous literature on infants' attention to emotional agents and objects. Specifically, infants' increased attention to the experimenter when she expressed sadness is in line with previous research demonstrating that sad caregivers attract infants' attention and prosocial behavioral responses and research that demonstrates that caregivers direct infants' attention to sad individuals over referents (Knothe & Walle, 2017; 2018; Zahn-Waxler et al., 1992). Conversely, infants' have been found to increase their attention to disgusting referents and receive more parent talk about disgusting referents (Knothe & Walle, 2017; 2018; LoBue & Rakison, 2013). However, 2-year-olds showed no difference between looking at the experimenter or the object during the disgust labeling events in the present study. This may have been because the object in the present study was not inherently disgusting (e.g., LoBue & Rakison, 2013), and therefore infants looked to the experimenter more to disambiguate the emotional signal that was directed toward the referent.

The results from infants' pointing in the test trials demonstrated that infants learned novel word-object associations when objects were labeled with joy, sadness, and disgust. To my knowledge, this is only the second study to show that toddlers can learn novel word-object pairs when labels are communicated with negative emotions (also see Ma et al., 2019). Importantly, the present study adds to the previous findings by demonstrating that 2-year-olds can learn the words for objects from dynamic discrete emotional displays, as opposed to static, valance-based labeling. The addition of dynamic labeling videos bolsters the ecological validity of our design. Further, the use of discrete emotions demonstrates that emotions, even of the same valence, differentially influence infants' attention, albeit perhaps not word-learning. Thus, uncovering the differences and similarities that discrete emotion communication has on infants' attention and word-learning provides a more nuanced picture of the underlying processes that contribute to infants learning of the words for objects.

Infant Attention to Discrete Emotion Contexts

The results of infants' looking behaviors to dynamic emotional events adds a novel component to the literature on infants' attention to emotional agents and objects. While many studies have assessed infants' visual attention to emotional faces (see Hoehl,

2014 for a review) and emotional referents (see Lobue & Rakison, 2013 for review), none to my knowledge have examined how dynamic emotional communicative cues influence infants' attention to agents compared to a novel object. This novel contribution is noteworthy because it may provide future insights into how emotional communication affects infants' attention and understanding of referential intent. Specifically, the attentional differences found between discrete emotions provides a novel lens for assessing how infants' attention to adults and objects relates to their inferences of referential intent and word learning.

In fact, experiments that include discrete emotions may provide insights on fundamental theoretical questions related to how infants learn the words for objects. It is not known whether the total amount of attention to objects is more predictive of word-object learning than quick, potent learning instances (see Gleitman & Trueswell, 2020 and Suanda et al., 2019 for competing accounts). The attentional difference between discrete emotions found in the present study provide a novel test of these two viewpoints. Specifically, if the overall amount of attention to objects is what facilitates word learning, then sadness should diminish the learning of word-object pairs. Rather, if the timing of infants' attention during naming events is more potent for word learning, then all emotions may generally facilitate word learning since they signal individuals' significant relations with referents and infants still attended to the object during labeling events during the sadness stimuli (Walle & Lopez, 2020). Thus, discrete emotion communication provides a novel window into the processes that underlie infants' word-object learning because it influences infants' real-time attention during word-to-world naming events.

Limitations and Future Directions

It is worth noting the limitations and possibilities for further research from the present study. First, the small sample size limits the clarity and generalizability of the findings. The predicted sample size needed to test the effect of discrete emotions on infants' word learning was 48 infants. In its current form, the study obtained just 12 usable participants because of the forced stoppage of testing due to the COVID-19 pandemic. Future research conducted with a larger sample size could detect moderate effect sizes that may unveil further differences between discrete emotions on infants' attention and word-object learning.

Second, the participants in the study were likely too old for the word learning paradigm. Most 2-year-olds in the present study learned the word-object associations and this may have created a ceiling effect that reduced the amount of variance in the results. Future research should consider using 20-month-old infants in this paradigm to create more variability in the results since infants at this age have still been shown to preferentially look at the target more than the alternate object in test after labeling events (see Ma et al., 2011). Additionally, a more nuanced analysis of infants' attention could be utilized to assess the temporal dynamics of infants' visual attention to emotional object-directed communication.

Finally, although the paradigm that was utilized is well validated and controlled, it may not reflect how infants learn the words for referents in the real world. Remarkable strides have been made in the last decade to empirically assess infants' word-object learning and real-time attention. Methodological techniques such as head-mounted eye-

cameras placed on infants in the naturalistic home environment without an experimenter present have provided a more ecologically valid picture of infants' everyday word learning and attentional experiences (see Clerkin et al., 2017). However, these methodologies have not yet been used to assess infants' learning and attention from naturalistic emotional communication. Notably, this methodology would also serve to mitigate concerns over posed and exaggerated emotional expressions used in much of developmental emotion research (e.g., Hoemann et al., 2020). The present study provides a necessary first step to understanding how dynamic emotional communication influences infants' attention and learning about objects and referential intent.

Chapter 5

Recent advances in developmental research have shown that infants learn the words for objects from contingent word-to-object communication that provides referential clarity (Gleitman & Trueswell, 2020). The studies presented in this dissertation demonstrate how verbal and emotional interpersonal communication influence referential intent and learning about objects in infancy. Here, I consider how these findings inform our understanding and provide future avenues of research on the role of interpersonal communication in learning about objects.

Chapter 2 supports a host of research demonstrating the importance of parents' object-directed verbal communication for facilitating word learning (e.g., McQuillan et al., 2019; Suanda et al., 2019). Novel to the studies presented in Chapter 2, encouraging infants' object-directed actions was related to crawling, but not walking, infants' receptive vocabulary size. This finding is intriguing considering that walking infants initiate more object-directed actions (Karasik et al., 2011), receive more object-directed verbal feedback from parents (Karasik et al., 2014), and know more words (Walle & Campos, 2014) than their same-age crawling peers. The increased vocabulary evinced in walking infants may be the result of this more advanced locomotor group receiving more verbs and object labels around their object-directed actions (West & Karasik, 2021). The results of Chapter 2 corroborate this notion, as crawling infants who received more caregiver object-directed verbal input, which included verbs and labels, knew more words than crawlers who did not. Indeed, receiving object labels and verbs contingent upon object-directed actions has been associated with word learning (Pereira et al., 2014; Suanda et al., 2019). The findings in Chapter 2 provide further support for the link between infants' object-directed actions and caregivers' object-directed verbal input supporting early word learning.

Infants also learn about objects from observing others' object-directed actions. Chapter 3 found that 2-year-olds can use sampling probabilities and emotions to infer an agent's intentions of selecting an object out of a sample. Specifically, infants inferred an experimenter's intentionality by giving her the object that she had previously selected when she expressed joy or disgust after non-random sampling events, but not when she expressed sadness or sampled at random. This shows that infants in the second year of life infer that an agent can intentionally select a preferred or an unpreferred object from a sample based on the discrete emotion expressed. This finding has implications for how infants infer intentional object-directed actions from adults' emotional reactions after their object-directed actions.

Moreover, these findings demonstrate that infants understand that emotions communicate agents' intentions to act on a specific object. Curiously, this was the case for joy and disgust, but not sadness. There are several reasons why only certain emotions communicated intent to infants. First, an individual could reasonably act to intentionally obtain an object which makes them happy (Reschke, Walle, & Dukes, 2017) or disgusted (Rozin & Fallon, 1987), but it would be strange for an agent to intentionally select an object that makes them sad (Reschke, Walle, & Dukes, 2017). Second, sadness may have drawn infants' attention away from the objects and sampling distribution, thereby causing the infants to miss whether the sampling event was intentional (Kushnir et al., 2010) because sadness directed infants' attention to the experimenter's face (e.g., Zahn-Waxler

et al., 1992). Both possibilities align with the function of disgust, which motivates the calculated avoidance and removal of contaminated referents (Cosmides & Tooby, 2000; (Rozin & Fallon, 1987), and sadness, which prompts increased attention and prosocial responses to alleviate distress (Zahn-Waxler et al., 1992). Taken together, the results of Chapter 3 demonstrate that discrete emotions communicate different intentions to act on objects that correspond to their function and relational significance of the expressor to the object (Walle & Lopez, 2020).

Chapter 4 combined findings from Chapter 2 (i.e., object-directed verbal communication facilitated infants word learning) and Chapter 3 (i.e., discrete emotions differentially communicate intentions to act on objects) to assess how object-directed verbal labeling communicated with discrete emotions influenced infants' attention and word learning. Findings indicated that infants learned the words for objects when an experimenter expressed joy, sadness, and disgust, but infants' attention to the object compared to experimenter during labeling events differed between discrete emotions. Specifically, infants attended more to the experimenter than the object during sadness labeling events but looked similarly at these elements in joy and disgust labeling events. This finding is in line with previous research indicating increased infant attention and behavioral responses to sad individuals (Zahn-Waxler et al., 1992) and parent talk to their infants about the sad individual rather than the source of the sadness (Knothe & Walle, 2019). Further, this looking time difference also provides a possible explanation for why sadness did not communicate intent in Chapter 3. Namely, infants' attention may have been diverted from the sampling distribution of objects to the experimenter's sadness expression.

The results from Chapter 4 also underscore a broader theoretical consideration: emotional communication may provide a window into the process of how infants learn the words for objects. Competing perspectives have debated whether the amount of infants' object engagement facilitates word-object learning (Suanda et al., 2019), which may garner some support from the results from Chapter 2, or if learning occurs during peak instances when infants can most efficiently derive referential intent and a word-to-world matching between word and object (Gleitman & Trueswell, 2020). Assessing learning about objects from emotional communication provides an additional lens to understanding this process. As discussed in Chapter 1 and suggested from the findings in Chapter 4, discrete emotions differentially influence infants' attentional engagement toward objects and individuals. However, just as crucial is acknowledging that emotions are a potent signal for attending to significant relations between individuals and objects in any given instant (Walle & Lopez, 2020). Therefore, examining infants' word-object learning process from the lens of emotional communication may illuminate a more nuanced picture of how infants learn about objects.

The collection of the studies in this dissertation demonstrate that both interpersonal verbal and emotional communication are important and exert distinct influences on learning about objects in infancy.

Avenues for Future Research

The studies in this dissertation provide multiple avenues of future research. A central theoretical question arises when considering the influence of emotions on infants' learning about objects: what information do emotions contribute to objects?

The findings from Chapter 4 did not demonstrate that discrete emotions had an effect on infants' word learning. This may have been because emotions enhance word learning generally due to their signaling of individuals' significant relations with the environment (Walle & Lopez, 2020). Perhaps a better outcome to assess would be the influence of emotions for learning the value about objects. Emotions communicate the significance that one attaches to a referent (Clement & Dukes, 2017). Thus, emotions may not necessarily facilitate the learning of object labels, but rather how an object should be valued in a social context. Recent theory on the role of affect in social learning processes corroborates this view. Dukes and Clement (2019) discuss that emotions communicate value to referents because they relate to the personal importance placed on objects and convey how others should feel about objects. As such, emotions correspond with various object values, such as aversion, contamination, or ownership, depending on the discrete emotion.

Deciphering the value of an object extends beyond the perception of physical object features to discerning the significance of the referent to the self and others (Gelman & Echelbarger, 2019). For example, one cannot necessarily determine if a dog is dangerous, sick, or has an owner from its physical attributes. This opaqueness of object values is what makes emotions such powerful means of communication. Without approaching a dog to determine if it will bite, observing someone else's fear can communicate that the dog is dangerous (Cosmides & Tooby, 2000) and contributes an aversive negative informational value to the dog (Vaish et al., 2008). Disgust, on the other hand, signals avoidance of spoiled or aversive foods (Cosmides & Tooby, 2000), and links to the object value of contamination (Gelman & Echelbarger, 2019). Interestingly, infants' object directed behaviors in Chapter 3 align with some understanding of contamination, demonstrated by infants helping to rid the disgusting objects from the larger sample. In the case of anger and sadness, infants' tendency to attend to agents in relation to objects during social referencing may correspond to ownership object values. Indeed, young children can infer ownership from adults' sadness toward broken toys (Pesowski & Friedman, 2016) and link adults' anger to specific objects (e.g., Repacholi & Meltzoff, 2007). In summary, fear may signal aversion, disgust decontamination, and anger and sadness ownership object values.

Future research is needed to further test how specific emotions may imbue objects with value. Indeed, the associations between emotions and object values adheres to infants' visual tendencies and behavioral responses, as fear and disgust result in increased attention and avoidance of objects while anger and sadness result in increased attention and responding to caregivers. However, as in word learning, the role of emotions in learning object values is understudied. Only a handful of studies have assessed the role of emotion on learning object values (e.g., Cleroux, & Friedman, 2020; Pesowski & Friedman, 2016). This may be because examining which value an infant or young child prescribes to an object is a difficult learning outcome to index. Many of the methodologies utilized throughout this dissertation (e.g., looking time, behavioral responses, and caregiver reports) provide numerous avenues of future research to assess how children learn object values from emotional communication.

As a whole, this dissertation has shown that verbal and emotional communication influence *how* infants learn about objects. Future research should continue to consider

these forms of communication in tandem to determine the similarities and differences in their functional communication, as well as *what* is learned from each communicative form.

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