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Mother's anxiety and depression during the third pregnancy trimester and neonate's mother versus stranger's face/voice visual preference

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ABSTRACT

Background: Neonates show visual preference for their mother's face/voice and shift their attention from their mother to a stranger's face/voice after habituation.

Aim: To assess neonate's mother versus stranger's face/voice visual preference, namely mother's anxiety and depression during the third pregnancy trimester and neonate's: 1) visual preference for the mother versus the stranger's face/voice (pretest visual preference), 2) habituation to the mother's face/voice and 3) visual preference for the stranger versus the mother's face/voice (posttest visual preference).

Method: Mothers (N = 100) filled out the Edinburgh Postnatal Depression Scale (EPDS) and the State Anxiety Inventory (STAI) both at the third pregnancy trimester and childbirth, and the "preference and habituation to the mother's face/voice versus stranger" paradigm was administered to their newborn 1 to 5 days after childbirth.

Results: Neonates of anxious/depressed mothers during the third pregnancy trimester contrarily to neonates of non-anxious/non-depressed mothers did not look 1) longer at their mother's than at the stranger's face/voice at the pretest visual preference (showing no visual preference for the mother), nor 2) longer at the stranger's face/voice in the posttest than in the pretest visual preference (not improving their attention to the stranger's after habituation).

Conclusion: Infants exposed to mother's anxiety/depression at the third gestational trimester exhibit less perceptual/social competencies at birth.

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Human neonates present even before birth several perceptual competencies that enable them to be more attentive to human stimulus, compared to other stimuli also available in the environment but not as important for survival. Specific responsiveness to human stimulus may result from genetic equipment selection or from learning experiences during the last trimester of gestation, and guarantees a social pre-adaptation that enhances the newborn survival in the out-of-uterus environment [1].

Neonates prefer complex, shiny visual stimuli with color contrast [2]; however, the most attractive visual stimuli are those that most resemble the human face [2–5]. The newborn is able to look at a schematic face, to differentiate between a false and a true face [6], and to prefer their mother's face to a stranger's face [7], even with confusing variables being controlled, such as body odor, color of hair or skin, etc. [8–10].

Newborns prefer human sounds as well, especially female voices, but more specifically their mother's voice [11] or their mother's native language [12,13]. Ockleford et al. [14], for example, observed a cardiac

deceleration¹ in response to the mother's voice versus a cardiac acceleration in response to unfamiliar voices in neonates with less than 24 h. Humans are born with a specific preference for listening to speech: they adjust their sucking amplitude to speech, as compared with complex non-speech analogues controlled for critical spectral and temporal parameters [15], or to an intonation that is closest to its mothers' regular speech [16].

Infants bring at birth considerable auditory experience from the gestational period. DeCasper and Fifer [11] commented that based on prenatal experiences newborns preferred their mothers' voice to another female voice. Maternal voice has been described as the most intense stimulus in the amniotic liquid. Some data suggests that neonates respond selectively to sounds, particularly to their mother's voice as they have experienced it repeatedly in the uterus. Newborns' preference for their mothers' voice during the first days after birth supposedly comes from prenatal learning experience; as similarly to newborns, fetuses also present a cardiac deceleration in response to their mothers' speech [e.g., 17–19]. Querleu et al. [20] noticed in one to two-hours-old infants without any contact after birth with their mother,

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¹ Cardiac deceleration corresponds to a cardiovascular attention response.

a significant different response to their mothers' voice compared to five strangers' voices: neonates presented a more complex behavior in response to their mothers' voice than to the strangers', still after intonation was controlled (since mothers' voices were frequently warmer).

Neonates exhibit a visual preference for their mothers' face/voice looking more at her than at a stranger [7,9–11,21,22]. The fact that the neonate is able of recognizing the mother's voice and of looking at her in response is an asset in the establishment of the mother–infant relationship: the newborn will look at the source of his mother's voice that guides him to her face. This behavior elicits the mothers' attention in return, and leads her to better interact with the offspring, strengthening interaction and bond in the dyad [18].

Newborns' preference for their mothers' face/voice is crucial to establish a privileged relationship with the mother and subsequently to receive the care needed to survive. But exploration of new stimuli is an important achievement for infant survival as well.

Habituation consists in a decrease or extinction of the response to a stimulus, after repeated presentations. The first studies about habituation in newborns [e.g., 23–25] and infants with less than a month of age [26], observing changes in cardiac or suction activity when presenting repeatedly the same (visual, auditory or olfactory) stimulus, go back to the 50s and 60s. More recently, research show habituation to auditory and vibrant-acoustic stimulus not only in neonates [e.g., 27,28], but also in fetuses during the third gestational trimester [29–31].

Sokolov [32] designated as 'oriented reflex' the infant's physiological and behavioral pattern change, displayed when exposed to a new stimulus. Several reports have been published since then, revealing that infants show oriented reflexes when exposed to new stimuli [e.g., 33–35]. Preference for a new auditory stimulus after habituation has also been observed in fetuses during the last gestational trimester [e.g., 36].

One of the first studies about preference for the mothers' face demonstrated that neonates not only preferred their mothers' face (*versus* a stranger's face), but also became used to after successive presentations, and shifted preference from the mother's face to a new stimulus (the face of a stranger) [7]. These results suggest that newborns not only recognize the characteristics of their mothers' face, but can also detect differences between two female faces, and even more surprising, explore new information when provided. The decrease of attention when faced with the repeated presentation of the mother's face (habituation), and the following preference for another female face, shows that newborn competency involves more than just an innate behavior of preference for what is already known.

Several studies have suggested that both maternal anxiety and depression during gestation may have a negative effect on the behavior and development of the fetus. Beside low estimated fetal weight [37], signs of behaviour immaturity (as less time in quiet sleep and more indiscriminated movements in active sleep, higher heart rate, more activity, delayed habituation to stimulus, etc.) have been observed in fetuses of anxious/depressed mothers, when compared with fetus of non-anxious/non-depressed mothers during pregnancy [e.g., 38–40].

Some studies did find a specific effect for depression, but not for anxiety on neonatal outcomes. In a recent report with 681 women with singleton pregnancies, the rate of spontaneous preterm birth was significantly higher among those with high depression scores (9.7%) as opposed to other women (4.0%), while anxiety was not significantly associated with this outcome [41]. Also, in a large sample of 3149 low-income, predominantly African-American pregnant women, Neggers et al. [42] found that negative affect was the only factor significantly associated with both infant prematurity and low birth weight.

At birth, infant's behavior of anxious/depressed pregnant women is less organized, as they show lower motor organization and autonomic stability, poor social orientation and habituation, and more signs of withdrawal and depression in the NBAS (Neonatal Brazelton Assessment Scales, [43]) [44–47]. Prenatal exposure to

maternal anxiety and depression has also consequences on infant temperament [48,49]. Woman's antenatal anxiety and depression was associated with infant neonatal temperamental difficulties: for example, high cry reactivity in response to novelty [49], negative emotionality and withdrawal/fear [50], disorganized sleep patterns [44,46], and indisposition and inconsolability [51,52]. Prenatal maternal anxiety and depression predicted infant temperament at 2 [e.g., 48] and 4 months of age [e.g., 49]. The impact on infant outcome shown in these studies was independent of the women's postnatal anxiety [e.g., 49]. For example, more sleep problems or disturbances, including more time in disorganized sleep and more cry/fussing, were reported in infants of depressed/anxious mothers during pregnancy, independently of the impact of postnatal anxiety or depression [e.g., 48,53,54].

Difficulties in discriminating stimuli, including preference for the face/voice of the mother *versus* stranger and longer habituation was also reported in infants of depressed mothers at delivery. Hernandez-Reif et al. [22] have shown that neonates of depressed mothers: 1) failed to show an initial visual preference for their mother *versus* a female stranger's face/voice, 2) required 1/3 more trials and almost twice as long to habituate, 3) and failed to show preference for a female stranger's face/voice after habituation. However, this specific perceptual/social competency has not been studied in newborns of depressed/anxious mothers during pregnancy, despite the important impact it may have on the mother–infant interaction.

The main aim of this study was to assess neonate's mother *versus* stranger's face/voice visual preference; namely mother's anxiety and depression during the third pregnancy trimester and neonate's: 1) visual preference for the mother *versus* the stranger's face/voice (pretest visual preference), 2) habituation to the mother's face/voice and 3) visual preference for the stranger *versus* the mother's face/voice (posttest visual preference).

2. Method

2.1. Participants

One hundred neonates born between January 2006 and December 2007 in a Maternity Hospital (Porto, Portugal) and their mothers were included in this study. Newborns were 1 to 5-days-old ($M = 87.99$ h; $SD = 94.04$) male or female; the majority were born full term and with a normal weight ($M = 3141.20$ g; $SD = 490.21$), length ($M = 48.58$ cm; $SD = 2.38$), cephalic perimeter ($M = 33.62$ cm; $SD = 5.94$), and ponderal index ($M = 2.74$, $SD = 0.37$). The mothers were primiparous and multiparous, and aged between 17 and 41 years old ($M = 28.82$, $SD = 6.50$). The majority was married or living with the infant's father, had completed nine or more years of school education, and was employed (see Table 1).

2.2. Measures

2.2.1. Socio-demographic questionnaires

Information about mother's age, ethnicity, nationality, occupational status, marital status, household arrangements, years of schooling, medical and obstetrical risk was collected during pregnancy. Data concerning childbirth (e.g., type of delivery) and the newborn (e.g., weight, length, etc.) was also collected at birth.

2.2.2. Paradigm "Preference and habituation to the mother's face/voice versus stranger" ([22], modified from [7])

The "Preference and habituation to the mother's face/voice *versus* stranger" (as better described in the procedure section) consists in an experimental situation with 3 phases [1) pretest visual preference, 2) habituation to the mother's face/voice, and 3) posttest visual preference], involving the participation of the mother and two strangers.

Table 1
Infant and mother's socio-demographic data (N = 100).

			%
Infant	Gender	Male	59
		Female	41
	Weight (g)	<2500	9
		≥2500	91
	Length (cm)	<48	29
		≥48	71
	Ponderal index	≤2.50	23
		>2.50	77
	Gestation age	<37	7
		≥37	93
Mother	Age (years)	<19	10
		≥19	90
	Years of schooling	<9	30
		≥9	70
	Professional status	Employed	66
		Unemployed	44
	Living	Without partner	10
		With partner	90
	Parity	Primiparous	70
		Multiparous	30

2.2.3. State-Trait Anxiety Inventory (STAI [55])

The State-Trait Anxiety Inventory (STAI-S/T) is a 2 twenty-item self-report scale for measuring anxiety that differentiates between the temporary condition of “state anxiety” (anxiety in a specific situation) and the more general and long-standing quality of “trait anxiety” (anxiety as a general trait)² [55]. Several studies have been using this instrument both during pregnancy [e.g., 56,57] and/or the postpartum period [e.g., 58]. STAI's Portuguese version has showed good internal consistency (Cronbach alpha = 0.87); authors advise a score equal or higher than 45 to screening high-anxiety states [59].

2.2.4. Edinburgh Postnatal Depression Scale (EPDS [60])

The Edinburgh Postnatal Depression Scale is a self-report questionnaire composed of 10 items in a Likert scale of 4 points (0–3) to assess depression. This questionnaire has been used in several studies with pregnant and/or postpartum women [e.g., 61–63], including in Portugal [e.g., 64–66]. EPDS Portuguese version showed good internal consistency (Cronbach Alpha = 0.85); an equal or higher score than 10 indicates the probable presence of a major depressive episode [67,68].

2.3. Procedures

Participants were recruited in a Maternity Hospital Out-patients Unit, following the authorization and approval of the Ethical Committee. The exclusion criteria were: not reading or writing Portuguese and at-medical risk or multiple gestations. The aims and procedures of the study were explained during the first obstetric regular appointment, and 90% of the contacted mothers agreed to participate after signing an informed consent form.

At the third pregnancy trimester (between weeks 30 and 34) as well as during the first 5 days after childbirth, mothers answered questions from the Socio-Demographic Questionnaires, and filled out the EPDS and the STAI. The Paradigm “Preference and habituation of the face/voice of the mother versus stranger” was delivered to the newborn on the first 5 days of life—from 5 to 120 h ($M = 87.99$, $SD = 94.04$). Newborn's age (hours of life) didn't differ in infants from the anxious and non-anxious ($Z = -0.768$, $p = .443$) and the infants from the depressed and non-depressed ($Z = -1.894$, $p = .057$) mother groups.

The “Preference and habituation to the mother face/voice versus stranger” paradigm included the mother (M), the newborn and two

female experimenters (strangers to the newborn) that were used as strange figures (S_1 and S_2). Testing occurred in the mother's hospital room. Along with the length of her hospital bed, the mother was placed between the two strangers. All 3 placed their feet on the floor and wore a white coat to minimize the presence of parasite variables and resorted to a black card 40 cm × 22 cm to cover their face whenever they weren't calling the newborn. Strangers and mothers were matched by hair color, skin tone and did not wear jewelry. The side of the strangers (S_1 and S_2) was counterbalanced. A third experimenter also wearing a white coat, held the newborn at the same distance (15–20 cm) from the mother and the stranger who was calling it. At the beginning of each trial, the mother or the stranger was asked to lower her screen and to call the newborn, catching its attention by saying “hello baby”, “look at me baby”, making it look at her as long as possible. The implementation of this procedure involved 3 phases:

First phase—Newborn's pretest visual preference: There are two stimuli: face/voice of the mother (M) and face/voice of the stranger (S_1) presented two times each, in two possible sequences (MS_1S_1M and S_1MMS_1). The stimulus starts when the mother/stranger lower her screen and calls out to the newborn and ends when the newborn looks away or moves its head 30° from the stimulus. The dependent variables were the duration of the infant's looking (measured in seconds) at the mother's face (sum of seconds of looking on the 2 trials) and at the stranger's face (sum of seconds of looking on the 2 trials).

Second phase—Newborn's habituation: In this phase only the mother and the newborn participate. Strangers remained present with their screens raised to obstruct their faces. The stimulus is presented 3 times (MMM), from which the researcher defines a baseline (average of the first 3 trials of looking at the mother). The stimulus (M) is then successively presented until the newborn presents a habituation response. Habituation response was defined as looking on 3 consecutive trials below the baseline criterion. The dependent measure for this phase was the number of trials to reach habituation.

Third phase—Newborn's posttest visual preference: The first phase procedure is repeated, but instead of the S_1 , it is the other stranger (S_2) that calls the newborn. As in the first phase, the dependent variables were the duration of the infant's looking (measured in seconds) at the mother's face (sum of seconds of looking on the 2 trials) and at the stranger's face (sum of seconds of looking on the 2 trials).

The whole procedure was recorded in DVD format by a fourth experimenter placed on the other side of the mother's bed, on the back of the mother and the strangers, at 1.5 m of the newborn. Two independent observers, unaware of the hypothesis of the study, visualized the DVDs and scored the dependent variables as defined. Data were computerized digitally for inter-observer reliability. Inter-observer reliability was adequate considering Pearson Correlations between the two judges for continuous variables—seconds looking to the mother ($r = .90$) and seconds looking to the stranger ($r = .81$)—and Cohen's Kappa for the number of trials to reach habituation ($\kappa = .58$).

2.4. Statistical analyses

Data were digitalized and statistical treatment was supported by SPSS 17.0. Non parametric tests were performed because data did not reveal neither a normal distribution nor homogeneity of variance, for the different groups under study. Mann-Whitney tests for independent samples were conducted for differences between the amount of time newborns looked at the mother versus the stranger in the visual

² In the presented analyses only state anxiety results were considered.

preference pretest and in the visual preference posttest, in the total sample and in each of the studied groups: anxious (STAI-S \geq 45), non-anxious (STAI-S $<$ 45), depressed (EPDS \geq 10) and non-depressed (EPDS $<$ 10) mothers. The same analysis was also applied to the study of differences between anxious (STAI-S \geq 45) versus non-anxious (STAI-S $<$ 45) and depressed (EPDS \geq 10) versus non-depressed (EPDS $<$ 10) mother groups regarding the amount of time newborns looked at: the mother in the visual preference pretest, the mother in the visual preference posttest, the stranger in the visual preference pretest and the stranger in the visual preference posttest. Wilcoxon signed-rank tests were used for related samples to test for differences in the duration of the infant's looking in the visual preference pretest versus posttest at the mother and at the stranger, in the total sample and in each of the studied groups: anxious (STAI-S \geq 45), non-anxious (STAI-S $<$ 45), depressed (EPDS \geq 10) and non-depressed (EPDS $<$ 10) mothers. Pearson's chi-square test were used to study associations between the infant habituation response to the mother's face/voice and the anxious (STAI-S \geq 45) versus non-anxious (STAI-S $<$ 45) and the depressed (EPDS \geq 10) versus non-depressed (EPDS $<$ 10) mother groups. Hierarchical multiple regression analyses were performed to identify significant predictors of neonate's preference for: the mother's face/voice (difference between the duration of the infant's looking at the mother and the stranger, in pretest) and, the stranger's face/voice (difference between the duration of the infant's looking at the stranger and the mother, in posttest). Predictors were mother's anxiety (STAI-S $<$ 45 versus STAI-S \geq 45) and depression (EPDS $<$ 10 versus EPDS \geq 10) during the third trimester of pregnancy and at delivery: mother's anxiety and depression during the third pregnancy trimester entered as block 1 and mother's anxiety and depression at delivery entered as block 2. The variance inflation factor $<$ 5 in all the analysis indicates no problems of multicollinearity. Co-morbid mothers (STAI-S \geq 45 and EPDS \geq 10) (16%) were not excluded from the analyses.

3. Results

3.1. Mother's anxiety and depression during pregnancy and neonate's visual preference for the mother versus the stranger's face/voice (pretest visual preference)

On the preference pretest neonates generally demonstrated visual preference for their mothers' face/voice, looking significantly longer at their mother than at the stranger ($Z = -3.100, p = .002$) (see Table 2).

Newborns of anxious mothers (STAI \geq 45 at the third pregnancy trimester), compared with newborns of non-anxious mothers, spend significantly less time looking at their mothers ($Z = -1.969, p = .049$); but no significant differences were observed on the duration they looked at the stranger ($Z = -0.436, p = .663$). Also, newborns of anxious mothers did not show any visual preference for their mother's face/voice versus the stranger's ($Z = 0.000, p = 1.000$), contrarily to the newborns of the non-anxious mothers group, who looked significantly more at their mother than at the stranger ($Z = -3.536, p = .000$) (see Table 3).

There were no significant differences between newborns of depressed (EPDS \geq 10 at the third pregnancy trimester) and non-depressed mothers in the time spent looking at the mother ($Z = -1.417,$

$p = .156$) or at the stranger ($Z = 0.711, p = .477$). Newborns of depressed mothers didn't show the usual visual preference for their mother's face/voice versus the stranger's ($Z = -0.553, p = .580$); on the contrary, newborns of non-depressed mothers spent significantly more time looking at their mother than looking at the stranger ($Z = -3.315, p = .001$) (see Table 4).

Mother's depression at the third pregnancy trimester was the only significant predictor of the neonate's visual preference for the mother's face/voice ($\Delta R^2 = .060, \text{Beta} = -.274, t = -2.271, p = .026$), while mother's anxiety at the third pregnancy trimester was not significant ($\text{Beta} = .030, t = -.245, p = .807$). Mother's depression at the third pregnancy trimester was the only significant predictor of the neonate's visual preference for the mother's face/voice ($\Delta R^2 = .037, \text{Beta} = -.270, t = -2.091, p = .040$), even when mother's anxiety and depression at delivery were added: mother's anxiety and depression at delivery (in block 2) didn't explain significantly any supplementary variability in the results ($F(4) = 1.796, p = .138$).

3.2. Mother's anxiety and depression during pregnancy and neonate's mother face/voice habituation

Habituation to the mother's face/voice generally required 3 trials (53.5%), but some newborns needed 4–6 trials (39.4%) or 7–9 trials (7.1%) until they were habituated to the stimulus. No significant differences were obtained in the number of trials needed to habituate to the mother's face/voice between the newborns of anxious mothers (STAI \geq 45 at the third pregnancy trimester) versus newborns of non-anxious mothers ($\chi^2(2) = 1.684, p = .431$), neither between the newborns of depressed mothers (EPDS \geq 10 at the third pregnancy trimester) versus the newborns of non-depressed mothers ($\chi^2(2) = 3.075, p = .215$).

3.3. Mother's anxiety and depression during pregnancy and neonate's visual preference for the stranger's face/voice after habituation to the mother's (posttest visual preference)

On the posttest visual preference phase neonates generally show visual preference for the stranger's face/voice, looking significantly longer to the stranger than to their mother ($Z = -3.136, p = .002$) (see Table 2).

No significant differences were observed between newborns of anxious mothers (STAI \geq 45 at the third pregnancy trimester) and newborns of non-anxious mothers, neither in the time spent looking at the mother ($Z = -0.782, p = .434$) nor in the time spent looking at the stranger ($Z = -0.517, p = .605$). Also, neonates of anxious ($Z = -1.957, p = .050$) and non-anxious ($Z = -2.487, p = .013$) mothers seem to show the usual visual preference for the stranger, looking significantly longer at the stranger than at their mother (see Table 3).

No significant differences were observed between newborns of depressed mothers (EPDS \geq 10 at the third pregnancy trimester) and of non-depressed mothers in the seconds of looking to the mother ($Z = -1.290, p = .197$) and to the stranger ($Z = -0.158, p = .874$). Newborns of non-depressed ($Z = -2.524, p = .012$) and depressed

Table 2
Looking at the mother and at the stranger's face/voice at the visual preference pretest and posttest (N = 100).

		Mother		Stranger	
		M (SD)	M (SD)	M (SD)	M (SD)
1	Pretest	9.71 (8.30)	6.85 (6.30)		
2	Posttest	6.15 (5.77)	9.08 (9.88)		

Measure unit: seconds of looking.

Table 3
Looking at the mother and the stranger's face/voice at the visual preference pretest and posttest in infants of anxious and non-anxious mothers.

		STAI \geq 45 (n = 23)		STAI $<$ 45 (n = 77)	
		Mother		Stranger	
		M (SD)	M (SD)	M (SD)	M (SD)
1	Pretest	6.84 (5.08)	7.41 (6.58)	10.56 (8.89)	6.69 (6.37)
2	Posttest	4.37 (2.28)	7.43 (5.95)	6.68 (6.37)	9.56 (10.77)

Measure unit: seconds of looking.

Table 4

Looking at the mother and at the stranger's face/voice at the visual preference pretest and posttest in infants of depressed and non-depressed mothers.

		EPDS ≥ 10		EPDS < 10	
		(n = 33)		(n = 67)	
		Mother	Stranger	Mother	Stranger
		M (SD)	M (SD)	M (SD)	M (SD)
1	Pretest	7.82 (5.70)	7.27 (6.30)	10.63 (9.21)	6.64 (6.33)
2	Posttest	4.50 (2.97)	8.05 (6.18)	6.96 (6.61)	9.58 (11.27)

Measure unit: seconds of looking.

($Z = -2.001, p = .045$) mothers spent significant more time looking at the stranger than looking at their mother (see Table 4).

No predictors were found for the newborn stranger's face/voice preference.

3.4. Mother's anxiety and depression during pregnancy and neonate's preference for the mother's versus the stranger face/voice before versus after habituation to the mother's

Neonates generally looked longer to their mothers' face/voice in pretest visual preference than in posttest visual preference ($T = -4.591, p = .000$). Nevertheless, they looked longer to the stranger's face/voice in posttest visual preference than in pretest visual preference ($T = -2.281, p = .023$) (see Table 2).

Newborns of anxious mothers (STAI ≥ 45 at the third pregnancy trimester) looked significantly less to their mothers in the posttest visual preference than in pretest visual preference ($T = -2.188, p = .029$). However, they did not look significantly longer at the stranger in the posttest visual preference than in the pretest visual preference ($T = -0.356, p = .722$) (see Table 3). Neonates of non-anxious mothers looked significantly less to their mothers in the posttest visual preference than in pretest visual preference ($T = -4.000, p = .000$), and look significantly longer at the stranger in the posttest visual preference than in the pretest visual preference ($T = -2.367, p = .018$) (see Table 3).

Newborns of depressed mothers (EPDS ≥ 10 at the third pregnancy trimester) looked significantly less at their mother in the posttest visual preference than in the pretest visual preference ($T = -3.383, p = .001$). But they did not look significantly longer at the stranger in the visual preference posttest than in the pretest visual preference ($T = -0.846, p = .398$) (see Table 4). Non-depressed mothers infants looked longer to their mothers in pretest visual preference than in posttest visual preference ($T = -3.325, p = .001$); and looked longer to the stranger in posttest visual preference than in pretest visual preference ($T = -2.070, p = .038$) (see Table 4).

4. Discussion

This study shows that 1 to 5-days-old newborns show visual preference for the mother versus a stranger, looking longer at their mother than at the stranger's face/voice, which corroborates reported data in the literature about neonatal preference for the mother face [e.g., 7–10] and voice [e.g., 11,14,20] compared to a stranger's. Results of this study also show that contrarily to neonates of non-anxious/non-depressed mothers, neonates of anxious/depressed mothers during the third pregnancy trimester did not look longer at their mother's than at the stranger's face/voice at the visual preference pretest (showing no visual preference for the mother). Results suggest the absence of this important perceptual/social competence in newborns of mothers who were both anxious and depressed during the third pregnancy trimester, as others have found in newborns of depressed mothers at delivery [22].

Our regression analysis results add some new empirical evidence: 1) neonate's preference for their mother's face/voice seems to be more affected by the mother's prenatal depression than by the mother's prenatal anxiety, and 2) mother's anxiety and depression at delivery are not the reason for these observed effects. In fact, mother's depression during the third pregnancy trimester is negatively related to the neonate's competence to show visual preference for the mother versus a stranger's face/voice, and maternal anxiety during the third pregnancy trimester is not a significant predictor when maternal depression is considered. These results pointed out that mother's antenatal depression may have a greater adverse impact on the fetus/infant's development than antenatal anxiety, as shown in some recent studies [41,42]. Furthermore, attending to the reported high co-morbidity between anxiety and depression during pregnancy [e.g., 46,62,69], the maternal anxiety effects obtained may depend on mother's depression, since they frequently are co-morbid, and anxiety is not always controlled. Moreover, data have also revealed that mother's depression during the third pregnancy trimester is still negatively related to the neonate's competence to show visual preference for the mother versus a stranger's face/voice even when concomitant mother's anxiety and depression after childbirth is controlled. These results support other empirical observations regarding behavioral difficulties in neonates of depressed women during pregnancy, which do not depend on the mother's depression/anxiety at the moment of assessment [48,53,54], and reiterate the importance of the mother's mental state during pregnancy for the infant's behaviour and development.

A decrease in neonate attention was observed after repeated presentation of the mother's face/voice. Results illustrate newborn's habituation (a decrease in visual attention after repeated presentation of the mother stimulus), in accordance with what has been presented in the literature [e.g., 7,23,27,34]. Habituation was present in both infants of anxious and depressed mothers and in infants of non-anxious and non-depressed mothers during the third pregnancy trimester. Mother's anxiety/depression during pregnancy appears to have no interference in the number of trials the newborn needs to show habituation, at least in this study, contrarily to what has been observed by others [22]. Infants in this sample are older than the ones that have been previously studied [22], which main explain the absence of differences in habituation.

Newborns' preference for a new stimulus (the stranger's face/voice) following habituation (to the mother's face/voice) was also observed in this study, in accordance to what literature reveals [e.g., 7,35]. This result suggests that usually newborns not only recognize the characteristics of their mother's face/voice, but can also detect differences between two female faces/voices, and explore new information when provided.

However, contrarily to what we expected based on published data [e.g., 22], neonates of both anxious and depressed mothers during the third pregnancy trimester, after becoming habituated to their mother's face/voice looked longer at the stranger's face and hence supposedly are as competent as non-anxious/non-depressed mother's neonates in showing preference for a new stimulus after habituation. Nonetheless, our results clarify that this does not correspond to a real shift in their attention, as newborns of anxious or depressed mothers during pregnancy looked less at their mother but not more at the stranger in the posttest compared to the visual preference pretest. On the contrary, neonates from both groups of non-anxious and non-depressed mothers during the third pregnancy trimester exhibited more attention to the stranger's than to the mother's face/voice after habituation, which corresponds not only to a decrease in their attention towards the mother, but also to an increase in their interest towards the stranger. What we in fact observed was a decrease in the neonate's visual interest towards the mother, which in newborns of anxious or depressed mothers during pregnancy does not correspond to an increase in the attention to the new stimulus, contrarily to what we observed in newborns of non-anxious and non-depressed mothers.

Important perceptual/social competencies, such as visual preference for the mother's face/voice, habituation to the mother's face/voice, and visual preference for the stranger's face/voice after habituation, are usually present in neonates at birth. Newborns with different prenatal conditions are however not equally competent in the expression of these competencies in the postnatal period. mother's depression seems to affect infant maturation during gestation negatively, interfering in the presence of perceptual/social competencies at birth, apparently more than the mother's antenatal anxiety or anxiety or depression at the time of birth.

A decrease in infant's perceptual/social competencies whose mothers were depressed during pregnancy may result from genetic and biological influences, but also from fewer learning experiences provided during gestation. For example, depressed mothers during pregnancy may not offer enough auditory stimulus for their child to develop at a period when the fetus is already prepared to receive and learn auditory information [70,71,72], as proved by experiments showing fetus' habituation and preference for a new stimulus after habituation [18,73,74]. In any of these cases, prenatal experiences seem to have a major impact on the development of important visual/social competencies. This may compromise the establishment of an adequate mother–infant interaction, and could also have an adverse impact on the recovery of the mother's anxiety and depression if that is the case in the postpartum period.

Neonates of anxious and depressed mothers during the third pregnancy trimester did not show preference for their mother versus stranger's face/voice, and therefore may not be as available to participate in the interaction with their mother. They also did not look longer at the stranger despite habituation to their mother's face/voice, which may lead them to not be as able to resort to alternative sources of stimulation and to learn about the unknown world. Failing to show a visual preference for the mother's versus a stranger's face/voice may interfere in the establishment of the relationship with the mother thus compromising the infant's development. Failing to improve attention to the stranger's after habituation to the mother's face/voice, possibly may not allow the child to be as capable to explore beyond the world he/she already know, compromising development as well.

Taking into account these four variables, mother's anxiety and depression, at the third pregnancy trimester and the postpartum periods simultaneously, this study suggest a greater impact of mother's depression on fetus development when compared to anxiety, as some studies have recently suggested [41,42]. A greater impact of prenatal exposure regarding postpartum exposure to maternal depression and anxiety also suggest that these effects do not depend on different experiences at birth, but rather on prenatal influences. Nevertheless, some variables highly correlated with both mother's prenatal anxiety and depression, such as tobacco and alcohol use [52,75–77], were not considered, which is this study's main limitation.

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