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A Tactful Conceptualization of Joint Attention: Joint Haptic Attention and Language Development

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ABSTRACT

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Research investigating associations between joint attention and language development have thus

far only investigated joint attention by way of visual perceptions while neglecting the potential

effects of joint attention engaged through other sensory modalities. In the present study, I aimed

to investigate the joint attention-language development relationship by investigating the possible

links between joint haptic attention and language development, while also exploring the likely

contributions of joint visual attention through a mediation analysis. Using video recordings from

an archival dataset, measures of joint haptic attention and joint visual attention were derived

from behavioral tasks, and measures of vocabulary development were attained from a caregiver

reported measure. Analyses revealed that joint haptic attention was associated with joint visual

attention, and that joint visual attention was related to language development; however, there

were no significant associations between joint haptic attention and language development. Study

limitations, future directions, and conclusions are discussed.

ACKNOWLEDGEMENTS

This work would not have been possible without the accomplishments of many great minds, too many to note here, who's theory and research ignited my curiosity and inspired me to follow in their path of empirical enlightenment. That said, at many times this seemingly endless path was dark and fraught with the horrors of uncertainty, self-doubt, fatigue, and failures; and although my journey is not over, it is with the greatest of humility that I stop to thank those individuals who have helped me to make it this far.

To my guide and mentor, Dr. Wallace Dixon, Jr. Thank you for being there to show me where to turn when I was lost, for advising me when problems arose, and above all – for your command of knowledge and love of a good debate, without which the following exposition would have fallen short. To my dissertation committee and the broader faculty of the department of psychology at East Tennessee State University, I thank you for your wisdom and the various perspectives you opened my eyes to, I am a better person and researcher for it. To my most loyal advocates and supporters, my family and friends, I would have given up on myself and this journey long ago without your boundless and ceaseless encouragement, thank you. And lastly, I give thanks to my light and love, my husband and son. To my husband, for selflessly helping me to pursue my goals, for keeping me laughing when all I wanted to do was cry, and for simply accompanying me on this journey – I look forward to a lifetime of journeys to come; and to my son, thank you for your kicks to the ribs which woke me from my three o'clock lassitude to get me back to my writing, my love for you and your father has been the greatest motivation of all!

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CHAPTER 1

INTRODUCTION

Within the philosophical and psychological literatures, there is robust theoretical and empirical evidence identifying the nature of a relationship between language and cognition. For instance, Vygotsky theorized language to play a crucial role in socio-cognitive development, by affording children the ability to understand social rules and control their own behaviors (Vygotsky, 1987). Experimental findings seem to support such theories, as early oral language skills have been found to be related to measures of school readiness and academic success, wherein self-control and knowledge of social rules are essential for favorable outcomes (Snow, 1991; Storch & Whitehurst, 2002). Also, more recent investigations into dual language learning have revealed that children who speak two or more languages frequently display advances in executive function measures such as attention, inhibition, and working memory compared to monolingual children (Carlson & Meltzoff, 2008).

Because of the important role language plays in thought and behavior, history is replete with models suggesting possible routes to, and constructs involved in, the process of language development. One heavily studied construct involved in the process of language acquisition is joint attention. Joint attention refers to dyadic or triadic exchanges between a child, a caregiver, and an object; wherein attention to the object is shared between the child and caregiver (Kim & Mundy, 2012). It is theorized that by participating in joint attention, children are granted additional stimuli, such as an object's label, which they would not have received while exploring on their own. To be sure, studies of joint attention and language have repeatedly and reliably evidenced strong links between a child's proclivity towards joint attention participation and

language development (Mundy & Gomes, 1998; Salley & Dixon, 2007; Todd & Dixon, 2010; Tomasello, 1988).

While studies of joint attention have proven to be a fruitful area of investigation concerning language development, to my knowledge, studies of joint attention have thus far almost exclusively examined the process of joint visual attention, or the sharing of gazes and visual stimuli between social partners. However, joint attention can be shared across a variety of modalities. Consistent with embodied theories of cognition, in which cognition and language develop through bodily interactions with the surrounding environment, it stands to reason that an investigation of joint haptic attention (e.g., shared attention to one's tactile, proprioceptive, and kinesthetic perceptions that are the result of bodily interactions with stimuli) may offer additional insights into the development of cognition and language (Botero, 2016; Howen, Visser, van der Putten, & VlasKamp, 2016).

In the following sections, I will describe the nature and development of joint visual attention, as well as its two primary forms and developmental course as described in the literature. Next, I will discuss joint visual attention relations with language development, theories of joint visual attention-language associations, and empirically supported moderators of the joint visual attention-language relationship. Following, I will introduce and define joint haptic attention, present theories suggesting specific utilities of the study of joint haptic attention, and describe how joint haptic attention may relate to both joint visual attention and language development. Finally, I will conclude with specific hypotheses concerning the role of joint haptic attention on the joint visual attention-language development relationship.

Joint Attention (JA)

As described by Seibert and Mundy (1982), the capacity for joint visual attention refers to an individual's ability to share visual attention towards an object or event with a social partner. This ability to coordinate visual attention usually begins to develop at around four months of age, and continues to develop and mature through early childhood (Mundy, Block, Van Hecke, et. al., 2007). Because joint attention has been shown to develop across cultures and child rearing practices, most researchers agree to the conceptualization of joint attention as a phylogenetic evolutionary adaptation, which now presents itself as a universal process in social animals (Tomasello, Carpenter, Call, Behne, & Moll, 2005); however, debate continues as to the specific nature and functions of joint attention.

Joint attention researchers have identified two main forms of joint attention; responding to joint attention (RJA) and initiating joint attention (IJA; Mundy & Newell, 2018). RJA, which begins to develop at around 12 months of age (Mundy, Block, Van Hecke, et. al., 2007), refers to instances wherein an individual is able to follow the gaze or gestures of a social partner in order to focus attention on a shared referent. For instance, a mother may point upwards to the sky at a passing airplane, and the child would follow the mother's pointing gesture and eye gaze in order to share attention to the flying object. In a dynamic and complex world, this ability helps a child to understand which referent a social partner is referring to at any given time.

Alternatively, IJA which typically does not begin to develop until 18 months of age, and continues to mature through early childhood, refers to an individual's ability to use gestures and eye gazes in an effort to request attention sharing with a social partner toward a common referent (Mundy, Block, Van Hecke, et. al., 2007; Mundy & Newell, 2018). For example, children may point upwards at a passing airplane in an effort to have the mother follow their pointing gesture

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and share attention to the flying object. Unlike RJA, this ability allows an individual to request specific attention and information from social partners.

<p style="text-align:center;">Joint Attention and Language Development (LD)</p>

Although both forms of joint attention have been associated with social and cognitive processes broadly (Mundy & Gomes, 1998; Mundy & Newell, 2018; Todd & Dixon, 2010), many researchers have specifically focused on the relationship between joint attention and language development (e.g., Tomasello, 1988; Mundy & Gomes, 1998). Because children learn language in dynamic settings with continuously changing objects and activities, it has been theorized that joint attention with their social partners organizes infants' opportunities to gain novel insights regarding the mapping of specific labels onto referents in the environment (Salley, Panneton, & Columbo, 2013).

To be sure, there is a well-established literature linking joint attention to language learning outcomes (Tomasello, 1988; Tomasello & Farrar, 1986). For instance, measures of gaze following, or RJA as measured in infancy and toddlerhood, have been found to be strong predictors of receptive language development (Mundy & Gomes, 1998). Additionally, in a study by Morales et al. (2000), higher RJA as measured at 6, 8, and 10 months was found to be associated with better receptive language performance at two years of age. Investigations of IJA have also identified strong ties to language development. Ulvund and Smith (1996) found IJA, as measured at 13 months, to be significantly correlated with both receptive and expressive language development at 2, 3 and 5 years of age; while Mundy and Gomes (1998) found IJA measured between 14-17 months to be associated only with expressive language abilities at 18 months.

While there is a well-established link between visual joint attention and language development, researchers are also aware that this relationship is dependent on many factors. Because of the developmental course of joint attention forms (i.e., RJA & IJA) and the various measures of language development (e.g., expressive versus receptive), the relationship between joint attention and language has been shown to differ as a function of age (Mundy, Block, Van Hecke, et. al., 2007). Additionally, because joint attention is dependent on a social relationship between a child and a social partner, research has also shown the joint attention-language development relationship to be dependent on a child's attachment type (Claussen, Mundy, Mallik, & Willoughby, 2002). Specifically, children embedded in secure attachment relationships are better able to engage in joint attention than are children classified as having a disorganized attachment type.

Further, for an individual to engage in a bout of joint attention, the individual must have the ability to control and maintain attention, as joint attention inherently requires attentional control in order to coordinate attention with others, as well as be interested in engaging with social partners in the first place. Thus, joint attention-language development relationships have been shown to be moderated by the temperamental superdimension of effortful control (Dixon & Salley, 2007) as well as developmental disorders related to social engagement such as autism spectrum disorder (Dawson et al., 2004).

In summary, the literature above presents evidence of the well-established joint attention-language development relationship and moderators thereof. However, there remains a curious point to this body of literature. Since the inception of the term joint attention, research has operationalized joint attention as gaze following or initiating behaviors, a purely visual perspective of what should be a multimodal concept. Therefore, research investigating the joint

attention-language development relationship has almost exclusively investigated joint attention engagement by way of visual perceptions, while neglecting the potential effects of joint attention engaged through other sensory modalities. Communicative social exchanges are rarely exclusive to the visual modality, and in most cases employ multiple senses. Thus, in an effort to enhance our understanding of the complex coordination of attention and resulting benefits, researchers would be well-advised to begin to re-conceptualize joint attention.

At its core, joint attention is modality-neutral. That is, there is nothing inherent to the construct that ties it to the visual modality (although the visual modality may be the easiest to investigate and the easiest means through which to verify the existence of bouts of joint attention). Instead, the process of joint attention should be broadly conceptualized as attention directed toward an object, action, or person, shared with a social partner through any sensory modality (e.g., visual, haptic, olfactory, gustatory, or auditory). In addition, the temporal parameters of joint attention need not be constrained to discrete interactions taking place within short temporal windows, as typically happens with visual joint attention. Just as alternate sensory modalities are more temporally extensive than vision, joint attention may also be temporally extended. By expanding the traditional operationalization of joint attention, the concept of joint attention becomes more inclusive of the sensory modalities in which joint attending may take place, and affords researchers the opportunity to examine a wider range of shared experiences.

The sensory modalities most useful to investigate may be those involving touch, body positioning, and bodily movement, also termed the haptic senses (Botero, 2016). While visual sensations have been suggested to be more complex and numerous than haptic events, "their appearance is independent of the perceiver," which is to say that visual sensations can arise in

the absence of bodily activity (Streri & Féron, 2005, p.3). Haptic sensations, in contrast, can only arise through bodily activity. Moreover, haptic sensations reflect individuals' direct engagement with their environment, through which they can change and elicit future perceptual experiences (Streri & Féron, 2005). For example, only through engagement of haptic sensations can individuals explore the instrumental functions of the environment by transporting and modifying objects. Additionally, without haptic sensations, visual acuity and optimal depth perception would be considerably attenuated. It is through the movement of the eyes, head, and body that individuals are capable of gaining optimal depth perception and visual acuity in general, as even the most stationary visual gaze is accompanied by numerous, small-scale saccades of the eyes.

A second reason for considering haptic sensations over and above those arising from the visual modality has to do with the fact that haptic sensations resulting from agentic engagement of the body with the environment provides infants with essential data for comprehending objects and others as physically independent of themselves (Botero, 2016). Whereas in vision, sensory receptor transduction results from light energy striking photoreceptors in the retina, haptic receptor transduction has been suggested to result from pressure detectors in the corporeal body (e.g., skin and muscles; De Vignemont & Massini, 2014). This pressure, or feeling of physical effort or resistance against the body, stands as the singular experience that presents individuals with data regarding an independence between the body and the physical world (De Vignemont & Massini, 2014). While visual and other sensations may indeed present individuals with a sense of independence between the body and *properties* of the physical world, such as event locations and timing, it is the physical existence-independence that privileges haptics over other senses (De Vignemont & Massini, 2014). This polarity between the self and the external world

experienced through haptic sensations may induce a polarity in cognitive conceptualizations of self and others, which has been suggested as a necessary foundation for engagement in joint visual attention (Botero, 2016; Mundy, Block, Van Hecke, et. al., 2007).

It is worth noting that in many cultures, such as the Zincanteco in Zambia, adults have fewer opportunities for eye contact, or facial gazes in social interactions with infants (Brazelton, 1973), as infants are typically strapped to the hips of their mothers throughout the majority of the day. Due to this positioning, mother and child rarely meet or share gazes, and instead primarily interact through tactile stimulation, although shared auditory and olfactory experiences can also be assumed. When compared to American infants, children from this Zambian culture did not exhibit any significant social delays as measured by the Brazelton (1973) Neonatal Behavioral Assessment; and surprisingly, infants from the Zambian culture were scored as having higher social interest than their American counterparts (Brazelton, 1972). Studies such as this suggest that constructs necessary for joint attention, such as social interest, can develop through various modalities, and should encourage us to investigate the role of joint attention in sensory modalities beyond that of vision.

<u>A Tactful Conceptualization of Joint Attention: Joint Haptic Attention</u>

In her article *Tactless scientists: Ignoring touch in the study of joint attention*, Botero (2016) argues that the inclusion of haptic perceptions in our conceptualization of joint attention will only serve to bolster our understanding of the nature, development, and impact of joint attention processes. As noted in the previous section, by haptic perceptions, I refer to tactile sensations resulting from the stimulation of sensory receptors found all over the body. For touch, such sensory receptors include the Ruffini cylinder and Pacinian corpuscles found within the skin (Goldstein, & Brockmole, 2017); for proprioception, these include the stretching of

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muscle spindles, Golgi tendon organs, and joint receptors on skeletal striated muscles, tendons, and joints, respectively (Purves, Augustine, Fitzpatrick, Katz, LaMantia, McNamara, & Williams 2001); and for kinesthetic sensations, these include the integration of proprioceptive sensations with sensations from vestibular sensory receptors such as the semicircular ducts, saccules, and utricles in the inner ear (Lincoln, n.d.).

Botero (2016) argues that an inclusion of haptic perception in joint attention research may allow for ontogenetically earlier studies of joint attention. Months before children have fully developed adult-like visual sensations, they have accumulated considerable experience perceiving the world through touch, proprioception, and kinesthetics. Consider the following: a mother holding her newborn child wrapped against her chest may become startled by a loud noise such as a dog barking or a doorbell ringing, and this startle reflex may cause the newborn to become distressed and to cry. Afterwards, once calmed herself, the mother may gently rub the newborn's head or back in a soothing fashion, which in turn, reassures the child and helps it to calm down. Here, without any need to resort to visual sensations, as the child could not view the mother's facial expressions when wrapped against the chest, a bout of joint attention ensued through the mutual detection of a corporeal experience.

More evidence that joint haptic attention occurs developmentally earlier than joint visual attention can be found in the study of facial mimicry. Here, infants of multiple species have been shown to mimic the proprioceptive experiences of their social partners, some as early as 42 minutes after birth (Meltzoff & Moore, 1983). While vision is indeed involved in this exchange, this joint sharing of haptic experiences occurs far sooner than joint attention exchanges through the visual modality, which typically do not occur until around 12 months of age (Mundy & Newell, 2018). Thus, facial mimicry presents joint haptic attention as one of the earliest forms

of joint attention (Meltzoff & Moore, 1983), as it does not require endogenous control of attention as is necessary for engaging in joint visual attention.

Lastly, haptic development and thus joint haptic attention may serve as important precursors to joint visual attention, using infants' capacity for understanding intentional agency as a vehicle. Many theorists agree that joint visual attention processes depend on a child's ability to recognize others as intentional agents (Mundy, Block, Hecke, Van, & Parlade, 2007). However, recent research points towards haptic perceptual development as the precursor to recognizing others as intentional agents (Botero, 2016; Libertus & Needham, 2011), primarily because haptic sensations provide infants with evidence of their own agency first. Libertus and Needham (2011) found that reaching experience increased 3-month-olds' attentiveness to faces. These results are consistent with the possibility that infants' enhanced attentiveness to faces was the result of their experiences with reaching, touching, and manipulating objects in their environment, which may have contributed to self-perceptions as intentional agents who can act on the world. Once an infant is capable of viewing herself as an intentional agent, she may then be better able to view others as intentional as well; which, in turn, would allow her to imbue the visual social cues found in the faces of her social partners with intentional meaning (however, as is typical in psychological investigations, these authors did not investigate whether infants also increased their attentiveness to nonvisual or non-facial cues). In sum, because the sharing of haptic sensations occurs ontogenetically sooner than the sharing of visual sensations, and because experiencing haptic sensations may provide a basis for the recognition of others as intentional agents, a suggested precursor to joint visual attentional processes, there is reason to suspect that haptic sensations, and the joint sharing thereof, may provide opportunities for, or may influence, joint visual attention.

Although haptic perception has not been the subject of joint attention research as it pertains to language acquisition and development, the importance of haptic perceptions in cognitive processing and language acquisition has been recognized in embodied theories of cognition. One such theory is the predictive processing model of cognition (Clark, 2015; Wiese & Metzinger, 2017). In brief, the predictive processing approach suggests that humans are constantly forming and updating predictions of the world around them. To do this, individuals compare two 'streams' of information; a bottom-up stream, which consists of sensory information that is being detected at any given point in time, as well as a top-down stream that consists of neural computations predicting what sensory information should be detected at that same point in time (Wiese & Metzinger, 2017). Because of the unlimited degrees of freedom in a constantly changing world, an individual's top-down predictions are often incorrect, which in turn signals a need to update the prediction for future use. The revision process is known as prediction error minimization, and it is continually in use from the beginning to the end of any action (Wiese & Metzinger, 2017)[1].

As an example of prediction and error minimization, consider an individual encountering a closed door. Usually when this happens, the individual reaches his arm forward to grasp and turn the door knob, then applies pressure on the knob to open the door. Say that each time the individual has encountered this door in the past, it has always been unlocked; thus, by way of top-down processing, the individual forms the prediction, consciously or unconsciously, that

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[1] Additionally, while it is generally assumed that predictions are stored in the brain in some respect, debate ensues as to the specific nature of prediction representations. Some argue that predictions are stored only as computational models, similar to Bayesian priors, while others feel predictions may be stored as mental representations, although not in the strict sense of representations within the Piagetian or information processing approaches (Wiese & Metzinger, 2017). Because the specific nature of prediction storage does not weigh on my research questions, I will remain agnostic to either theory (e.g., computations or representations) beyond suggesting that predictions are saved in some regard.

once the door knob has been grasped, turned, and pushed, the door will open. However, on this day, the door is locked, and the bottom-up sensory data received does not match the individual's top-down prediction; in fact, the sensory data received are indicative of the face and body crashing against the locked door. Because there is a mismatch between top-down and bottom-up processes, the individual's top-down prediction will be updated to reflect the fact that *sometimes* this particular door may be locked, and future attempts to open this door will reflect this change in prediction, by possibly testing the handle before assuming the door is unlocked.

Importantly, within the predictive processing model of cognition, cognitions (e.g., predictions and error minimization), perceptions, and actions are intricately linked; as individuals are unable to test and refine predictions without moving their bodies, interacting with the world, and using the resulting experiences to compare against a priori predictions (Clark, 2015; Wiese & Metzinger, 2017). Furthermore, because an individual's agency and engagement with the physical world results in haptic sensations, haptic sensations are essential components of predictive processing; as predictions are rendered in the haptic modality and haptic sensations serve as the data for error minimization (Clark, 2015; Wiese & Metzinger, 2017). It should be noted that while traditional models of cognition (e.g., information processing) tend to minimize the role of embodied sensations and actions in cognitive processes, the two approaches are not entirely incompatible. It is simply the case that the predictive processing model of cognition places a much higher priority on the role of haptic sensations in cognitive development.

Evidence for the close association between haptic perceptions, cognition, and language can be found in studies linking motor activity and development to cognitive function. Neuroimaging studies have shown that brain regions related to cognition (e.g., prefrontal cortex) and language (e.g., Broca's area) are co-activated during motor tasks such as action imitation

(Abe & Hanakawa, 2009; Nishitani, Schürmann, Amunts, & Hari, 2005). Action planning, observation, and understanding have also been associated with prefrontal and Broca's area activation (Abe & Hanakawa, 2009; Nishitani, Schürmann, Amunts, & Hari, 2005); and, although they do not activate haptic sensations, Clark (2015) suggests these operations are just as essential to prediction generation and modification by allowing an individual to essentially experience the action and resulting sensory stimuli through observation and imagination.

There has also been evidence of relationships between motor abilities and language. LeBarton and Iverson (2013) found the emergence of sitting skills to be associated with receptive vocabulary at 10 and 14 months of age. Libertus and Violi (2016) found walking status at 10 months to be related to larger vocabularies. And, fine motor skills measured between 12 and 18 months have been associated with expressive language at 36 months (Walle & Campos, 2014).

One of the most compelling links between motor/haptic sensation activation and language learning, however, has been demonstrated in studies concerning the role of gestures in communication and learning (Cherdieu, Palombi, Gerber, Troccaz & Rochet-Capellan, 2017; Iverson & Goldin-Meadow, 2005). Iverson and Goldin-Meadow (2005) not only found close associations between gesture use and language, but also that changes in gesture use predated, and predicted changes in language. Specifically, words that children first communicated through gesture later moved into children's verbal vocabulary, and children who used gesture-word combinations earlier (e.g., pointing to a dog and saying "run") also used two-word combinations earlier (e.g., "dog run"; Iverson & Goldin-Meadow, 2005).

Other studies have shown in adults that manual gestures facilitate language learning, and that seeing and imitating gestures during a learning session can prove to be particularly beneficial to recall of verbal labels (Cherdieu, Palombi, Gerber, Troccaz & Rochet-Capellan,

2017). In an experimental study comparing two groups, Cherdieu et al., (2017) found that adults who both saw and imitated gestures during a learning session were able to recall significantly more anatomical labels and localizations than a comparison group who only viewed the gestures. Studies of this nature suggest that activation of haptic sensations may provide supplementary cues to form, consolidate, and recall representations/predictions created during language learning, and further, that that coordination with a social partner can offer additional benefits.

Just as it is theorized that engagement in joint visual attention provides greater learning opportunities than visual engagement alone, it stands to reason that engagement in joint haptic attention would be similarly advantageous. Additionally, within the predictive processing theory of cognition, Clark's (2015) notion that observing the actions of others may be equal to self-generated action in prediction modification and generation gives further credence to the idea that engagement with haptic perceptions in a social exchange would prove more beneficial than haptic engagement alone; as children are given the opportunity to create and modify predictions based on the observations of their social partner's actions.

For example, a child exploring a novel object in solitude, say a TV remote control, might note the rubber buttons and the tactile sensation they may provide, and she might also find that she is capable of making noise with the remote by drumming it against the coffee table. However, with a social partner, she may be encouraged to engage in a wider range of uses for the remote such as using it as a make-shift telephone or microphone. The child may also view the social partner using the device in its intended fashion of pushing the buttons or pointing it towards the television, and be encouraged to imitate this action. By increasing the number of haptic perceptions she is exposed to through joint attention with a social partner, regardless of the fact that the visual modality was used in the service of establishing joint haptic attention, the

child might be granted the ability to form a more robust mental representation/prediction to be used for future problem solving or language learning opportunities.

To summarize, in the above sections I have recapped the reliable association between joint visual attention and language development, presented a new construct of joint haptic attention, and outlined how haptic sensations may subserve the development of joint visual attention and, eventually, language. In this accounting, joint haptic attention acts as a substrate upon which joint visual attention develops, which raises the possibility that joint haptic attention may itself to be related to language development. However, the specific nature of how joint haptic attention may underlie joint visual attention and language remains unknown.

It is possible that joint visual attention mediates the joint haptic attention and language development relationship through the contributions of joint haptic attention to joint visual attention. That is to say, the well-established link between joint visual attention and language development may be a function, partially or entirely, of the relationship between joint haptic attention and language. To the extent that haptic perceptual development is necessary for engagement in joint visual attention (e.g., understanding others as intentional agents, understanding movements, and using movements to gain new perspectives), and that joint haptic attention should provide opportunities for this development, it may be that infants who are more skilled in joint haptic attention also become more skilled in joint visual attention, which in turn would provide language learning benefits. This would be an example of a full mediation model, because the relationship between joint haptic attention and language development would be fully accounted for by the impact of joint haptic attention to the joint visual attention-language development relationship (Figure 1, where $c' = 0$). Alternatively, because joint haptic attention has been suggested to provide unique sensory experiences which are necessary for forming

robust mental representations/predictions, as is the case with gesture imitation and language

learning, it is also possible that joint haptic attention may provide individual contributions to

language development over and above that of joint visual attention. This would be an example

of a partial mediation model wherein joint visual attention may explain *some* of the variance in

the joint haptic attention-language development relationship, but a relationship remains between

joint haptic attention and language development even when controlling for the impact of joint

visual attention (Figure 1, where $c´ > 0$).
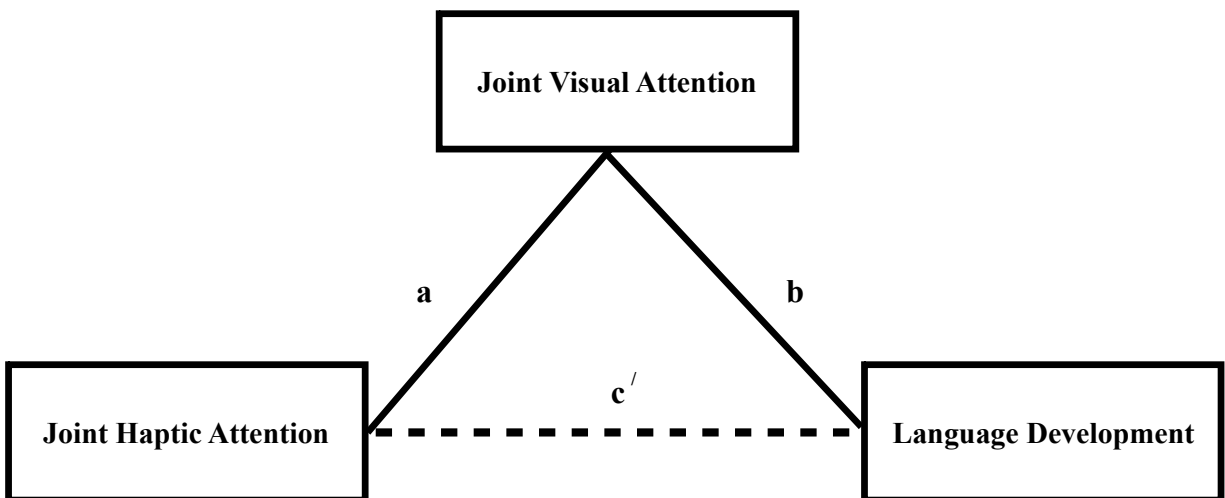
Figure 1: Illustrated Mediation Model of Relations Between Joint Haptic Attention, Language
Development, and Joint Visual Attention.

Current Study

The specific aim of the current investigation is to explore the specific nature of influence

that engagement in joint haptic attention may have on joint visual attention and language

development. Based on the line of reasoning reviewed above, I propose that infant participation

in joint haptic attention will provide a basis for joint visual attention-language development

relationships or offer unique contributions to language development as evidenced through a full

or partial mediation model (Figure 1 where $c' = 0$, or Figure 1 where $c' > 0$, respectively). A significant full mediation model would suggest that participation in joint haptic attention provides necessary skills for the engagement of joint visual attention and, as a consequence, language development. Alternatively, a significant partial mediation model would suggest that participation in joint haptic attention provides individual contributions to language development beyond that of joint visual attention. Additionally, as stated in the introduction, relations have been found between joint visual attention and both receptive and expressive language measures. While I do not expect differential relations to be found in mediation analyses between the two language measures, I do plan to test the mediating effect of joint visual attention on both receptive and expressive language. Specific hypotheses for the current investigation include:

- H1: My three variables of interest: joint visual attention, joint haptic attention, and language development, will show significant and positive linear associations with one another in the following ways:
    - H1A: Because joint visual attention and language comprehension and production have reliably been associated in previous literature, the current sample will show a positive and significant linear relationship between the three.
    - H1B: Because recent studies have shown associations between motor development and language comprehension and production, joint haptic attention and language development in the current sample will be significantly and positively correlated with one another.
    - H1C: Because haptic perceptual development has been proposed as a substrate for joint visual attention development, and because the social sharing of haptic attention in bouts of joint haptic attention should provide additional benefit, joint

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haptic attention and joint visual attention in the current sample will be

significantly and positively correlated with each other.

- H2: Because of the hypothetical associations between joint haptic attention, joint visual

  attention, and language development, I posit that joint visual attention will either fully or

  partially mediate relations between joint haptic attention and language development.

  Specifically:

  - Because joint haptic attention has been presented as a precursor to joint visual

    attention and has the potential to influence receptive and expressive language

    through joint visual attention, and further, because joint haptic attention has been

    suggested to provide unique sensory experiences which are necessary for forming

    robust mental representations/predictions, relationships between joint haptic

    attention and language comprehension and production will be mediated, either

    fully or partially, by joint visual attention. Specifically, contingent upon the

    acceptance of H1 showing significant and positive associations between joint

    haptic attention, joint visual attention, and language comprehension and

    production, a mediation analysis will reveal that joint visual attention either fully

    accounts for the relationship between joint haptic attention and language

    comprehension and production, or that joint haptic attention provides unique

    contributions to language comprehension and production over and above that of

    joint visual attention (Figure 1).

CHAPTER 2

METHODS

Participants

Data for the present investigation was derived from an archival dataset collected between 2015 and 2017 by The Program for the Study of Infancy at East Tennessee State University. Eighty-eight infants (48 males) between the ages of 12 and 20 months ($M = 15.40$ months, $SD = 1.71$ months) participated in a one-time laboratory visit which generally lasted around 45 minutes. Participants were primarily from high income families ($M = \$68,758$, $SD = \$51,503$), although there was large variation in this measure. The primary caregiver ranged in age from 21 to 41 years of age ($M = 31.18$, $SD = 4.76$), while the secondary caregiver ranged in age from 21 to 59 years of age ($M = 34.8$, $SD = 6.71$).

All participants were identified through the Tennessee Bureau of Vital Statistics and were contacted by phone to determine interest. If caregivers were interested in participating, they were sent a package in the mail containing five surveys to be completed and returned to the laboratory at the time of their visit; however, not all surveys (see below) were relevant to the current study. Once in the laboratory, experimenters briefed caregivers about the study, reviewed the informed consent documents, and addressed any questions. At the conclusion of the visit, caregivers and infants were compensated with a $20 gift certificate and were allowed to ask general questions concerning child development.

Materials and Tasks

As part of a larger study, participants engaged in multiple behavioral tasks at the time of their visit. Of the five surveys caregivers completed, three were relevant for the current investigation, the *MacArthur-Bates Communicative Development Inventory: Words and*

Gestures (CDI-WG; Fenson et al., 2007); the *Infant Behavioral Questionnaire-Revised Version* (IBQ-R; Gartstein & Rothbart, 2003); and a demographic questionnaire. These were used to assess infant receptive and productive vocabulary, the superdimension of effortful control and subdimensions thereof, as well as child age, respectively. Behavioral tasks relevant to the current study included a modified version of Brooks and Meltzoff's (2005) gaze following procedure, and a task called Elicited Imitation with Inappropriate Object Substitution (EIIOS). These tasks were used to assess infant joint visual attention and joint haptic attention, respectively.

Caregiver Report Measures

Language. The CDI-WG is a caregiver report checklist which measures infant vocabulary comprehension and production. Specifically, caregivers report on their children's understanding of and ability to say 396 words grouped into 19 lexical categories, comprising noun and predicate (i.e., adjective and verb) open-class forms as well as a variety of closed-class forms (e.g., prepositions, pronouns, and conjunctions). Caregiver reports can be summed to derive scores of total vocabulary comprehension and production. Measures derived from the CDI-WG for the current study included total language comprehension and total language production.

Behavioral Tasks

Gaze Following. Infant joint visual attention was derived from a gaze following procedure similar to Brooks and Meltzoff's (2005) procedure. In our case, infants were seated on their caregiver's lap across the table from an experimenter who placed a colorful carousel toy on each side of a six-foot by three-foot rectangular table, outside of the child's reach. The experimenter then gained eye contact with the child by calling the child's name, saying "Look,"

and then alternating looks to each of the carousel toys for eight seconds each. Experimenters made sure to regain infant eye contact in between gazes by first waiting for spontaneous eye contact. If the child did not spontaneously look back to the experimenter's face, the experimenter then tried nonverbal strategies such as tapping their nose to elicit eye gaze; and finally, if nonverbal strategies did not work, the experimenter would then call the child's name to gain eye contact. The task was composed of six total trials (i.e., experimenter alternating looks to the carousel toys). The first three gazes occurred under normal conditions, while the final three gazes occurred in combination with an exogenous distractor (i.e., a brief eight-second Elmo video playing on a monitor mounted on the wall behind and above the experimenter, in view of the infant). For purposes of the present study, joint visual attention was defined as the total amount of time an infant spent looking at the same colorful carousel toy as the experimenter, during the period of time that the experimenter was looking towards the carousel toy. Only joint visual attention during non-distracted trials were used.

EIIOS. To evaluate an infant's ability to participate in joint haptic attention, a measure of elicited imitation with inappropriate object substitution (EIIOS), a measure originally employed to assess gesture imitation and executive function, was employed. In this task, as in gaze following, children were seated on their caregiver's lap across the table from an experimenter. The EIIOS task consisted of four trials. On each trial, the experimenter presented the child with one of four toys: bear, brush, cup, or car. The child was allowed to explore the toy for 30 seconds. After the initial exploration period, the experimenter retrieved the toy and modeled a canonical action for the toy (i.e., hug the bear, use the brush to comb one's hair, sip from the cup, and 'drive' the car). The child was then given the toy for another 30 seconds as an opportunity to imitate the experimenter's actions, with the experimenter cue "Your Turn!" After the

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canonical trial, the experimenter once again retrieved the toy, but this time modeled a non-canonical, or inappropriate, action for the toy (i.e., 'drive' the bear, sip from the brush, brush hair with the cup, and hug the car). The child was then given another 30 seconds to imitate the inappropriate action, again with the experimenter cue of "Your Turn!"

This procedure was repeated for each toy, with toy order of presentation randomized across participants to control for order effects. There were four order conditions. In each order condition, two of the four EIIOS trials were always presented in pairs, bear with brush and cup with car. Unrelated tasks were interposed between the bear/brush trials and the cup/car trials. In two of the order conditions the bear and brush tasks occurred first, while in the other two the cup and car tasks occurred first.

Joint haptic attention was measured by summing the total number of times a child successfully imitated experimenter canonical and noncanonical actions within each toy condition. Scores of canonical and noncanonical actions across toy conditions were then summed to compute a score for both total canonical action imitation and noncanonical action imitation. For instance, if a child successfully imitated four canonical and two noncanonical actions in the car condition, two canonical and zero noncanonical actions in the brush condition, one canonical and three noncanonical actions in the bear condition, and zero canonical and noncanonical actions in the cup condition, the child's total canonical score would be seven and the total noncanonical score would be five.

Also, because the familiarization period presented an opportunity to observe a child's natural predilection to perform either canonical or noncanonical actions without modeling or instruction, the total number of actions (e.g., canonical or noncanonical) performed during the familiarization period were subtracted from the total number of canonical and noncanonical

actions. For example, if a child had a total score of seven canonical actions and three noncanonical actions but performed a total of two canonical and one noncanonical actions during familiarization periods, the child's adjusted canonical score would be five and the adjusted noncanonical score would be two.

Although originally designed to measure gesture imitation and executive function, this task can also serve as a measure of joint haptic attention because, at its core, it requires infants to view and imitate a modeled action with specific haptic sensations. As noted in the introduction, imitation of actions and gestures are one way in which infants and their caregivers jointly share in haptic sensations, and this joint sharing of haptic sensations through imitation has previously been shown to positively influence learning and recall in a language learning task (Cherdieu, Palombi, Gerber, Troccaz & Rochet-Capellan, 2017).

Behavioral tasks were coded using DataVyu coding software version 1.3.7. Interrater agreement was ensured by using teams of human coders. Coding teams first viewed video-recorded study tasks (e.g., gaze following and EIIOS) to develop a system of rules for coding behavioral measures. For each task, rules stated that coders must agree as to whether a task was performed (e.g., looking towards the correct carousel toy or imitating experimenter actions) or not, and that codes of the same action from the two coders must appear within one second of each other in the DataVyu transcript. Once rules were derived, teams then independently coded ten percent of the total sample of video recordings to ensure an interrater agreement of 80% or above. To calculate interrater agreement, we divided total agreed upon codes by agreed upon plus non-agreed upon codes. Pre-coding interrater agreement for the gaze following task was 81%, and pre-coding interrater agreement for joint haptic attention participation ranged from 87.25% to 100% across the four toy conditions. Coders then independently evaluated the total

sample of video recordings. Post-coding interrater agreement was ensured by recoding ten percent of the total sample for interrater agreement. Post-coding interrater agreement in the gaze following task was 81%, and interrater agreement for joint haptic attention ranged from 89% to 95.75% across toy conditions.

Post-Hoc Measures

While not central variables of interest to the current study, the following caregiver report measures were used in post-hoc exploratory analyses.

Effortful Control. The Infant Behavior Questionnaire-Revised (IBQ-R; Garstein & Rothbart, 2003) is a caregiver report survey in which caregivers indicate on a scale of one (never) to seven (always) the frequency of 91 behaviors and responses to stimuli they observed during the previous two weeks. Scores from the IBQ-R can be summed to generate scores on 14 subdimensions which themselves can be summed to create scores for three superdimensions: effortful control, negative affectivity, and surgency. All subdimensions of the IBQ-R have shown high internal consistency with Chronbach's alpha scores ranging from 0.70 to 0.90 (Garstein & Rothbart, 2003) . For purposes of the present investigation, as discussed below, the superdimension of infant effortful control, as well as the subdimensions of activity level, distress to limitations, duration of orienting, and approachability were derived from the IBQ-R.

CHAPTER 3

RESULTS

Descriptive Statistics

Of the eighty-eight infants included in the current sample, one was excluded due to a developmental disorder (i.e., Down syndrome). Of the remaining 87 subjects, there were many caregivers who did not submit or complete all surveys relevant to the current study (i.e., the MCDI-WG, the IBQ-R, and the demographic questionnaire). Additionally, due to child fussiness or refusal to perform, experimenter error (e.g., skipping tasks during the laboratory session), and video recording difficulties (e.g., child not being in view of the camera or poor camera angles), some missing data resulted when scoring behavioral measures. A complete list of descriptive statistics and sample sizes for caregiver report and behavioral measures can be found in Table 1.

Table 1.

Descriptive Statistics for Caregiver Report and Behavioral Measures

	N	Minimum	Maximum	Mean	SD
Caregiver Report Measures					
Vocabulary Comprehension	77	0.00	327.00	108.70	72.77
Vocabulary Production	77	0.00	282.00	23.17	44.52
Effortful Control	75	3.89	6.29	5.04	0.60
Effortful Control Subdimensions					
Activity Level	74	1.67	6.00	4.09	0.96
Distress to Limitations	74	2.29	6.29	4.31	1.05
Duration of Orienting	74	1.00	6.50	4.12	1.22
Approachability	74	3.00	7.00	6.08	0.65
Child Age in Months	87	12.00	20.00	15.40	1.71
Behavioral Measures					
Joint Visual Attention	86	.00	27.99	11.42	5.09
Joint Haptic Attention					
Canonical Imitations	80	-7.00	22.00	3.19	4.89
Noncanonical Imitations	81	-3.00	10.00	1.30	2.00

While both language development measures (i.e., vocabulary comprehension and vocabulary production) for the most part followed normative trends of increasing with age, both score means were well below the average word count for children of similar age found in normative studies (Fenson et al., 1994). Because the MCDI-WG version is meant for infants from eight to 16 months of age, I compared mean scores on each language measure (i.e., vocabulary comprehension and vocabulary production) to the normative language scores on only children 16 months and below from the current sample. When comparing the current sample means to normative means (Fenson et al., 1994), both vocabulary comprehension and production were within the 25th percentile of similarly-aged children.

Since the current investigation used a modified version of the Brooks and Meltzoff (2005) gaze following procedure, I was unable to compare the average looking time of the current sample to previously reported ranges, as previous studies only counted whether or not a child engaged in joint visual attention, and not the amount of time a child spent engaged in joint visual attention. Additionally, while other studies have employed similar gesture imitation tasks (Shore, O'Connell, & Bates, 1984), this study was the first to use the elicited imitation of inappropriate object substitution task with a familiarization condition and on children in this age range; therefore, I was also unable to find comparison means for the joint haptic attention measure. However, negative scores resulted from adjusting for actions performed during the familiarization period.

<div align="center">Data Management</div>

The overarching hypothesis for the present investigation was that the relationship between joint haptic attention and language development would be mediated, either partially or fully, by joint visual attention. However, this hypothesis was contingent on significant

correlations between three other variables of interest, joint haptic attention, joint visual attention, and language development. Absent these associations, a mediation model would not be warranted.

<div align="center">Zero-Order Correlations</div>

I first hypothesized that joint visual attention-language relationships would replicate those found in previous literature, with responding to joint attention being positively and significantly associated with receptive language scores. Also, because recent studies have shown associations between motor development and language comprehension and production, I speculated that joint haptic attention and language development would be significantly and positively correlated with one another. Lastly, due to theories suggesting that haptic perceptual development and thus joint haptic attention may act as a substrate for joint visual attention, I proposed significant and positive associations between joint haptic attention and joint visual attention. As shown in Table 2, Pearson's correlations indeed revealed significant and positive associations between joint visual attention and vocabulary comprehension, as well as significant and positive associations between total joint haptic attention and joint visual attention; although the latter association was primarily driven by a relationship between canonical imitations and joint visual attention and not noncanonical imitations. However, neither measure of joint haptic attention (i.e., canonical or noncanonical imitations) was associated with either measure of language development (i.e., vocabulary comprehension or vocabulary production). Thus, I did not proceed with mediation analyses.

Table 2.

Correlations Among Joint Haptic Attention, Joint Visual Attention, and Language Development

	1	2	3	4	5
1 Total Joint Haptic Attention	—				
2 Canonical Imitations	0.94**	—			
3 Noncanonical Imitations	0.58**	0.28*	—		
4 Joint Visual Attention	0.26*	0.27*	0.12	—	
5 Vocabulary Comprehension	0.14	0.14	0.07	0.24*	—
6 Vocabulary Production	0.00	- 0.04	0.11	0.12	-0.01

Note: $*p < 0.05$, $**p < 0.01$

Post-Hoc Analyses

During the course of video coding, it became apparent that decorations on the wall to the child's left (i.e., Blue's Clues stickers intended to make research participants comfortable in the otherwise strange laboratory setting) may have had a disproportionate effect on children's gaze-following to the left-side stimulus. To evaluate the effect of the Blues Clues stickers, I created proportion scores of infant looking time to both the left ($M = 3.37$, $SD = 2.03$) and right ($M = 4.25$, $SD = 2.81$) carousels. I calculated looking times during non-distracted trials only because the current study did not employ looking times during the distracted trials. I then conducted a paired samples t-test to evaluate whether there was a significant difference in looking time to the left versus the right carousel. Indeed, the analysis revealed that infants spent significantly more time looking towards the right carousel than to the left, $t(85) = -2.59$, $p = 0.01$. This finding demonstrated that children spent less time, on average, looking at the left stimulus, following the gaze of the experimenter, than at the right.

Further, because order of looking to the left versus right stimuli (i.e., LRL versus RLR) was randomly assigned to participants, it was possible that task engagement between participants may have varied as an artifact of assignment condition; as some participants had more

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opportunities to look towards the right than other participants (i.e., there were more opportunities for right looks in the RLR condition). To explore this possibility, I compared total looking time (i.e., the sum of time spent looking to the left and right carousels) between participants in the LRL assignment condition ($N = 50$) and participants in the RLR assignment condition ($N = 37$), using a one-way ANOVA. ANOVA analyses revealed that assignment condition (i.e., LRL versus RLR) did not have a significant effect on total looking time, $F(1,84) = 0.00$, $p = 0.98$, suggesting that children were equally engaged across the two order conditions.

Because my expected hypothesis proposing that joint haptic attention would be related to language development was not supported in the current sample, I conducted a series of exploratory analyses in an attempt to explain these unanticipated null findings. As mentioned in the introduction section, the joint visual attention-language development association has been found to be dependent on many factors such as child age, effortful control, and developmental disorders. In the present investigation, it was possible that the joint haptic attention-language development relationship was also dependent on child age, effortful control, or developmental disorders. I explored each of these possibilities in turn, to the extent that appropriate, potentially moderating measures were available in the dataset.

To explore whether the joint haptic attention-language development relationship differed as a function of child age, I created a dichotomous measure of child age using a median split which resulted in young ($M = 14.28$ months, $SD = 0.70$) and old ($M = 17.15$ months, $SD = 1.31$) age groups. I then computed split level correlations to investigate whether the relationship between joint haptic attention and language varied by child age. After transforming all r correlation coefficients to z scores, none of the corresponding correlations were significantly different as a function of age group.

I also evaluated the potentially moderating effect of child age using only children who were in the language burst phase of language development (i.e., 14-18 months). Here, age was entered in regression analyses as a continuous measure; however, only children between the ages of 14 and 18 months were included in analyses. Moderation analyses were calculated for both joint haptic attention measures (i.e., canonical and noncanonical imitations) and both language measures (i.e., vocabulary comprehension and vocabulary production) for a total of four regression analyses. Moderation analyses did not reveal any significant effect of child age on the joint haptic attention-language development relationship for either language measure; although child age did explain significant variance in vocabulary production scores even when accounting for canonical ($R^2 = 0.10$, $F(2,60) = 3.43$, $p = 0.04$; $\beta = 0.32$, $p = 0.01$) and noncanonical ($R^2 = 0.11$, $F(2,61) = 3.77$, $p = 0.03$; $\beta = 0.32$, $p = 0.01$) actions (see Table 3).

Next, to examine the possibility that the joint haptic attention-language development relationship differed as a function of attentional, or effortful control, I first dichotomized my sample into high ($M = 0.49$, $SD = 0.32$) and low ($M = -0.50$, $SD = 0.35$) effortful control groups using a median split. I then conducted split level correlations to see if the associations between joint haptic attention and language development varied by group; however, after transforming all r values to z scores, none of the corresponding correlations were significantly different as a function of effortful control group.

Next, in an effort to gain more statistical power by using the entire range of scores, I explored the possible moderating effect of effortful control as a continuous variable in regression analyses for both joint haptic attention measures (i.e., canonical or noncanonical) and each language measure (i.e., vocabulary production or vocabulary comprehension) for a total of four regression analyses. Moderation analyses revealed no significant effect of effortful control on

the joint haptic attention-language development relationship; however, effortful control did explain significant variance in vocabulary comprehension measures even after accounting for canonical ($R^2 = 0.12$, $F(2,66) = 4.29$, $p = 0.02$; $\beta = 0.31$, $p = 0.01$) and noncanonical ($R^2 = 0.10$, $F(2,67) = 3.51$, $p = 0.04$; $\beta = 0.30$, $p = 0.01$) actions (See Table 3).

Finally, while the current sample only included typically developing children, I reasoned that it might be possible to indirectly assess the impact of developmental disorders on the joint haptic attention-language development relationship by evaluating specific subdimensions of temperament that commonly characterize certain traits of developmental disorders. For instance, children with ADHD often score high on measures of activity level, a subdimension of surgency, as well as duration of orienting, a subdimension of effortful control (Auerbach et al., 2008; Meeuwsen, Perra, VanGoozen & Hay, 2018). Additionally, high scores of distress to limitations, a subdimension of negative affectivity, as well as low scores of approachability, a subdimension of surgency have been associated with autism spectrum disorder (Zwaigenbaum, Bryson, Rogers, Roberts, Brian, Szatmari, 2005).

To examine whether certain traits associated with Autism Spectrum Disorder or ADHD impacted the relationship between joint haptic attention and language development, regression analyses were computed for all four temperament subdimensions (i.e., activity level, duration of orienting, distress to limitations, and approachability) for both joint haptic attention measures (i.e., canonical or noncanonical) and each language measure (i.e., vocabulary comprehension or vocabulary production) for a total of sixteen regression analyses. Analyses did not reveal any significant effects of the four temperament subdimensions on the joint haptic attention-language development relationship; however, duration of orienting did explain significant variance in vocabulary comprehension even after accounting for canonical ($R^2 = 0.12$, $F(2,65) = 4.37$, $p =$

0.02; $\beta = 0.32$, $p = 0.01$) and noncanonical ($R^2 = 0.11$, $F(2,66) = 4.22$, $p = 0.02$; $\beta = 0.33$, $p =$

0.01) actions (see Table 3).

Table 3.

Main Effects of Exploratory Regression Analyses Regressing Language Development onto Joint Haptic Attention Controlling for Age, Effortful Control, and Effortful Control Subdimensions

JHA Measure	Variable	Vocabulary Comprehension				Vocabulary Production			
		B	SE	β	*df*	B	SE	β	*df*
Canonical									
	Age	2.20	7.46	0.04	62	8.64	3.30	0.32*	62
	Effortful Control	37.59	13.94	0.31**	68	- 6.38	9.32	- 0.08	68
	Effortful Control Subdimensions								
	Activity Level	- 2.45	9.50	- 0.03	67	7.33	5.90	0.15	67
	Duration of Orienting	19.78	7.30	0.32**	67	- 3.00	4.80	- 0.08	67
	Distress to Limitations	-6.80	8.56	- 0.10	67	- 1.21	5.40	- 0.03	67
	Approachability	14.35	13.81	0.13	67	12.03	8.62	0.17	67
Noncanonical									
	Age	2.83	7.50	0.05	63	8.60	3.25	0.32*	63
	Effortful Control	36.39	14.18	0.30*	69	- 7.57	9.28	- 0.10	69
	Effortful Control Subdimensions								
	Activity Level	- 3.75	9.48	- 0.05	68	7.26	5.80	0.15	68
	Duration of Orienting	19.83	7.02	0.33**	68	- 2.90	4.58	- 0.08	68
	Distress to Limitations	- 6.50	8.60	- 0.09	68	- 1.65	5.34	- 0.04	68
	Approachability	12.22	13.81	0.11	68	10.82	8.48	0.16	68

Note: *$p < .05$, **$p < 0.01$; JHA = Joint Haptic Attention

CHAPTER 4

DISCUSSION

The overarching goal of the present investigation was to explore the potentially mediating effect of joint visual attention on the relationship between joint haptic attention and language development. However, this goal was contingent on significant associations between joint visual attention and language development; joint haptic attention and language development; as well as joint haptic attention and joint visual attention. Only two of these three expected correlations were obtained.

Because previous studies have shown positive and significant associations between gaze following or responding to joint attention and vocabulary comprehension, my finding of a significant and positive association between joint visual attention and vocabulary comprehension was expected. However, it was unexpected that the two language measures (i.e., vocabulary comprehension and vocabulary production) would not be associated with one another. Typically, studies employing the MCDI-WG reliably find strong associations between the number of words a child can understand and the number of words a child can say (Fenson et al., 2007). It may be that caregivers in the current sample did not fully understand the instructions for completing the MCDI-WG, and future studies should have caregivers complete the checklist in the laboratory to ensure quality reporting through detailed in-person instruction. Alternatively, because many researchers feel that parent report measures can be biased or incorrectly completed, an in-laboratory language measure completed by trained experimenters may be another avenue in which to avoid peculiar data. However, studies using the same administration format as used in the current investigation have been successful in gaining language data which follows the trends (i.e., associations between vocabulary comprehension

and vocabulary production) of the normative MCDI-WG study (Fenson et al., 1994; Laakso, Poikkeus, Katajamäki, & Lyytinen, 1999).

The failure to confirm a positive and significant association between joint haptic attention and language development was unanticipated, as previous literature has reported relations between motor development, gesture use, and language development. It may be that because the measure of joint haptic attention in the current study only required children to imitate a behavioral action with no or little communicative intent, the current measure may be associated with learning or cognitive ability more broadly, and not language development specifically. Future studies may wish to investigate the joint haptic attention-language development relationship by employing a joint haptic attention measure that includes communicative intent explicitly. Or, in an effort to gain a more robust measure of joint haptic attention, future researchers may wish to measure joint haptic attention through a latent variable model, wherein multiple behavioral, each addressing one or more facets of joint haptic attention (e.g., concurrent or sequential tactile attention, concurrent or sequential proprioceptive attention, or concurrent or sequential kinesthetic attention) across a range of contexts, are aggregated in a model to represent the overarching concept of joint haptic attention. Just as the various subdimensions of temperament can be combined to produce a total score on effortful control, surgency, and negative affectivity, latent measurement modeling affords researchers the ability to capture the multifaceted nature of complex constructs. Although a composite score of joint haptic attention through latent measurement modeling might prove to be a more powerful measure to capture associations of joint haptic attention across a wide range of cognitive and social outcomes, a confirmatory factor analysis would need to verify whether the various measures indeed conform to a single factor.

Lastly, as hypothesized, analyses found that joint haptic attention and joint visual attention were related. However, contrary to expectations, this association was primarily driven by canonical action imitation within the joint haptic attention task. Noncanonical actions were thought to be the better index of joint haptic attention, because they comprised those actions that children should not have experienced before entering the lab. In contrast, children's performance of canonical actions may have merely indexed their recall of what or how each object was used, as cued by the experimenter during the modeling phase. As to why the noncanonical imitations were not associated with joint visual attention, it may be that a single instance of joint haptic attention (e.g., a single action imitation) does not confer benefits to engaging in joint visual attention. When considering the predictive processing account of cognition, single action imitation would grant children only a rudimentary prediction of what the action is and what it is used for. However, with experience imitating and performing the action across contexts and situations the original and primitive prediction may transform into a refined and accurate prediction of what the action is and what it is used for.

<u>Exploratory Analyses</u>

Since there was the possibility that Blue's Clues stickers on the walls of the laboratory could have influenced child looking time to the left or right within the joint visual attention task, a t-test was conducted. Analyses revealed that children spent significantly more time looking towards the right carousel than to the left carousel (near the Blues Clues stickers), indicating that the stickers may have indeed served as a distractor to looking towards the left carousel target. However, when evaluating whether looking time differed as an artifact of looking condition (i.e., LRL or RLR) a one-way ANOVA did not reveal a significant difference in total looking times between assignment conditions. These results suggest that while children may have looked more

towards the right carousel, those children who had more opportunities to look towards the right (e.g., RLR assignment condition) than to the left (e.g., LRL assignment condition) in non-distracted trials did not have significantly longer looking times overall; suggesting that assignment order did not need to be accounted for in the joint visual attention measure. The lack of a significant difference in total looking time notwithstanding, while laboratory decorations may help children to feel comfortable in performing behavioral tasks in a laboratory setting, future studies employing a gaze following task should ensure that laboratory decorations are not visible when viewing target visual stimuli to avoid distraction or at least are distributed in a balanced fashion.

Post-hoc analyses also explored six potential moderators (i.e., child age, effortful control, activity level, duration of orienting, distress to limitations, and approachability) of the relationship between joint haptic attention and language development; however, these yielded no significant interaction effects. For child age, it may be that the limited age range of participants in the current sample obscured my ability to detect moderation effects as a function of age. Because joint haptic attention has been proposed to begin as early as minutes after birth, future studies may wish to evaluate joint haptic attention across a much wider time frame in an effort to capture age effects on the relationship between joint haptic attention and subsequent language development.

It was especially interesting that the relationship between joint haptic attention and language development did not differ as a function of effortful control, as the current measure of joint haptic attention shares many features with common measures of executive function, of which effortful control is commonly used as a surrogate measure. However, it may be that for the canonical actions the toys and actions used in the joint haptic attention measure were overly

common, to the point that children did not need to employ attentional or behavioral control to imitate the model, as they may have had considerable experience playing with these toys and performing these actions before. Additionally, while there was some theoretical support for examining temperament subdimensions (i.e., activity level, duration of orienting, distress to limitations, and approachability) as proxy measures for the developmental disorders of Autism Spectrum Disorder and ADHD, the failure to find a significant moderation effect on the joint haptic attention-language development relationship may be because these single dimensions failed to capture the multifaceted and dynamic nature of Autism Spectrum Disorder or ADHD.

Significant main effects produced from exploratory analyses were, for the most part, as expected. That child age explained a significant amount of variance in productive vocabulary scores is consistent with previous literature suggesting that expressive language increases with age (Fenson et al., 2007). The main effect of effortful control and duration of orienting on vocabulary comprehension was also as expected and consistent with previous literature (Dixon & Smith, 2000); wherein children with higher levels of attentional control commonly score higher on measures of vocabulary comprehension and production. The fact that effortful control and duration of orienting in the current sample did not explain significant variance in vocabulary production scores, as mentioned above, may be a product of the anomalous language sample in the current study.

<u>Study Limitations</u>

While the current study did find associations between joint visual attention and vocabulary comprehension as well as heretofore unexplored associations between joint haptic attention and joint visual attention, these results should be interpreted with caution, as a set of study limitations do exist. First, the odd language sample in the current study is cause for

concern, as a specific explanation for the atypical data relationships (e.g., a non-significant association between vocabulary comprehension and vocabulary production) cannot be elucidated. As mentioned above, it may be that caregivers in the current study did not understand the instructions. If this was the case, it is unclear which language measure is the more reliable index of children's language abilities. Future attempts at replication should ensure the quality of language data by using more specific instructions, giving in-person instructions, or employing an in-laboratory language measure overseen by a trained experimenter.

Secondly, because the current investigation was conducted using an archival dataset, exploratory analyses were limited by the measures collected as part of the broader study. Although I was able to explore the potentially mediating effect of child age and effortful control through post-hoc analyses, there are many other factors that have been shown to impact the joint visual attention-language development relationship that the current study did not have measure of. For instance, as mentioned in the introduction section, joint visual attention-language development relationships have been shown to differ as a function of attachment type; a measure of which was not included in the present data set. Future studies assessing joint haptic attention-language development relationships may benefit from the inclusion of an attachment measure to explore this possibility. Also, while the current study attempted to evaluate the possibly mediating effect of developmental disorders by exploring certain temperament subdimensions commonly associated with ADHD and autism, future studies may wish to directly investigate the impact of developmental disorders on the joint haptic attention-language development relationship by including atypically developing infants and children in the study sample.

Future Directions

Because the current study was the first to explore joint haptic attention, and because this

study was based on a few assumptions about joint attention, there remains many avenues for

future research. First, because this study only explored joint haptic attention by way of action

imitation, future research should explore joint haptic attention through a variety of measures, as

imitation is only one way in which caregiver and child can share a haptic experience. Haptic

attention can also be shared by a caregiver simply touching a child (e.g., rubbing their back), a

caregiver and child touching the same object at the same time (e.g., petting a dog together), a

caregiver and child performing the same action sequentially (e.g., imitation), or even a caregiver

and child performing the same action concurrently (e.g., dancing together).

One assumption of the present investigation was that joint attention can be shared

through any sensory modality; thus, future research should begin to explore joint attention

through sensory modalities aside from joint visual or haptic attention, as a case for the inclusion

of each sensory modality can be made. For instance, joint aural attention, such as listening to the

same song together, may provide infants additional opportunities for learning language. Also,

because many communicative exchanges are composed of a collection of sensory experiences, it

may be useful to explore the combined effect of jointly attending to various sensory modalities at

the same time; such as a mother pointing to a rabbit hopping across the field while mimicking

the hopping action by bouncing the child in her arms (i.e., a combination of joint visual attention

and joint haptic attention).

The current study also assumed that joint attention can be considered not only when

caregiver and child are attending to a sensory experience concurrently, but also sequentially;

therefore, future research should explore joint attention (in any sensory modality) within a

broader time frame. For example, research could examine whether there are similar benefits to looking at the same picture in a book at the same time versus a caregiver looking at a picture on a page out of view of the child, then turning the book so that the child can view the picture. By experimentally controlling condition of joint attentional engagement (i.e., concurrently versus sequentially), a study such as this could provide empirical evidence in support of the assumption that the temporal parameters of joint attention need not be constrained.

Lastly, while there have been studies assessing the impact of walking and reaching experience on joint visual attention (Libertus & Needham, 2011; Walle, 2016), these studies are rare, and should be replicated and extended. As mentioned in the introduction section, infants begin exploring and jointly attending to their haptic senses as early as minutes after birth, long before they begin to reach or walk. Thus, future research should continue to explore the associations between joint haptic attention and joint visual attention earlier in life and over time. Longitudinal studies such as this could offer causal inferences as to the impact that joint haptic attention may have on joint visual attention.

Conclusion

To summarize, the current investigation presents gaps within the joint attention literature wherein research has only investigated joint visual attention while neglecting other sensory modalities such as joint haptic attention. The most unique contribution of the current study, however, is the association between joint haptic attention and joint visual attention; suggesting that joint haptic attention may be a fruitful area of research. However, because this is the first study of its kind, and the first to demonstrate this association, researchers should be cautious as to the interpretation or reliability of these results. Future research should replicate and extend these findings across measures, contexts, and constructs to help identify the specific nature of the

relationship between joint haptic attention, joint visual attention, and social and cognitive

constructs commonly related to joint visual attention.

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