Maternal Psychological Burden, Mother-Child Interaction, and Infant's Looking Behavior

by

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Abstract

A number of studies have documented effects of maternal depression, stress, psychological burden on children's developmental outcomes. Studies suggest that dyads affected by depression or depressive behaviors show compromised mother-child interaction and cognitive developmental outcomes. However, there has been little investigation of the microstructure of mother-child interaction to approach the potential mechanism underlying the relation between the maternal depression/depressive behaviors and infant's developmental outcomes. The goal of this study was to characterize the microstructure of mother-child object play behaviors by focusing on parental' scaffolding and their 3 to 18 months-old-infants' socially coordinated visual experiences during a 10 minutes play. The results showed that the healthy mothers' attention to toy object and hands (parent's own and the infant's) and their child's attention to toy object were significantly more frequently observed when compared to the effected group. The findings point to the possible pathway in which maternal threshold depressive symptoms may influence early learning via visual experiences with object during social interactions.

Introduction

Around 15 million young children are living with mothers affected by postpartum depression in a number of ways (Khourdaji et al., 2012; Cummings et al., 2008; Wood & Miller, 2008). The complex social circumstances under which many of these children are growing up place them at increased risk for developmental delays involving cognition, attention, language, and school readiness (Milligan et al., 2015; Conners-Burrow et al., 2014). The impact on child development has been of great concern for the field of public health (Cummings et al., 2008; Wood & Miller, 2008), and the concern is significant since the postpartum depression occurs during the most important phase of infancy (Franceschini et al., 2007). For example, one study comparing mothers with and without maternal depression and/or threshold depressive symptoms suggested that children of affected mothers have compromised infant-focused speech (Marwick, & Murray, 2010), and another study concerning intellectual development suggests that maternal depression is linked to increased delay in understanding the object concept and risk of later impaired language acquisition and other prolonged cascading effects such as understanding functional/verbally mediated properties, understanding sensory features (e.g., form, motion, color), and motor properties associated with the object handling (Martin, 2007; Mirhosseini et al., 2015). These cognitive and behavioral consequences of individuals' social circumstances are getting attention, and there is an increasing effort to improve these children's cognitive outcomes.

Despite the accumulated evidence indicating maternal depression's negative impact on children and the impact of maternal threshold depressive symptoms emerge as early as the postpartum period (Murphy-Eberenz et al., 2006), the mechanistic understanding— the underlying learning contexts and early experiences—of how postpartum depression influences learning has not been fully understood (Priel et al., 2019). One line of research looking into the immediate social input potentially points to a method in which we can study how parents' states of mind influences infants' learning experiences and how maternal mood may play a role in providing

scaffolding and/or a useful context in particular early experiences. Specifically, recent studies point to the importance of parental attention and early visual experiences during parent-child interactions around object naming in the early foundations of cognitive development—attention and language development (Yu & Smith, 2012; Gogate et al., 2010; Hirotani et al., 2009; Kuhl et al., 2003, Rader et al., 2012; Rolf et al., 2009; Burling & Yoshida, 2019). It has also been suggested that maternal threshold depressive symptoms and/or depression affect parent-infant one-on-one social play and language interactions (Zee-van Den Berg, el. al., 2017; Gogate, 2010). However, we lack comprehensive knowledge of the developmental links between such factors and parent scaffolding of infants' visual experiences during play, and whether differences in such visual experiences account for the documented impact of maternal psychological factors on developmental outcomes. To initiate the effort, as a first step, the thesis aims to characterize the nature of early object play experiences in two population groups: healthy parent-child dyads and depressed and/or threshold depressive symptomatic parent-child dyads who are at risk for potential aversive group differences in parental scaffolding child's visual experiences during social play.

Significance of Early Mother-Child Interactions

It has long been proposed that parents are the initial support system for nourishing learning experiences and extending an infant's competence (e.g. Yoshida & Smith, 2005; Gogate, 2010; Grace, Evindar, & Stewart, 2003). Recent studies have been documenting how parent child interactions play a critical role for developing an enriched environment and creating an essential component for stimulating early learning experiences. Maternal scaffolding literature specifically suggests the importance of five key factors that gauge the quality of mother-child interactions for cognitive development: (1) how often mothers talk to their babies, (2) how mothers talk to their babies impacting infant's attention, (3) how parents' attention impacts children's attention, (4) how object holding guides children's attention, and (5) amount of multisensory experiences through "visually optimal naming moments" (VONM) which occur

during parent object naming while the object is clearly captured in the child's view (Pereira, Smith, & Yu, 2014; Yoshida & Burling, 2011; Yoshida & Smith, 2008).

The first factor, speech input, has long been linked to increased quality of early experiences and the outcome of language development (Yoshida & Smith, 2005). Adult speech has been observed to assist some children in acquiring language and enables communication throughout different points of early development (Buckley & Buckley 2003). Second and fifth factors have been often shown in observation studies. Active social engagement encourages babies to attend to speakers' mouths and by the end of the third month infants are able to follow another person's gaze (Buckley & Buckley, 2008). By 4 months, babies will deliberately turn their heads towards the source of the voice, scanning the area for the speaker. At around 6 months, infants start to become more selective towards sound. Additionally, a study transcribing parents' speech samples showed a direct link between parents' speech frequencies and the child's vocabulary development (Buckley & Buckley 2003). Another line of studies looked into Visually Optimal Naming Moments (VONM) or high-quality object naming events where toddlers played with novel objects as the parent voluntarily named the objects during a free-flowing play session. The study indicated that visually optimal moments (VONM) are important for efficient word learning which involves "timely naming" accompanied by clean sensory input (Pereira, Smith, & Yu, 2014; Yu & Smith, 2012). The study measured the clarity of visual input by recording centering measures (e.g., how well the object positioned in the middle of child's viewing field) and image size (e.g., object's occupied pixels in the child's viewing field), and the results supported that both variables are dynamically related to the naming of an object by a parent and indicated that parents named objects when the target was being attended to by the child. These findings indicate that the sensory motor, perceptual, and linguistic processes are all influential factors when creating optimal visual moments for learning (Pereira, Smith, & Yu, 2014; Yu & Smith, 2012). Third factor, parent's attention navigates child's attention, has been documented in Joint Attention (JA) literature. JA – socially shared attentional experiences such

as parent and child visually attending to the same referent— is essential for language, social, and cognitive development (e.g., Buckley & Buckley, 2003; Zee-van Den Berg, el. Al, 2017; Yoshida & Burling, 2011), and that caregivers through their attention allocation provide effective nonverbal cues to intended referents. The literature further makes it clear that an individual's background characteristics, such as age and socioeconomic status (SES) uniquely influence JA as well as other early manifestations of social scaffolding. However, knowing the potential importance of social scaffolding with families with depression is only a beginning. A recent effort linking maternal depression and attentional capacity looked into various attentional responses to visual stimuli reported that adults who struggled with depression had a dramatically slower response time compared to the control and anxious groups when presented with stimuli located in peripheral regions within the visual field (D'Hondt et al., 2012). Considering the results in the framework of interactive situation, it can be speculated that mothers in the depression group may be less sensitive to the child's activities if the mother is not fully attentive to the child, and thus may be less "socially engaging". Fourth factor, object holding navigating attention and learning, can be seen in a variety of studies concerning early social cues. For example, a study documenting parent's hands are predominantly captured in infants' field of view (Yoshida & Smith, 2008; Yoshida & Burling, 2011). It was also found that 60% of the time, shifts in gaze towards a new object followed by a *hand acting on an object* (Yoshida & Smith, 2008). Further, another study focused on a specific object holding—looming-- which occurs when the mother moves an object forward and downward from herself to the infant, while simultaneously shaking the object or moving an object rapidly in a lateral translation or rotation (Gogate, Maganti, & Laing, 2013). The attention to hand motions reported was used predominantly by mothers when teaching their 6 to 8-month-old infants novel names of objects and are found to accompany labeling moments and a significant impact on novel word learning outcomes (Matatyaho & Gogate, 2008).

Methodological Challenges

All the scaffolding behaviors (e.g., amount of speech, type of speech) are often well defined and clearly operationally defined. However, making detailed observations on some of the key behavioral variables has been challenged by the technological limitation. Specifically, unlike speech annotation, annotating visual experiences (e.g., counting where the child is looking) demands researchers to make inference of "the attended area" by looking at the child's face (e.g., head and eye direction) in the social context. Though this observation method has created a large of portion of our current understanding of child development, the limitation regarding subjectivity can be critical when the research questions concern the visual side of early input.

Recent studies made significant progress on directly measuring at what the child is looking during an interactive context. One pioneer study has put a small head-camera to the child's forehead to make observations on what components (e.g., parent's face, parent's hands, their own hands, and an object) of the social play with the parent come to the child's viewing field opened up the possibility in accessing to child's viewing experiences (Yoshida & Smith, 2008), and this has been followed by recent work with eye tracking system for the better precision (e.g. Franchak, Kretch, Soska, & Adolph, 2011; Burling & Yoshida, 2019). With these technological advancements, we have learned the role of parents' attention in organizing young child's visual experiences, and the significant relationship among caregivers' moment-to-moment object showing and naming behavior, the child looking at the object, and the child's object word learning outcome (Smith, Yu, & Pereira, 2014). The recent work using an eye tracking system (instead of the head-mounted mini camera) further improved the calibration level of gaze direction, and documented parents' object naming and showing directly influences infants' sustained attention (SA), a critical skill for early learning (Burling & Yoshida, 2019). Further, a study concerning infants' social attention suggests that infants dedicate more time attending to objects during social play compared to independent play, and these differences have been considered to be attributable to increased attentional guidance from the parent

during social play (Wass et al., 2018). Also, children of parents that attended to their visual shifts and hand gestures such as pointing or reaching reciprocated the same treatment, thus, resulting in an increased frequency of joint attention moments that is critical for language development (Yu & Smith, 2016). These studies suggest the strong role of parent-child interaction in navigating learning, yet the relation has not been broadly investigated. In the present study, the head-mounted eye-tracking system was used to carefully characterize the play behaviors and consequential visual experiences across the depression and healthy control groups to address the nature of the impact of maternal depression on child development.

Relevant Impact of Maternal Depressive Symptoms

Researchers have accumulated evidence directly linking maternal depression with parental behaviors. For example, a few studies documented a contribution from mediating roles in parenting (e.g., child monitoring) that result in associations between depressive symptoms and children's developmental outcomes (Elgar et al., 2007). A recent experimental study suggests that activating states of worry and rumination in mothers with depression leads to decreased quality of mother–child interchanges (Stein et al., 2012). It has been suggested that the negative effects on mother–child interactions may be due to the tendency for depressed mothers to experience an increase in cognitive load and narrowing in focus. Further, a study concerning the speech rate as a parental input indicated that both affected mothers tend to be withdrawn and speak less to their children (Stein et al., 2012) During the study, mothers with MDD and General Anxiety were assessed for play quality and were given three age-appropriate toys which require motor-cognitive support from the mother to provide scaffolding. Overall, the anxious and depressed mothers rated their thoughts as being more recurrent and more difficult to control than mothers in the control group (Stein, 2012). In all, the findings from depression literature suggest that parental input might be a factor connecting the depression and child outcomes, and findings from early visual experience literature demonstrated that parental input has direct impact on child's moment-to-moment looking behaviors. The current study aims to

combine the different lines of literature and clarify both parental behavior –speech, object handling, and looking behaviors—in dyads affected by Maternal burden such as maternal depression or threshold depressive symptoms and potential differences in child looking behavior during mother-infant play.

Current Aims and Research Questions

The present study is motivated by three distinct research findings: (1) the negative impact of maternal depression that spills over the offspring's' developmental outcomes, (2) influence of depressive symptoms and/or maternal threshold depressive symptoms on maternal attentiveness during parent-child social interaction, (2) parent-child interaction plays a critical role for developing an enriched environment and early learning experiences, and (3) eye tracking technique has revealed visual experiences during parent-child interaction are shaped by parental input and predictive of word learning. The present study used the eye tracking methodology to characterize the microstructure of parent-child interaction behaviors by focusing on the specific behavioral variables that have been documented to have an impact on later developmental outcomes. There were five specific behavioral variables that were motivated by the literature and included in the present study: parental speech, sustained attention (SA) –to object, face, hand, object holding of parent and child, and socially coordinated attention such as visually optimal naming moment (VONM) and joint attention (JA) (see Table 1). The present study compared these variables across two groups of mother-child dyads: (1) Affected group that includes typically developing children and mother who are diagnosed with depression and/or threshold depressive symptoms and children and (2) Control group that includes typically developing infants and mothers who do not have depression and/or are not threshold depressive symptomatic. We will document how the ways in which mother's behaviors are impacted by maternal depression and/or threshold depressive symptoms and how the potential impact shapes children's early visual experiences during the interaction.

There were three hypotheses. It is expected to have reduced frequencies in mother's behavioral input, specifically speech, SA (to toy objects, infant's face and hands), and object holding among the affected group when compared to the control group. Second hypothesis is that there will be reduced opportunity in the affected group's child's looking, specifically, SA (to toy objects, parent's face and hands) which require parental scaffolding. Lastly, it is expected that there will be reduced opportunities of socially coordinated visual experiences such as JA and VONM among the affected group relative to those in the control group. These coordinated moments demand high responsiveness from parents.

INSERT TABLE 1

There is a prominent need to understand the specific mechanisms by which postnatal depression influences child development. Understanding the impact that specific parental behavior has on children's cognitive development can help identify preventative methods to minimize possible negative outcomes from vulnerable populations such as infants with mothers struggling with threshold depressive symptoms.

Methods

Participants

Participants were recruited throughout pediatrics offices, daycares, research institutions, libraries, our website, and schools in Greater Houston area. Thirty-four mother-infant dyads (17 females, 17 males) between the ages of 3 to 18 months participated in the study. Fourteen of them were children whose mother was identified as being depressed and/or threshold depressive symptomatic (M= 11.98 months, SD = 4.173), and 14 were control group with no indications of depression and/or threshold depressive symptoms (M= 10.85 months, SD = 4.47). For children in both groups were typically developing, there was no known child diagnosis of

ASD, ADHD, or other disorders reported by the parents. Table 2 provides information on the ages and pre-study basic screener scores of participants in the study.

INSERT TABLE 2

Materials

Depression related measures. To identify the group of each dyad (either the control or affected group), we used self-reported history of psychiatric conditions by using psychiatric status assessments such as the Hopkins Symptom Checklist (SCL-10) (Rosen, 2000), Edinburgh Postnatal Depression Scale (EPDS) (Cox, Holden, & Sagovsky, 1987), Inventory of Depression and Anxiety Symptoms (IDAS) (Gonzalez, 2012), and the Mini International Neuropsychiatric Interview (MINI) (Matijasevich, 2014). Data from the MINI was collected both prospectively and retrospectively; three mothers were originally recruited as potential healthy controls and included in the depression group after receiving high scores and were later contacted for a MINI assessment via phone call. The remaining ten mothers met criteria for depression with the MINI and completed the interview prospectively. On top of age and sex variables, we matched the participants' average annual household income between the groups using self-reported data from the John D. SES Basic Information Form. Controlling the household income is important given the previous studies documented that low socio-economic status has been linked to compromised parental scaffolding (Pettersson, 2018), infant's attentional capacity (Adler et al., 2000; Clearfield & Jedd, 2013) and greater risk of suffering from depression (Beeber et al., 2014). The John D. SES Basic Information Form was also used to screen any known child diagnosis of ASD, ADHD, or other disorders.

Also, the present study utilized multi-item measurement scales instead of exclusively using the MINI to assess depressive systems in order to help avoid possible response bias during the Mini International Neuropsychiatric Interview (MINI) due to discomfort or difficulty in

verbally admitting to awkward symptomology to interviewer (Pettersson, 2018). Specific requirements for participation included meeting criteria for depression or other psychological disorders recognized by the MINI and supplemental measures (EPDS, IDAS, SCL-10). In addition, only parents who did not complete the MINI, yet, fully completed the additional self-reported maternal depression measures and met criteria for at least one of the supplementary reports were contacted to complete a retrospective MINI depression screening to ensure more valid responses from participants and attempt to conduct an accurate analysis on maternal depressive symptomatology. The supplementary measures used included the EPDS which has been considered suitable for screening Major Depressive episodes among women with a score of 8 (Matijasevich, 2014). The criteria for SCL-10 is a score of 1.8 or greater (Rosen, 2000). Annual income averages were roughly 42,310 / year for both groups. Lastly, the IDAS does not have respective cut-off scores, thus, the assessment was compared scores with normative data (Nelson, O'Hara, & Watson, 2018) as a guide for later conducting retrospective MINI depression screenings (Ingram & Siegle, 2002; Joiner et al., 2005). Incorporating thorough depression screening provided us with necessary information to accurately discern each mother's mental state for grouping of the participants. Please see Appendix for the list of measures and the specifics that are used for depression symptomatology. Table 2 also indicates the scores and includes the significance values from the t test results for both groups.

Vocabulary Measures. MacArthur-Bates Communicative Development Inventories (MCDI) is a validated inventory with which parent report current and emerging vocabulary and communication skills in their child (Fenson et al, 1993). The MCDI assessment specifically looks at four specific domains: level of syntactic development, vocabulary size, differentiation between vocabulary and syntactic development, and nominal/pronominal style. We incorporated the MCDI assessment to help address possible confounding effects from dissimilarities in vocabulary and language skills that has previously been attributed to influence attention (Gogate, 2010; Heal, 2005).

Alberta Infant Motor Scale (AIMS). AIMS is a validated observational scale to assess the motor development of children from birth until the acquisition of independent walking. It contains 58 items, which assess the control and integrity of the antigravity muscles during observation of infant motor skills in prone, supine, sitting, and standing positions. AIMS is included in the present study to account for the potential contribution of early motor coordination to immediate visual experiences (Kretch et. Al., 2014).

Procedures

In the current study, parents were seated in a small chair across from their infant with a small white table (75cm x 50cm) in between them. Infants 12 months and older sat in a generic children's classroom chair. Younger infants were placed in a Bumbo seat appropriate for children 5- 12 months old. Two room cameras (AXIS M1054 1280x800 resolution digital cameras with Motion JPEG compression for fast motion between frames) were used: one camera was attached to the wall and one was attached to the ceiling. The wall-mounted camera was 2.5 meters away from the table and captured a third person view of the session. The ceiling camera was placed 2 meters above the table. The eye-tracking device uses a 640x480 camera with a 42.2° vertical angle and 54.4° horizontal angle for the head view and an infrared sensor for monitoring corneal reflections and pupil orientation from the eye.

After the dyad gets seated at the table, we comfortably adjust the head-mounted eye tracking system on both participants appropriately. One researcher distracted the baby while a second researcher place a cap on the infant's head with velcro facing forward, on the forehead. After placing this cap, the second researcher attached the eye-tracking device to the velcro and adjusts the view to ensure the first-person view camera captured the entire scene and that the eye was clearly visible in the eye video. A third researcher outfits the parent with an eye-tracking device while the first experimenter prepares the infant for calibration. The calibration procedure involved a calibration board 18 measuring 60 cm x 40 cm and contained 9 dots distributed throughout the view to record adjustments of the orientation of the eye and head

cameras. Using an attractive toy, the experimenter pointed to dots one-by-one, ensuring that the infant looked at each one. Once calibration is complete, for both parent and child, the play session begins with an audio recording navigating the mother. Mother listens to the recording that announces a different word every 40 seconds for the mother to use each word as she plays with objects. A total of 8 toy objects are presented in a box and left on the floor besides the mother. Mothers were told to play freely by using any toy(s) during the play session. The entire visit, from filling out forms to the play session, took about 30-40 minutes. One experimenter stays behind the curtain and monitors the session through the recording system. After the session, the experimenter stops the recordings, and come back to the room and take off all the systems.

Video Processing

After the study, videos were exported from the recording computer desktop to the lab server. A wall-mounted camera records the task scene and the parent's voice is also recorded. Then, the first-person views from the mother and child and their respective eye video recordings were synchronized using a software, Yarbus eye- tracking software. Using Yarbus and our calibration method, a correlation criterion of 0.75 was established to ensure the estimated position of eye gazes correlated with the actual position of an eye gaze. Videos from the ceiling and wall were exported into Adobe Premiere, where, along with the synced first-person view, they were processed into a four-quadrant, synced video by using a custom eye-tracking capture software developed by the lab (https://github.com/iamamutt/yoshida-lab-cap). Once all videos had been synced into their final version, they were exported to begin manual, frame-by-frame, behavioral annotation using an open source video annotation software (Datavyu). The target behavioral variables and instances were annotated (time stamped) by using the wall mounted camera view (scene view) and head-mounted camera view (child's view and mother's view) by well-trained coders.

Video Annotation for Variables of Interest

Parent Speech. Parents' every utterance was transcribed and annotated. Annotations for mother's speech which encompasses everything from the use of target words and statements that call for attention to verbal sounds are important to be included.

SA. Using the synced eye video from Yarbus, every instance of eye gaze was annotated in Datavyu. These included moments where the infant looked at their own hands, parent's hands, parent's face, or the object. Specific visual regard and the duration of sustained attention were recorded when they were directed towards a target variable.

Object Holding. All the instances of parents' and infant's object holding were annotated. This includes any co-occurring actions such as showing and shaking.

VONM. All the frames in which the object being captured larger than 70% of head-mounted camera view were annotated and then selectively annotated as VONM when these moments were accompanied by parent's object labeling.

JA. Every simultaneous looking instance by the parent and child to the same object (e.g., toy object, hands) was counted as JA. The coders used both the child's and parent's view to identify the frames that contained an object in view longer than 500ms (Pereira, Smith & Yu, 2014).

Results

The purpose of the present study is two-fold, to add to the literature regarding the effects of maternal depression on interactive behaviors and to address how the potential impact further shapes children's early visual experiences that have been associated with attentional development and learning. To explore the present study's goal, the following working hypotheses were tested: (1) reduced frequencies in mother's frequency of speech, SA to toy objects, infant's face and hands, and object holding among the affected group when compared to the control group, (2) reduced SA to toy objects, parent's face and hands among the affected group when compared to the control group, and (3) reduced socially coordinated visual

experiences , JA and VONMs, among the affected group relative to those in the control group. Table 3 lists the mean frequencies of each variable with standard deviation for the two groups.

INSERT TABLE 3

Mother's Behaviors: Speech, SA, and Object Holding,

To address the first hypothesis concerning the group differences in how mothers provide scaffolding during object play with their infants, a set of paired sample t-tests was used to compare frequencies of parent speech, SA (to objects, hands, and to the child's face), and object holding (toy manipulating). There were significant group differences in mother's SA. Mother's SA to toy object, $t(32)=2.31$; $p < .05$, mother's SA to child hands $t(32)= 2.24$; $p < .05$, and mother's SA to their own hands $t(32)= 2.26$; $p < .05$. However, there were no other significant group differences in mother's scaffolding frequencies: SA to the child's face (p= 0.177), speech (p=0.467) and object holding— right hand object holding (p=0.599), left hand object holding (p=0.688). The results suggest that the group effect on mother's social scaffolding was found only with the mother's looking behaviors, specific to SA to objects and hands.

Infant's Behaviors: SA

The second hypothesis concerns the child's looking behaviors across the groups. A set of paired sample t-tests was used to compare frequencies of child's SA to toy objects, parent's face and hands (parent and their own) between the affected group and the control group. The analysis suggests that frequencies of overall SA demonstrated significant group differences. Infants in the depression group had less SA compared to the infants in the control group $t(32)=2.05$; $p < .05$. To further investigate the type of SA, the group comparisons were made for SA to their own hands, the toys, or their mother's hands or face. Findings showed no group

differences for SA to their hands (p=0.89), to their mother's hands (p=0.17) or to their mother's face (p=0.13). The group difference on SA was mainly a product of the group difference on infant's SA to toy object $t(32)=2.48$; $p < .05$.

Socially Coordinated Experiences: JA and VONM

To address the third hypothesis regarding the socially coordinated visual experiences, JA and VONMs, a set of paired sample t-tests was conducted. The results suggest that there was no group effect on JA moments (p=1.27), nor was there on VONM (p=0.20).

Discussion

The current thesis examined if depressive and/or threshold depressive symptoms in mothers impacts mother-infant interactions. The thesis aimed to document microstructure of the target behaviors that are relevant to children's early attention and learning by using head-mounted eye tracking systems to compare these variables between two sample groups: infants and mothers with depressive symptoms and/or are threshold depressive symptomatic (affected group) and infant and mothers without those characteristics (control group). The results from the group comparisons indicated two reliable group differences in looking behaviors—parents in the affected group had less SA to hand and toy objects when compared to the control group, and infants in the affected group looked at toy objects less when compared to the control group. These results are interesting in that they provide insights into the way the individuals in the two groups experience social referencing, the process wherein infants use social cues of engagement in adult to organize their behaviors given the task context. Specifically, the results indicate that differences in the process might be explained through visual experiences,

There are three aspects of the process that are specifically relevant to the present study, and these include (1) coordination of visual attention, (2) relevancy to emotional development, and (3) practical implication. In the discussion, these points are fist discussed then current limitations will be addressed.

Different Pathways for Achieving Visual Experiences with Object

Studies with typical sample such as typically developing infants with healthy parents who are from middle income family background documented that new born infants spend many hours looking at human face (mostly caregiver's) (Jayaraman et al., 2015; 2017) and gradually begin to pay more attention to hands (parent's and their own) (Burling & Yoshida, 2019) and their own objects manipulation (Madej, 2016; Smith et al., 2015; Yu & Smith, 2012; Utti, Shah, Sheth, Öğmen, and Yoshida, 2017). This makes sense in the framework of language learning. Learning about objects (object recognition), infants first "find" object from complex and cluttered visual scene and the learning about them requires extensive object looking experiences, and learning the object name requires also requires extensive experiences of object looking while hearing the names. These object experiences are initial building blocks for language development (Ruff & Rothbard, 2001). To effectively achieve this type of high-quality object looking and learning moment, young children are using many cues—adult's gaze (JA), speech, object handling, and combination of these (e.g., VONM), and these different pathways through which young children are navigated to the object-name correspondences. One way of achieving object-name link is through JA, and even very young infants follow the direction of social partner's gaze and manage to attend to the referent (Butterworth & Jarrett, 1991). Another pathway is speech. Evidence from adults and children suggests that speech and eye gaze are tightly linked (Borovsky, Elman, & Fernald, 2012; Griffin & Bock, 2000). For example, an experimental study showing visual stimuli and then the corresponding word documented the strong tendency of adult participants to look toward objects referred to by speech (Griffin and Bock, 2000). A series of experimental work with infants and young children also document that speech guide attention throughout development in a variety of task contexts such as visual search, preferential looking paradigm, and sentence processing, among others (Vales & Smith, 2015; Bergelson & Swingley, 2012; Tincoff & Jusczyk, 2012). Another effective cue guiding children's attention to object is parent's object holding and showing. Recent studies documenting how parents show objects to young infants suggest that parents show objects to

the infant in the way that they show objects' flat surfaces (oppose to depth or angles) by shaking and looming objects (Matatyaho & Gogate, 2008; Thelen & Smith, 1998), which has been shown to support young infants' object segmentation/recognition (Busking et al., 2010; Johnson et al., 2008; Valenza & Bulf, 2011). Furthermore, combined pathway such as object handling and speech together (e.g, VONM) appear to be the most constrained situation for navigating attention to object and to the name. Through eye-hand coupling, with object labeling, leads to coordinated joint shifts in visual attention and to an overall high rate of looking at the same object at the same time, and may be the dominant pathway through which physically active toddlers align their looking behavior with a social partner (Yu & Smith, 2013). Indeed, the VONM has been considered to be highly redundant, manual engagement with objects, hand movements and eye movements, and tightly coordinated both temporally and spatially across participants (parent and child). All these suggest that parents actively offer scaffoldings, though a variety of referential cues, and they are often combined and coordinated to effectively navigate young children's attention to object. Many propose that young children need these pathways to achieve effective object looking experiences which lead to healthy vocabulary development. Accordingly, the present study hypothesized that these highly "demanding" experiences –parent's object holding, object labeling, JA, and VONM--for which parents involve heavily might be compromised among mothers with depressive and/or threshold depressive symptoms, as a potential mediation for the link between maternal depression and child's developmental outcomes.

However, in the present study, the group differences were only in SA—parent's looking requires task involvement (object shaking/holding). Interestingly, the affected group managed to generate compatible amounts of speech, object holding, looking at child's face, JA instances and VONMs. These unexpected results raise interesting questions and speculations regarding that there might be potentially different pathways in which infants and young children may achieve effective object looking for these different groups. One speculation is that having these

cues—parental verbal input, object holding, child's face monitoring—do not always guarantee the effective object looking. Young infants from the affected group received these referential cues, yet did not achieved compatible amount of object looking experiences. This could be due to that parent's looking at object and/or hands may require much more "task specific involvement" than naming the object, object holding/shaking, and/or combined forms (e.g., JA and VONM). We do not know the specific link between types of social scaffoldings and the demandingness, but how different groups use the similar cues (thus their interaction may appear to be similar), yet the child has different visual experiences with objects is likely relevant. There are increased research effort characterizing parental input—scaffolding, social cues, responsiveness—and the effectiveness of these parental involvement on children's learning outcomes, but we are only beginning to understand moment-to-moment relationship between these input and infant's experiences. Another speculation is that infants in the control group might have more object looking outside of the JA and VONM, and that might have generated the group difference in object looking. Object looking outside of parental scaffolding (e.g., JA and VONM) can advance with skill given that SA to an object does not always have to be created with parental involvement. In other words, despite of the equivalent JA and VONM, which have been linked to word learning and language development (Chen, Castellanos, Yu, & Houston, 2019; Buckley, B., & Buckley, B., 2003), infants' experiences with objects without social scaffolding might not be comparative. We do not yet know the role of SA to object outside of parental scaffolding for early learning, but this is something important to further explore in the future.

Relevancy to Emotional Development

Although the present study specifically focuses on the behaviors that relevant to attention and language learning in the framework of social referencing, the results and implications appear to be relevant to the important aspect of social-emotional development. For example, parent-child *social coordination* is not only beneficial for cognitive development.

Synchronized emotional experiences are also critical for effective communication between infant and his/her social partner. In fact, the literature suggests that during social interactions, people shape each other's emotional states by resonance mechanisms and synchronized autonomic patterns (e.g., Vanutelli et al., 2017). There is a prominent need to understand the specific mechanisms by which postnatal depression influences social and emotional development, and the similar approach might benefit the field. After all, social and emotional development is a product of learning—processing and acumination of useful data. A parent's ability to stimulate emotional understanding and social competence occurs by directing the child's attention to quality information (e.g., Milligan et. al., 2015). In order to facilitate effective learning, mothers must be well aware of both the child's surroundings, emotional state, and frame of regard. However, this can be a higher hurdle for mothers who have depressive symptoms, are struggling and stressed, and/or are mentally preoccupied. Excessive parenting stress impedes maternal sensitivity, incites punitive parental reactions, and adversely shapes the parent-child relationship (Azhari et al., 2019). This is directly illustrated in a study which investigated the relationship between depressive symptoms and specific types of parenting behaviors including developmental stimulation, positive involvement, and negative control (Beeber et al., 2014). The results suggest that depressive symptoms showed some significant impact on positive involvement and developmental simulation. Vanutelli et al. (2017), further explored the hypothesis that cooperative social interactions require engaging in a social mind state and positive involvement, suggesting the importance of synchrony in communication, which aligns well with the models for language learning and socio-emotional development.

Given the similar synchronous process that is relevant to social-emotional development, the present results indicating that surface similarities of parental interaction (and some coordinated behaviors) may not always guarantee the same outcomes appears to be relevant to this domain. It has been proposed that parent's effective scaffolding requires acknowledging and interacting with a child as an autonomous mental being critical components for developing

social, emotional and language abilities (Milligan et al., 2015). Effective scaffolding includes demonstration of task relevant behaviors, incorporating an open and engaging interaction with a child to help strengthen their understanding of their own surroundings which helps guide the development of a more positive outlook on the world. Studying the microstructure of parent's looking behaviors (beyond overt behaviors) and child's experiences may help researchers understand the impact that a specific parental behavior has on children's cognitive, social, and emotional development. The present approach therefore can help identify the key behaviors to intervene, and preventative methods to minimize possible negative outcomes across the domains from vulnerable populations such as children with mothers struggling with threshold depressive symptoms.

Practice Implication

Depression is often stigmatized, and mothers of young infants are especially susceptible to pressures from society to conceal negative emotions, unhappiness, and frustrations with demanding child-bearing duties during early childhood years. Nonetheless, postpartum depression affects around 400,000 births every year (National Research Council and Institute of Medicine, Cummings et al., 2008; Wood & Miller, 2008). Therefore, it is critical to develop intervention methods that center around stimulating authentic engagement including the ability to experience negative emotions. The present study showed both similarities and differences in the mother-child interaction experiences, and the possibility of how similarly structured mother's scaffolding lead to different visual experiences for the affected and control groups. This highlights the importance of taking both parties, mother and the child, into the account when developing intervention methods. It has been suggested that possible preventative measures to protect children of mothers affected by depression should include targeting the dynamic of mother/child interactions rather than solely focusing on the mother's behavior so it directs the attention towards the collaborative play instead of exhausting affected mothers' efforts (Beeber et al., 2013).

Only twenty-five percent of individuals struggling with threshold depressive symptoms receive treatment, and depression is twice as likely to affect women compared to men (Sintag-Padilla et al., 2013; Gaynes et al., 2005). Yet it is also documented that identification of and treatment for maternal depression will likely support short- and long-term outcomes for both mothers and their children (Sontag-Padilla, et al., 2013). It is important to continue the effort of studying the process of how maternal depression and/or threshold depressive symptoms affect the offspring, and the effort should be taken interdisciplinary approach since the mother-child synchrony appears to be the key process across many domains of child development.

Limitations

The present study was designed to attain a mechanistic influence that depression has on parent-child dynamics and the results provided insights into the behavioral characteristics associated with depressive and/or threshold depressive symptoms. However, the present study has a few limitations that are important to consider for future studies. These include technological challenge, measurement usage limitations, and a few potential confounds.

First, during one study session, their eye tracking system got loosened and fell out of place. Although the experimenter paused the session, adjusted the equipment, and recalibrated the eye tracking system prior to resuming the session, the mother (from the affected group) used her right hand to hold the camera piece in place time to time. This is only one incident, yet this particular data set should be replaced with a new participant dyad for future analysis. Second, scoring methods used in a few depression assessment measures can be further improved. Specifically, the MINI assessments utilized in the study were delivered both prospectively and retrospectively; three mothers were originally recruited as potential healthy controls and included in the depression group after receiving high scores on the MINI that were later contacted for a MINI assessment via phone call. The remaining ten mothers met criteria for depression with the MINI and completed the interview prospectively. The utilization of multiple screening tools and inconsistent times of reference for participant data collection are

weaknesses in the current thesis, however, the intention was to include thorough depression screening to accurately discern each mother's mental state to help alleviate participant discomfort in outwardly communicating depressive symptoms with experimenters and the finite number of participants recruited. In the future, the use of measurement tools can be refined further to optimize both scientific and practical demands. The third limitation concern potential confounding factors. There were three factors that appear to be relevant to the research questions, yet the corresponding data for those factors were not collected thus there is no way of controlling them. One factor is their marital status. There has been documented that mothers living with their partner experienced notably more effective parenting compared to single mothers (Beeber et al., 2014), and this might be buffering the documented negative effect on the play behaviors. Thus, future studies should account for the marital status. Another factor the present study failed to control is their quality of sleep. According to a recent study, depressive symptoms and attention were both irritated in adults with inadequate sleep supporting a negative correlation between sleep duration and the presence of depressive symptomatology (Lehto & Uusitalo-Malmivaara, 2014). It would be valuable to include matched sleep measures in order to combat possible confounding effects from sleep deprivation or incompatible amounts of sleep between groups. Lastly, another possible explanation for the differences identified solely in looking frequency of mothers with threshold depressive symptoms towards objects and hands, and their child's looking frequency of object (and not in any other variable) may be because of the distraction and discomfort that prevent the affected group to fully get involved in the task. These distraction and discomfort can be associated with anxiety that is common when in an unfamiliar setting, and the magnitude of such effects might be increased for the affected group. Although the study design has allowed us to track moment by moment behaviors while allowing participants the freedom to play as they would at home, mothers are still aware that they are in a novel place with cameras recording their interaction. These factors may drive mothers' responsiveness and the infant's visual experiences, and thus limit generalizability.

Conclusion

The thesis results provide initial insights into the differential experiences of infants during play that are related to depressive symptoms. Research on maternal depression often focuses on the negative effect of the symptoms and the potential link to developmental outcomes of the offspring (Cummings et al., 2008; Elgar et al., 2007; Goodman & Gotlib, 1999; Lim, Wood, & Miller, 2008; Onunaku, 2005; Field, 2000; Conners-Burrow, et. al. 2014; Buckley & Buckley, 2003). Several previous studies confirmed that mothers who are struggling with depression/ depressive symptoms are less sensitively attuned to their babies than mothers who are not depressed (e.g., Murray 2001; Harris et al., 1989). As informative as such findings may be, there are limitations in studying the affected behaviors without investigating how these behaviors are received at that very moment by the offspring. Parental behaviors are not only "given" to the infant, these parental behaviors change the way the child process information through the developing years, and such child's responses feedback to the parent's behaviors (e.g., Vanutelli et. al, 2017; 2009). The present study, which certainly warrants further studies, contributes to potential mechanisms for how maternal depression may influence the early cognitive development and potential insights into intervention ideas.

Table 1: The list of target behavioral variables and the annotation protocol.

Variables	**Annotation Protocol**
Parent speech	Every utterance was transcribed and annotated. Annotations for mother's speech which encompasses everything from the use of target words and statements that call for attention to verbal sounds are important to be included.
Parent/child (SA)	Every instance of eye gaze was annotated in Datavyu. These included moments where the infant looked at their own hands, parent's hands, parent's face, or the object. Specific visual regard and the duration of sustained attention were recorded when they were directed towards a target variable.
Parent/child Object holding	Every instance of parents' and infant's object holding were annotated. This includes any co-occurring actions such as showing and shaking
VONM	Instance when an object is captured larger than 70% of head-mounted camera view were annotated and then selectively annotated as VONM when these moments were accompanied by parent's object labeling.
JA	Every simultaneous looking instance by the parent and child to the same object (e.g., toy object, hands) was counted as JA. The coders used both the child's and parent's view to identify the frames that contained an object in view longer than 500ms

Table 2: Descriptive statistics of the sample

	Control Group	**Affected Group**	**Significance value of t test**
Variable	**Mean (SD)**	**Mean (SD)**	
Age	10.85 (4.47)	11.98 (4.17)	P= 0.47
MINI	Criteria Not Met	Criteria Met	n/a
IDAS (raw score)	41.94 (14.75)	106.00 (15.42)	P< 0.01
SCL-10	1.22 (.04)	1.87 (.08)	P< 0.01
EPDS	5.00 (1.20)	9.00 (.37)	P< 0.01
Annual Income	$42,353 (2,8345.95)	$41,194 (9,815.64)	P> 0.05 (P= 0.1006)

Table 3: Means and standard deviations for the target variables for two groups.

VARIABLES	Control Group		Affected Group	
	Mean Frequency	**SD**	**Mean Frequency**	**SD**
Parent Speech	103.88	29.31	102.71	31.23
Parent SA				
Object	217.35	34.82	121.00	39.44
Child Hand	89.52	31.83	46.47	9.07
Parent Hand	56.71	12.51	24.59	4.95
Child Face	165.47	25.05	116.29	34.94
Child SA				
Object	186.18	18.74	118.06	26.13
Child Hand	12.88	3.33	11.88	2.71
Parent Hand	91.94	11.92	71.35	23.49
Parent Face	41.12	9.60	25.24	6.14
Parent Holding				
Right hand	41.47	16.75	45.06	17.19
Left hand	36.82	13.37	34.29	9.20
Child Holding				
Right hand	32.71	8.02	18.47	6.15
Left hand	29.65	7.16	20.06	3.96
VONM	105.65	16.35	102.29	50.11
JA	220.53	35.90	144.00	22.07

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APPENDIX

SCL-10

The Symptoms Check List-10 (SCL-10) is a widely used scale for mental health in epidemiological studies. The SCL-10 is a self-administered instrument that mainly explores symptoms of anxiety and depression. The questionnaire was completed by participants at home and handed in at the lab. The SCL-10 questions explored the presence and severity of the following ten symptoms during the preceding week: “Sudden fear without apparent reason”, “Afraid or worried”, “Faintness or dizziness”, “Tense or upset”, “Easily blaming yourself “, “Sleeplessness”, “Depressed or sad”, “Feeling worthless”, “Feeling that everything is a struggle”, and “Feeling hopelessness with regard to the future”. Each question was rated on a four-point scale ranging from 1 (not at all) to 4 (extremely). Missing values were replaced by the sample mean value for each item, but questionnaires with three or more missing values were excluded from the analyses. The average SCL-10 score was calculated by dividing the total score by the total number of items. A higher score value indicated more symptoms (Kvamme, J., Grønli, O., Florholmen, J., & Jacobsen, B., 2011).

MINI

The Mini-International Neuropsychiatric Interview (MINI) was originally developed as a brief, simple procedure to provide a short diagnostic structured interview compatible with the DSM-111-R and ICD-10 criteria. Its algorithms and question formulations are similar to those of the Composite International Diagnostic Interview. The Mini-International Neuropsychiatric Interview (MINI) has acceptable validity and reliability against the structured clinical interview for DSM-111-R .

EPDS

Edinburgh Postnatal Depression Scale (EPDS) is a 10-item pencil and paper test and the most advocated screening postnatal depression screening test (Elliott et. al., 2005). The scale was developed and validated following dissatisfaction with standard instruments for detecting depression (Cox, Holden, & Sagovsky, 1987). Response categories are scored 0, 1, 2, or 3 according to the severity of the symptom. Items 3 and 5– 10 are reverse scored. The total score is calculated by adding item scores together.

IDAS

Inventory of Depression and Anxiety Symptoms (IDAS) is specifically designed to contain multiple scales which focuses on the cognitive and emotional symptoms of depression. The IDAS consists of 64 items that individuals rank on a 5-point Likert-type scale. The 64 items are part of two general scales, and 10 specific subscales which are: Well-being, Panic, Lassitude, Insomnia, Suicidality, Social Anxiety, Ill Temper, Traumatic Intrusions, Appetite Loss, and Appetite Gain. All the subscales consist of eight or fewer items. There are currently no cut-off scores indicating severity of categories (Nelson, G. H., O'Hara, M. W., & Watson, D., 2018;Ingram & Siegle, 2002; Joiner et al., 2005), thus, the present study conducted a matched pairs t-test between groups and compared scores with normative data from a 2018 study by the Dr. O’Hara and Watson from the University of Iowa (Nelson, G. H., O'Hara, M. W., & Watson,

D., 2018) as a guide for later conducting retrospective MINI depression screenings (Ingram & Siegle, 2002; Joiner et al., 2005).