Infant Behavior and Development 71 (2023) 101824

Contents lists available at ScienceDirect

Infant Behavior and Development

journal homepage: www.elsevier.com/locate/inbede

Oxytocin attenuates racial categorization in 14-month-old infants

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ARTICLE INFO

Keywords:
Racial categorization
Infants
Oxytocin
Affiliation

ABSTRACT

Intergroup bias – the preferential attitudes one holds towards one's social group – is a ubiquitous socio-cognitive phenomenon. In fact, studies show that already in the first months of life, infants manifest a preference for members of their own social group. This points to the possibility of inborn mechanisms involved in social group cognition. Here we assess the effect of a biological activation of infants' affiliative motivation on their social categorization capacity. In a first visit to the lab, mothers self-administered either Oxytocin (OT) or placebo (PL) via a nasal spray and then engaged in a face-to-face interaction with their 14-month-old infants, a procedure previously shown to increase OT levels in infants. Infants then performed a racial categorization task presented on an eye-tracker. Mothers and infants returned a week later and repeated the procedure while self-administering the complementary substance (i.e., PL or OT, respectively). In total, 24 infants completed the two visits. We found that whereas infants in the PL condition on the first visit exhibited racial categorization, infants in the OT condition in their first visit did not. Moreover, these patterns remained a week later despite the change in substance. Thus, OT inhibited racial categorization when infants first encountered the to-be-categorized faces. These findings highlight the role of affiliative motivation in social categorization, and suggest that the neurobiology of affiliation may provide insights on mechanisms that may be involved in the downstream prejudicial consequences of intergroup bias.

1. Introduction

Throughout human history and across cultural communities, humans have consistently organized themselves into social groups (Henrich, 2015; Sapolsky, 2018; Tomasello, 2016). Thus, the need to affiliate - to feel part of a group whom one can trust for cooperation and protection – has evolved. Such disposition is thought to represent a crucial adaptation; humans need social groups in order to survive and thrive, and group cohesion is a key mechanism of evolutionary adaptation. Despite its benefits, a common and robust psychological consequence of the organization into groups is intergroup bias, the tendency to favour one's group over others'. Often, such ingroup favouritism is accompanied by outgroup derogation and leads to the endorsement of discriminatory ideologies, laws, and practices, including violent ones, in relation to other groups. Given these deleterious consequences, social psychologists have devoted decades of research to investigate the mechanisms driving intergroup biases in adults (Jost et al., 2004; Sidanius & Pratto, 2001; Tajfel, 1982). Recent developmental evidence suggests that aspects of intergroup bias may have their seeds early in life, thus prompting the search for mechanisms driving the very early emergence of such a bias. The present work tackles such a mechanism and focuses on one process that underpins intergroup bias. We ask whether triggering a biological mechanism implicated in social affiliation may impact

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https://doi.org/10.1016/j.infbeh.2023.101824
Received 11 July 2022; Received in revised form 11 February 2023; Accepted 12 February 2023
Available online 1 March 2023

processes of representing social groups in 1-year-old infants.

Already by 3 months, infants can differentiate between those familiar and those unfamiliar to them in their social environment (Bar-Haim et al., 2006), and prior to their first birthday, infants can discriminate between categories of people based on race (Anzures et al., 2010; Ferera et al., 2021), gender (Leinbach & Fagot, 1993; Quinn et al., 2002), and age (Damon et al., 2016). Moreover, by the end of the first year, infants already hold positive attitudes towards those similar to them (Kinzler et al., 2007; Pun et al., 2018; Xiao et al., 2017), and in general hold distinct expectations regarding within- vs. between-group interactions (Jin & Baillargeon, 2017). Evidently, these intergroup biases can only emerge once infants represent distinct social groups. Thus a fundamental question in attempting to understand the origins of intergroup bias is what drives infants' discrimination of social groups? Or complementarily, what mechanism underlies infants' representation of social groups?

Arguably, the categories represented are those that "stand out" in infants' natural environment due to their relative prevalence (Ferera et al., 2021; Pauker et al., 2016; Singarajah et al., 2017), or those marked in their culture via labels (Waxman & Leddon, 2011). Nevertheless, an important insight from this literature on infants' social categorization is that, barring the possible exceptions of gender- and language-based categories, there is substantial malleability in the definition of social categories (Liberman et al., 2017). For instance, labelling exemplars of shirt-color-based categories was as effective as labelling race-based categories, in facilitating 19-month-olds' formation of these respective categories (Diesendruck & Deblinger-Tangi, 2014). Moreover, exposure to faces of other-races improved infants' general visual recognition memory to other-race faces (Anzures et al., 2012; Spangler et al., 2013), and such increased exposure to racial diversity led to a reduction in young children's intergroup biases (Qian et al., 2017; Setoh et al., 2019). Importantly, recent evidence shows that not only perceptual exposure can influence infants' recognition of other-race faces but also motivational context. Specifically, it was found that the other-race effect can be eliminated via affiliative cues such as emotional expressions (Quinn et al., 2020) or speech production (Minar & Lewkowicz, 2018). In other words, although infants may latch on to certain criteria for representing distinct social groups, these representations can be re-shaped by various factors, including motivational ones.

Grounded on evolutionary theory and neurobiological discoveries, we targeted a motivational factor that possibly contributes to infants' representation of group boundaries. Evolutionary theorists suggest that affiliation is among the key motivations for social group formation (Baumeister & Leary, 1995; Feldman, 2021; Fiske, 2010; Henrich, 2015; Herrmann et al., 2007). In order to survive, humans needed to affiliate with others whom they could trust, cooperate with, and learn from, so as to jointly hunt, work, care for their offspring, and fight off intruders. Work with adults reveal that engaging them in alternative affiliation-based social grouping (e.g., based on membership in a sports team) was powerful enough to effectively eliminate their presumably automatic processing of more conventional social groups (i.e., race) (Pietraszewski et al., 2014). Recent developmental work indicates that such motivation also affects infants and young children's social group behavior and cognition (for a review see Diesendruck, 2021). For instance, a recent study showed that whereas priming 14-month-old infants with a competitive motivation enhanced racial categorization of men, priming with a collaborative motivation hindered it (Ferera et al., 2018). In fact, although after a neutral prime 14-month-olds evinced racial categorization, infants primed with collaboration did not, suggesting that although infants at this age *can* categorize men by their race, an affiliative orientation seems to dampen this capacity. Following these findings, and based on the evolutionary perspective presented above, here we investigated whether the oxytocin system, a neurobiological system involved in social affiliation (Feldman, 2012, 2016), could have the same effect as collaborative priming on infants' social categorization. Would a boost to infants' oxytocin levels inhibit the discrimination of faces based on their race?

Oxytocin, a peptide functioning as both neurotransmitter and hormone, is produced in the hypothalamus and released into the amygdala, hippocampus, brainstem, as well as regions of the spinal cord that regulate the autonomic nervous system (Maestripieri et al., 2009; Neumann, 2008; 2009). A function of oxytocin across mammalian species revolves around processes of mother-offspring bond formation (Feldman, 2012; 2016; Keverne & Curley, 2004; Meaney, 2001; Pedersen, 2004; Ross & Young, 2009). In humans specifically, oxytocin has been related to numerous components of parenting, such as affectionate behaviors, synchrony, and infant social engagement (for reviews, see Carter, 2014; Feldman, 2017; Rilling & Young, 2014).

In addition to its critical role in shaping the primary attachment, it has been suggested that the role of oxytocin extends to serving as a catalyst for group formation, and as a trigger for trusting and caring behaviors within social groups more broadly (Kosfeld et al., 2005), and parochial cooperation in particular (De Dreu et al., 2020). For instance, exogenous administration of oxytocin has been shown to promote adults' trust and social collaboration (Arueti et al., 2013; Declerck et al., 2010; Liu et al., 2019; Yan et al., 2018), and adults' oxytocin levels rise when they are both the recipients and deliverers of trustworthy behaviors (Zak et al., 2005). Relatedly, oxytocin nasal inhalation has led adults to perceive novel people as more familiar (De Dreu & Kret, 2016; Rimmele et al., 2009), and boosts their willingness to approach others, especially strangers (Cohen & Shamay-Tsoory, 2018). Further related, oxytocin is argued to orient perceptual focus to the *individual* rather than the categorical level of a social stimulus; oxytocin administration (compared to placebo) improved White men's ability to identify individual Black faces (Blandon-Gitlin et al., 2014; Gamer et al., 2010), and improved recognition of voice identity (Borowiak & von Kriegstein, 2020). Taken together, these findings indicate that oxytocin serves as a general affiliation trigger, operating as a "flattener" of the social world wherein all people become more approachable, and are represented primarily as individuals and potential collaborative partners. In a sense, oxytocin may "broaden" what constitutes one's in-group. As such, a central hypothesis of the current study is that oxytocin may inhibit the discrimination between potential social groups already in infancy, at the first stages of social categorization development when the boundaries of social groups are still quite malleable.

In the present study, we assessed how an increase in infants' endogenous oxytocin levels may affect their capacity to discriminate between racial categories (Black and White men). We targeted White 14-month-old infants as prior studies have found that infants of this age have a budding capacity to differentiate between such categories (Anzures et al., 2010; Ferera et al., 2018). Specifically, it was

shown that 9- (Anzures et al., 2010) and 14- (Ferera et al., 2018) month-old White infants living in a predominantly White environment were able to discriminate between their own- and other-race categories. We therefore had reason to believe that under normal conditions (i.e., under placebo), our participants would be capable of discriminating between these racial categories. Our main question was whether oxytocin would dampen this capacity. The study involved a double-blind, within-subjects cross-over design, hence, half of the infants were exposed to placebo in their first visit and oxytocin in their second (a week later), and the other half vice versa.

This design allowed us to further tap, for the first time in infants, an additional aspect of oxytocin, namely, its social salience reactivity (Fischer-Shofty et al., 2013; Gamer et al., 2010; Kemp & Guastella, 2011; Xue et al., 2020). According to this account, the effect of oxytocin may vary according to the available social representations. In particular, in the absence of oxytocin at the time of first exposure, infants presumably would be able to represent racial categories – as infants this age have been shown to do (Ferera et al., 2018). For these infants, would oxytocin administration a week later maintain that representation given that the categories would by then be available? In contrast, would oxytocin administration on first exposure to faces of Black and White men, dampen the representation of racial categories? And if it did, would that effect hold a week later? This design, therefore, allowed us to assess the endurance of the oxytocin effect – an under-examined issue in human subjects (for example, see Eckstein et al., 2019).

A further important aspect of our study is the method used for manipulating oxytocin levels in our infant participants. Due to ethical concerns, oxytocin is not administered to young infants and thus we employed a non-intrusive indirect method to boost the infant's oxytocin system, which was found effective in increasing oxytocin levels in infants (Weisman et al., 2012b). Specifically, in Weisman et al.'s study, fathers inhaled oxytocin, and then engaged in a 30-minute interaction with their 5-month-old infant. It was found that oxytocin administration increased not only fathers' salivary oxytocin, but also led to a parallel increase in the infants' salivary oxytocin levels. We applied this method to mothers and their 14-month-old infants, consistent with research indicating that the cross-generational transmission of oxytocin is similar in mothers and fathers (for support, see Feldman et al., 2010).

We assessed infants' racial categorization using a task previously employed to assess infants' categorization of various types of stimuli (Damon et al., 2016; Erickson et al., 2014; Ferry et al., 2013; Robinson & Sloutsky, 2007), including races (Anzures et al., 2010; Ferera et al., 2018, 2021). In this task (see Ferera et al., 2018), we first assessed infants' baseline preference for looking at pictures depicting faces of a White vs. a Black man. Then infants were exposed to nine exemplars of one of these categories (e.g., faces of White men), and were finally shown a test trial identical to the baseline one, namely, pairing an additional exemplar of the familiarized category (e.g., another White man) with an exemplar from the "novel" contrasting category (e.g., a Black man). Using this method, Ferera et al. (2018) found that White 14-month-old infants indeed looked longer at a novel racial category exemplar, relative to their baseline looking preference, thus exhibiting successful racial categorization. The question addressed here was whether raising 14-month-olds' oxytocin level prior to the categorization task would dampen this capacity.

2. Method

2.1. Participants

Twenty-four healthy mothers (mean age 33 years, range 24–45 years) and their healthy 14-month-old infants (14 girls; mean age 14.4 months; range 12–16 months) constituted the final sample of participants. Nineteen additional families were excluded due to incomplete data collection in their first visit (two), their second visit (eleven), or both (six). Mothers' exclusion criteria included pregnancy, mental or physical illness, and medication intake. Infants' exclusion criteria included premature birth, birth-related complications, and illness. All participants were White, living in predominantly White cities (according to the national Central Bureau of Statistics, between 0.001%−3.8% of residents in the cities from where infants were recruited are defined as Black). Based on a survey conducted with the 24 families who composed the final sample, 2 reported that their infant had never seen a Black person, 4 reported that their infant had seen a Black person once, 8 reported that their infant had seen a Black person once a month, 9 once a week, and 1 every day.

Families were recruited via ads around the university and in Facebook. As a reward for their participation, families received a gift voucher for a book store as well as a souvenir t-shirt for the infant. The research was approved by the Bar-Ilan University's Institutional Review Board and by the Helsinki committee of the Sourasky Medical Center, Tel Aviv. All mothers signed an informed consent form.

Given the pioneering nature of this study, we had no benchmark as to the possible effect size of oxytocin delivery on infants' racial categorization. The only relevant measure we did have, regarded infants' – of this age – capacity to categorize racial stimuli. Specifically, a previous study presented infants at this age, from similar background, with the exact same stimuli and DV following a neutral prime (thus equivalent to the placebo condition). It was found that infants significantly increased their looking time at the novel exemplar from baseline to test (for details see Ferera et al., 2018). A one-sample t-tests analysis against zero (i.e., no change from baseline to test) with m=0.0799 and sd=0.1339 resulted in an effect size of 0.59. Using this as an estimate, and setting α of 0.05 and power of 0.8, rendered a total sample size of n=19 for detecting categorization. Therefore, in the present study we aimed for a total sample size of n=38, and ran a few additional participants to accommodate for attrition (thus resulting in running the study on 43 participants). Unfortunately, the complex design of the study resulted in substantial data loss, and so attrition rates were much higher than expected. Thus, the final sample of participants consisted of n=24.

2.2. Design and Procedure

Dyads completed two visits to the lab, one week apart. Twelve dyads were randomly assigned to one of two administration orders: either placebo administration to the mother at the first visit and oxytocin at the second, for short, V1PL-V2OT condition, or vice versa,

i.e., V1OT-V2PL condition. The procedure was identical in both administration orders and visits, except for whether oxytocin or placebo was delivered to the mothers (see Fig. 1). Both visits were conducted by the same two female experimenters. Each visit took approximately two hours.

The procedure in each visit included three phases. In the first phase, mothers and infants arrived at the laboratory, and mothers were asked to sign consent and health (e.g., non-pregnancy) forms. Once the mother and infant had acclimated, two critical pre-administration baseline measures were assessed: OT levels in both mothers and infants, and infants' looking time preferences. Specifically, mothers' and infants' baseline oxytocin levels were measured from their saliva (Oxytocin T1). Infants were asked to chew a

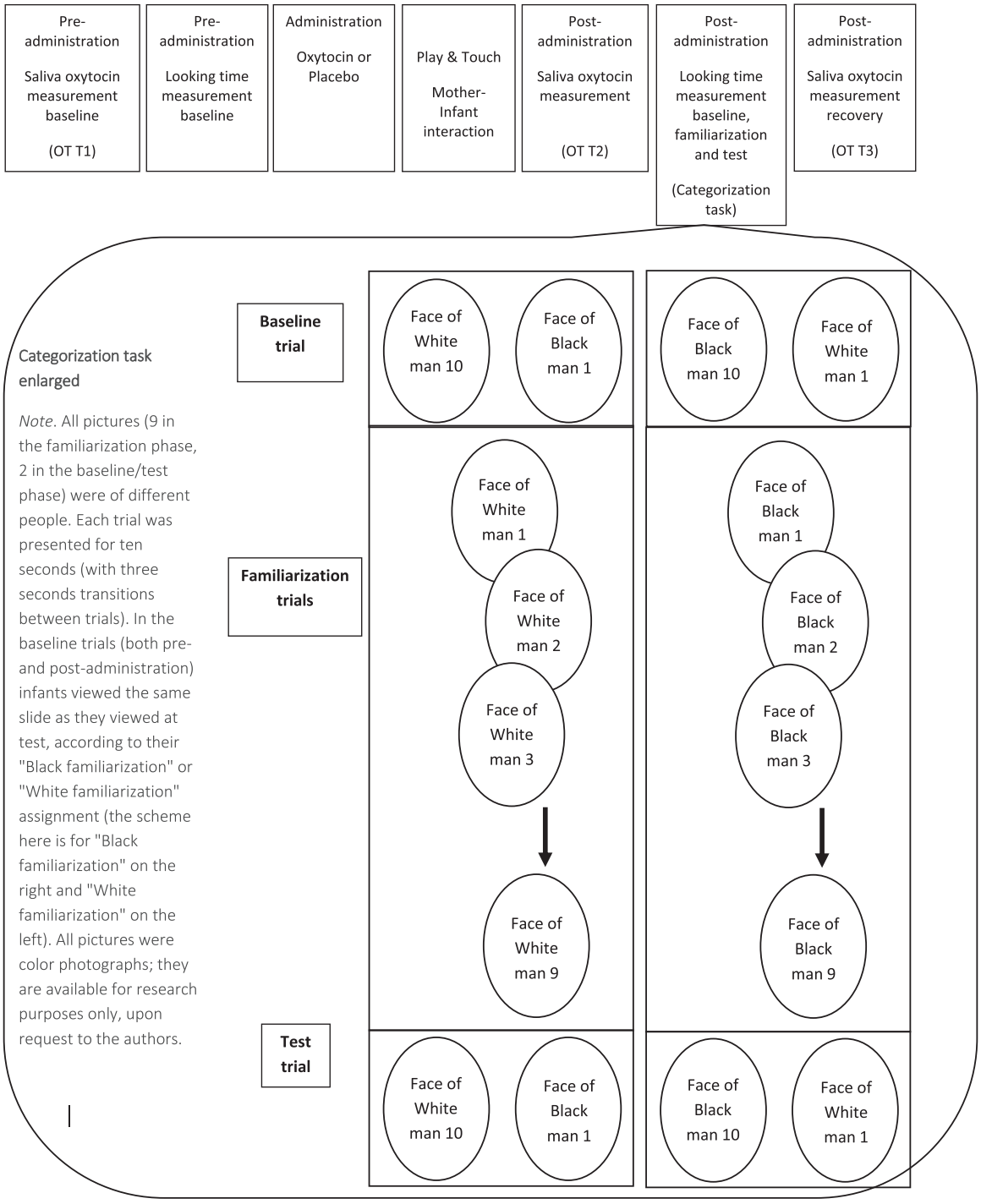


Fig. 1. Sequence of events in each visit (from left to right).

salivette for 40 s, and mothers were given an option to either chew a salivette for 40 s or spit directly into a test tube (i.e., passive droll). Immediately afterward, infants' "pre-administration" baseline looking pattern at the (to be) test stimulus was measured. This stimulus consisted of a single slide with a pair of faces of men: a White man and a Black man (see Fig. 1 for a schematic example). These two pre-administration measurements were conducted to verify whether there were any a priori differences between the two administration order conditions in terms of baseline OT levels and preferential looking towards one of the faces.

In the second phase, the mother was invited to a separate room, where she self-administered – via a nasal spray – 24 IU of either oxytocin (Syntocinon Spray; Novartis, Basel, Switzerland; three puffs per nostril) or placebo (depending on administration order condition) under the supervision of the experimenter. Participants and experimenters were blind to substance condition. The administration took about two minutes, during which the infant played with the other experimenter in the play room. After administration, the mother re-joined her infant at the play room, and they were left alone for a "play-and-touch" interaction for thirty minutes (similar to the procedure that successfully induced rise in infants' oxytocin level in (Weisman et al., 2012b). The only instruction the mother received was to play freely with her infant while maintaining close physical contact. The interaction was recorded and viewed online by the two experimenters to ensure the instruction was kept and no extraordinary events occurred. Both experimenters agreed that all mothers indeed adhered to this instruction. At the end of the thirty minutes, a second measurement of oxytocin level was taken from the mothers' and infants' saliva (Oxytocin T2). This was the critical measurement as it occurred immediately prior to the categorization task.

The third phase of the experiment consisted of the categorization task and a final OT measurement. Mothers and infants were led into the eye-tracking room, where infants were sat 60 cm away from a 22″ monitor. An SMI Red-M eye-tracker (sampling rate: 120 Hz) placed under the screen captured infants' looking behavior. The experimenter located the infant's eyes using SMI software iView, adjusting the position of the monitor as necessary, while the infant watched an intriguing neutral video (running horses). Once infants were comfortable, the experimenter started the SMI's calibration sequence, which involved presenting visually interesting stimuli (an infant laughing) at each of a 2-points calibration followed by a 4-points validation procedure. Using the feedback from the validation, the experimenter repeated the calibration until the infant's gaze was within approximately 2° of the validation stimulus locations. All infants eventually calibrated, and once they did, the categorization task started. During infants' testing, the mother stood at the back of the infant's chair and was instructed to keep silent and not interfere during the task. Thus, no eye contact or any other form of mother's behavior could influence the infant.

The categorization task was identical to the one used by Ferera et al. (2018), and consisted of eleven trials: a baseline trial, nine familiarization trials, and a test trial (see Fig. 1 for a schematic display). The baseline and test trials were identical, and presented faces of a Black and a White man simultaneously, side by side, with approximately 27 cm space between them. Each of the nine familiarization trials presented one picture of a face at the centre of the screen, either of White or Black men (counterbalanced between subjects). Each picture showed a man's face (from shoulders up), looking straight, with a neutral expression. Pictures appeared on the screen as 10 cm wide and 12 cm high, presented on a grey background. In order to facilitate infants' categorization, six of the familiarization trials were labelled using a non-word (see Balaban & Waxman, 1997; Erickson et al., 2014, for evidence of the facilitatory effect of labels in this task, but see Robinson & Sloutsky, 2007, for a more general debate on the relation between labeling and categorization). Each of the eleven trials (the baseline, nine familiarization, and the test) was presented for ten seconds with three seconds transitions between trials. Most of the pictures were taken from the NimStim face set (Tottenham et al., 2009).

The crucial index of categorization was whether infants' looking time at the contrasting – "novel" – category exemplar at test significantly increased, relative to their baseline looking rate. For instance, for infants who saw faces of nine Black man during familiarization, the measure was the change in looking time at the White man from baseline to test. If looking time increased, it would indicate that infants viewed: a) all nine familiarization exemplars as similar, b) the additional exemplar from the familiarized category shown at test as similar to the familiarization exemplars, and c) the novel exemplar from the contrasting category shown at test as distinct.

Fifteen minutes after completing the categorization task, a final salivary sample was drawn (Oxytocin T3), but due to the small number of usable samples (see explanation below), these data were not analyzed. Mothers and infants were thanked and freed to go. The same procedure was repeated a week later (Visit 2), with the only change being the substance administered, such that mothers who got placebo in Visit 1 got oxytocin in Visit 2 (V1PL-V2OT), and those who got oxytocin in Visit 1 got placebo in Visit 2 (V1OT-V2PL). At the end of the second visit mothers were thanked for, rewarded, and debriefed.

2.3. Oxytocin measurement

All saliva samples were analysed using the Enzo® (NY, USA) oxytocin ELISA kit, according the manufacturer instructions. The calibration curve was extended by adding calibrator of 3000 pM, which allowed us to evaluate samples with high oxytocin concentration. The concentrations of samples were calculated using Matlab-7 according to relevant standard curves. The intra-assay and inter assay coefficient of variability were less than 20%, which is within the manufacturer's reported range.

It is important to note that in order for samples to be analysed, a minimal amount of saliva should be obtained. This is true for both methods of saliva collection (i.e., chewing a salivette or spiting into a test tube). The instructions were to chew the salivette for at least 40 s or to spit into the tube until it reaches a certain height in the tube. Unfortunately, not all infants and mothers were able to adhere to these instructions. Therefore, not all saliva samples – of both infants and mothers – were usable for analyses.

3. Results

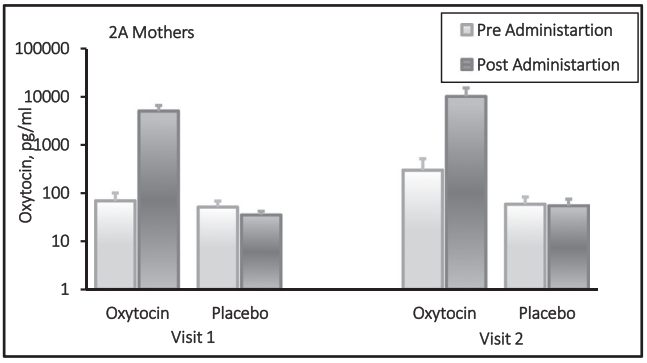
3.1. Preliminary analyses

Given that the between-subjects manipulation involved the order of the visits in which OT was delivered, it was important to assess whether there were any differences between infants assigned to the two order conditions – V1PL-V2OT and V1OT-V2PL – in terms of two key baseline measures. First, we compared infants' and mothers' OT saliva level in the two administration order conditions at the outset of the first visit, i.e., before substance administration (OT T1). We found no difference between the two administration order conditions (among infants and mothers for whom sufficient data were available), with similar levels both among infants, $t(8)=-0.053$, $p=0.96$ ($M_{V1PL\text{-}V2OT}=106$ pg/ml, $M_{V1OT\text{-}V2PL}=103$ pg/ml), and mothers, $t(19)=0.622$, $p=0.54$ ($M_{V1PL\text{-}V2OT}=43$ pg/ml, $M_{V1OT\text{-}V2PL}=61$ pg/ml).

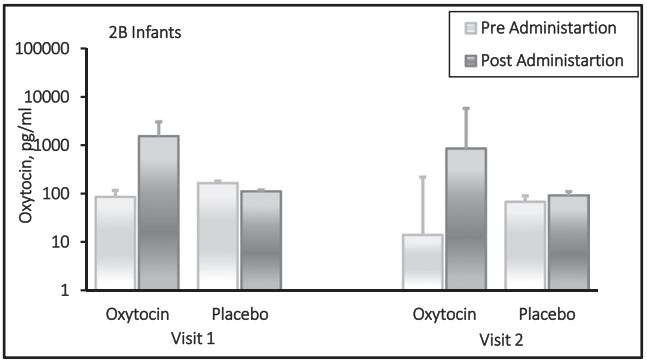
Second, we evaluated whether there was any difference between infants from the two administration order conditions, regarding their looking time preferences vis-à-vis Black and White men. This provided an indication as to how novel, Black faces seemed to infants in the two order conditions. To this end, we compared the proportion of time infants looked at each of the faces presented in the baseline slide. Here too, we found no difference between the two administration order conditions, with infants in both groups looking approximately the same proportion of time at the (to be) novel exemplar ($M_{V1PL\text{-}V2OT}=46\%$, $M_{V1OT\text{-}V2PL}=44\%$, $t(19)=-0.39$, $p=0.70$). In sum, in terms of these two critical measures, there were no a priori differences between infants in the two administration order conditions.

3.2. Manipulation check

We first assessed that the oxytocin manipulation was successful, and mothers' and infants' oxytocin levels increased when mothers' inhaled oxytocin (see *SI-Method* for details on the analyses). Only 17 of the 24 mothers delivered enough saliva on T1 (pre-administration measurement) and T2 (post- administration measurement) in both visits. A repeated measures ANOVA including mothers' oxytocin level in each measurement (T1 and T2) of the two visits (Visit 1 and Visit 2) as within-subjects factors, and administration order (V1PL-V2OT or V1OT-V2PL) as a between-subjects factor, revealed a significant triple interaction among the factors, $F(1,15)=6.886$, $p<0.05$, $\eta^2=0.315$. As can be seen in Fig. 2a, oxytocin level rose substantially between T1 and T2 in both visits only after oxytocin administration and not after placebo administration, consistent with prior work (Weisman et al., 2012a). The rise was more



a. Mothers (n=17; eight of them were in the oxytocin on first visit condition)



b. Infants (n=6; three of them were in the oxytocin on first visit condition)

Fig. 2. Oxytocin (pg/ml) levels in each visit (in a logarithmic scale, for ease of presentation); bars represent standard error of means.

marked in Visit 1 than in Visit 2. Unfortunately, only six infants out of the 24, delivered enough saliva on T1 and T2 in both visits, thus making inferential statistics inappropriate. Nevertheless, as can be seen in Fig. 2b, their pattern of oxytocin levels mirrored their mothers'. Moreover, descriptive examination of their individual data reveals that only 1 of them did not show a substantial increase in OT level (among mothers, only 2 out of the 17 did not show a substantial increase; see raw data values in *SI-Data*). It thus seems that oxytocin levels at T2 (post-administration measurement) in infants whose mothers had inhaled oxytocin, were higher than in infants whose mothers had inhaled placebo – consistent with the work by Weisman et al. (2012b) showing a similar transmission between fathers and their infants. Noteworthy also, this pattern was not affected by administration order. The crucial question was whether the oxytocin manipulation impacted infants' racial categorization.

3.3. Categorization performance

We used SMI's BeGaze software to code and analyse the data. For the familiarization trials, a single AOI was defined that included the entire face (apart from the grey background; the AOI was a rectangle of 213435px in size). For the baseline and test trials, two AOIs were defined: one including the entire face at the left of the screen and the other including the entire face at the right of the screen (each AOI was a rectangle of 199920px in size). The raw dependent measure was Net Dwell Time (i.e., total looking time including fixations, saccades, etc.) at each AOI.

Our focal measure was looking time at the novel exemplar. We defined the dependent measure in the same way as done previously by Ferera et al. (2018). First, in order to compensate for individual differences in infants' looking time, we converted infants' raw looking time (in seconds) into percentages, by dividing "looking time at the novel exemplar" by "total looking time at both novel and familiar exemplars". Then, our dependent measure of categorization was the *change* in infants' percentage of looking time at the novel category exemplar from "post-administration" baseline to test trial. This measure allowed correcting for any a priori looking preferences infants might have towards White vs. Black man (for a discussion, see Oakes (2010)). Given this measure, a positive change meant that infants looked longer at the novel exemplar after familiarization, indicating that that exemplar had become more salient – presumably due to the fact that it was discriminated from the other test-exemplar and all the familiarization exemplars. In other words, change scores significantly higher than zero indicated categorization had occurred.

To assess infants' categorization performance, a repeated measures ANOVA including the two visits' (Visit 1 and Visit 2) change scores as dependent measures, and the administration order (V1PL-V2OT or V1OT-V2PL) as between-subjects factors, revealed only a significant main effect of administration order, $F(1, 22)=8.036$, $p<0.05$, $\eta^2=0.268$. As can be seen in Fig. 3, infants whose mothers received oxytocin in their first visit and placebo in their second visit (i.e., the V1OT-V2PL condition) looked significantly less at the novel exemplar (across both visits; $M=-3.5\%$, $SE=5$, $n=12$) than infants whose mothers received placebo in their first visit and oxytocin in the second (i.e., the V1PL-V2OT condition; $M=16.7\%$, $SE=5$, $n=12$). Breaking it down by visit, in the first visit, infants looked longer at the novel exemplar when their mothers inhaled placebo (V1PL-V2OT) than when they inhaled oxytocin (V1OT-V2PL), $F(1, 22)=6.451$, $p<0.05$, $\eta^2=0.227$. In turn, in the second visit, infants looked longer at the novel exemplar when their mothers inhaled oxytocin (V1PL-V2OT) than when they inhaled placebo (V1OT-V2PL), $F(1, 22)=4.626$, $p<0.05$, $\eta^2=0.174$.

These patterns were confirmed when analyzing whether the change in the percentage of looking time at the novel exemplar was greater than zero (as zero indicated no change from baseline to test). One-sample one-tailed t-tests revealed that in the first visit, only under the placebo condition (V1PL-V2OT) did infants evince categorization ($M_{V1PL\text{-}V2OT}=15.7\%$, $SE=7.6$, $n=12$; $t(11)=2.046$, $p<0.05$; $M_{V1OT\text{-}V2PL}= -6.9\%$, $SE=4.5$, $n=12$; $t(11)=-1.529$, $p=0.155$). In contrast, in the second visit, only under the oxytocin condition (V1PL-V2OT) did infants evince categorization ($M_{V1OT\text{-}V2PL}=0.00\%$, $SE=6.1$, $n=12$; $t(11)=0.00$, $p=1.0$; $M_{V1PL\text{-}V2OT}=17.7\%$, $SE=5.4$, $n=12$; $t(11)=3.240$, $p<0.01$).

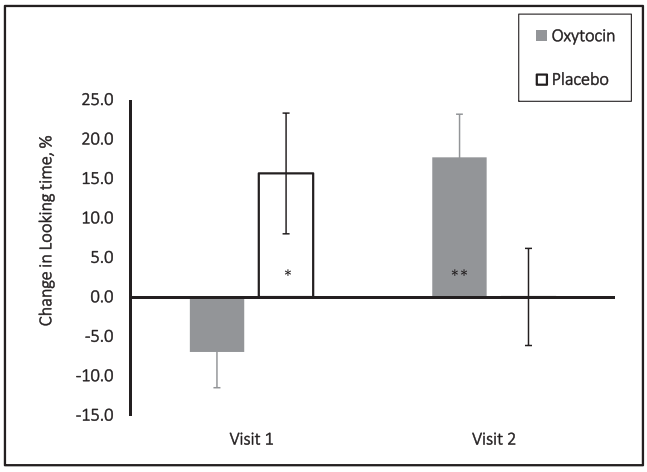


Fig. 3. Categorization scores: Mean change in percentage of looking time at the novel exemplar from baseline to test trial in each visit (n = 24 infants); bars represent standard error of means. Note. Comparison against "no-change" (i.e., zero), * *p < 0.01, *p < 0.05, one-tailed.

These results on infants' change scores suggest that the effect of enhanced oxytocin levels on infants' racial categorization performance may vary as a function of infants' knowledge of the relevant social stimuli. When receiving placebo in their first visit, infants may have "noticed" the racial category during the familiarization trials, and thus discriminated between familiar and novel exemplars at test – just as infants this age have been shown to do (Ferera et al., 2018). Once this category was formed and accessible, upon receiving oxytocin in their second visit, these infants continued to notice these racial categories. In turn, infants exposed to oxytocin in the first visit, were seemingly unable to notice the common features characterizing the racial category. They did not represent a racial category, and this absence of categorization, remained one week later, when receiving placebo. If this interpretation is correct, then there should also be differences in the familiarization processes of infants in the different administration orders. Specifically, for infants whose mothers received placebo in their first visit (i.e., the V1PL-V2OT condition), seeing nine faces of what they came to notice as exemplars of the same racial category, should have led to increased habituation to that "kind" of face. In contrast, if infants whose mothers received oxytocin in their first visit (i.e., the V1OT-V2PL condition) did not notice the commonality across the familiarization faces, then their attention to these faces should not have diminished during this phase, as they kept viewing each face as unique.

To assess this possibility, another set of analyses examined infants' looking pattern during familiarization. To this end, we followed a strategy previously used by Balaban and Waxman (1997): We computed for each infant a "familiarization decrease" score, by multiplying the average looking time on each familiarization trial block (Block 1 = familiarization trials 1–3, Block 2 = familiarization trials 4–6, and Block 3 = familiarization trials 7–9) by the appropriate contrast weights for a linear trend (−1, 0, +1), and summed the resulting products. In this way, if a participant did not show a linear change in looking time over familiarization blocks (i.e., maintained his/her interest in the faces), the contrast score should equal zero. A negative score indicates looking time decreased during familiarization, consistent with habituation. One-sample t-tests against zero (i.e., no change) revealed that in the V1PL-V2OT condition (i.e., the group who evinced categorization in both visits), there was a significant decrease in looking time during familiarization in both visits ($M_{visit1\ (PL)}$=−1.95 s, $t(11)$=−2.327, $p<0.05$; $M_{visit2\ (OT)}$=−1.27 s, $t(11)$=−2.214, $p<0.05$). In contrast, in the V1OT-V2PL condition (i.e., the group who did not evince categorization in either visit), there was no significant decrease in looking time during familiarization in either visit ($M_{visit1\ (OT)}$=−0.82 s, $t(11)$=−1.395, p=0.191; $M_{visit2\ (PL)}$=−0.12 s, $t(11)$=−0.187, p=0.855) (see Fig. 4).

These results of the familiarization phase cohere with those derived from the categorization change scores. They indicate that infants in the V1PL-V2OT condition, noticed the similarity across familiarization faces, and thus "lost interest" in that particular type of face. Consequently, upon being shown a novel face from a contrasting type, their attention was drawn to it. In turn, infants who were in the V1OT-V2PL condition, seem not to have noticed the similarity across familiarization faces, keeping their interest in each individual face. Thus, for them, the face from the putatively novel type was not seen as such, as they had not formed a category with which that exemplar contrasted.

4. Discussion

A necessary, though by no means sufficient, process in the emergence of intergroup biases is the perceptual discrimination between groups. This process begins to develop towards the end of the first year, at least with regard to racial categories (Ferera et al., 2018, 2021; Lee et al., 2017). Here we replicated this finding, and showed that under natural conditions (i.e., Placebo), when first encountering to-be-categorized faces, 14-month-olds successfully formed race-based categories ("Blacks" and "Whites"). The novel finding revealed here is that increasing infants' oxytocin levels at this first encounter attenuates this capacity.

Oxytocin is involved in numerous affiliative functions in humans: from the formation of parent-infant bonds (Carter, 2014; Feldman, 2017; Rilling & Young, 2014), through the facilitation of collaborative and trusting behaviors in adults (Arueti et al., 2013; De Dreu et al., 2020; Declerck et al., 2010; Kosfeld et al., 2005), the perception of strangers as more familiar and approachable (Cohen & Shamay-Tsoory, 2018; De Dreu & Kret, 2016; Rimmele et al., 2009), and to the highlighting of individuating features (Blandon-Gitlin et al., 2014; Borowiak & von Kriegstein, 2020; Gamer et al., 2010). The present findings suggest that already at the earliest stages in the development of the capacity to discriminate among members of racial groups, oxytocin lowers the potential salience of

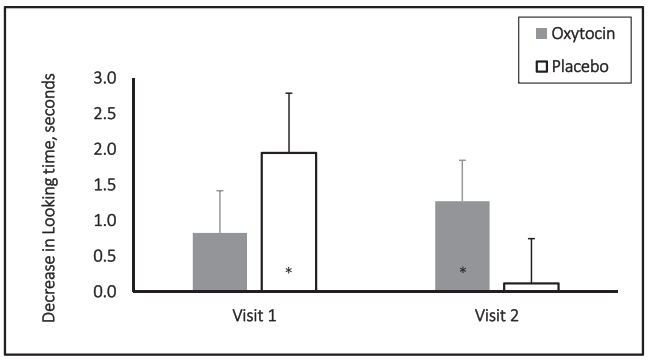


Fig. 4. Familiarization scores: Decrease in looking time at the exemplars during familiarization trials in each visit (n = 24 infants); bars represent standard error of means. Note. For the sake of readability, the graph presents positive values, even though the changes were reductions in looking time. Comparison against "no-change" (i.e., zero), *p < 0.05.

racial-discriminatory features in people's faces to infants. This was evident in the infants in the V1OT-V2PL condition in the first visit, both in their failure to look longer at an out-of-category exemplar after familiarization as well as in the lack of habituation to same-category exemplars during familiarization.

Interestingly, this oxytocin effect was observed only when it was delivered prior to infants' first exposure to the to-be-categorized faces. When instead, placebo was administered in the first visit and oxytocin in the second (i.e., in the V1PL-V2OT condition), the oxytocin boost in the second visit did not revert the categorization process that had ensued in the first visit. One possible interpretation of this finding is that the effect of enhanced oxytocin levels on infants' social categorization performance varied as a function of the infant's prior experience with the relevant social stimuli during the experiment. Although most prior work with younger infants had demonstrated effects of exposure on racial discrimination and categorization across longer periods of time (e.g., Anzures et al., 2012), it is possible that given that the two visits were identical in terms of settings and medium, there was substantial scaffolding for infants in Visit 2 to have a trace of what they had seen in Visit 1. Moreover, the findings from Visit 1 indicate that infants in the V1PL-V2OT condition had indeed categorized the faces by race. It will be valuable to address this interpretation systematically in the future.

The above conclusion, however, is consistent with the notion that one of the main effects of oxytocin is highlighting socially-relevant stimuli (Fischer-Shofty et al., 2013; Rimmele et al., 2009). In the present context, the socially relevant stimuli may have varied between the two substance administration orders. Specifically, it may be argued that in their first visit to the lab, for our participants, who were White infants living in a White environment, Black men were fairly unfamiliar. Under the placebo condition (i.e., V1PL-V2OT), infants were able to "learn" this new social category and discriminate between its exemplars and the more familiar ones (as was demonstrated that they indeed can, Anzures et al., 2010; Ferera et al., 2018). In their second visit to the lab, these participants were no longer naïve: they had already recognized the racial categories, which then constituted the socially relevant stimuli highlighted by the oxytocin upsurge. In contrast, infants who were under the oxytocin condition in their first visit (i.e., V1OT-V2PL), did not "learn" the category, but rather had acquired experience with a diversity of individuals. Thus, under placebo in the second visit, they simply started-off with a somewhat depressed capacity to detect the differentiating features between Whites and Blacks. We assume that the activated affiliation motivation in the first visit did not turn infants *unable* to categorize but rather directed their attention to the individuating, but not the category-defining features of the faces. It is important to note in this discussion, that this difference between the two administration orders was unlikely due to any a priori differences between the two groups of infants. As our baseline analyses indicated, there were no differences between the groups neither in terms of oxytocin levels, nor in terms of preferential looking to White or Black faces.

Further noteworthy about this carry-over effect of oxytocin delivery in the first visit to the second visit taking place a week later, is its resemblance to findings among adults. For instance, oxytocin-administered adult participants were found to be more likely to later remember familiar happy faces and less likely to remember angry and neutral faces as compared to participants administered a placebo (Guastella et al., 2008). In the same vein, oxytocin improved adults' recognition memory for familiar faces (Rimmele et al., 2009), and affected adults' later processing of socially salient stimuli (Eckstein et al., 2019). Research on infants' long term memory demonstrated that infants show memories for stimuli weeks or months after their exposure (Bauer, 2007), and that in-lab experiences influenced infants' face recognition of other-race faces and was carried over between testing sessions (Spangler et al., 2013). The present findings suggest that oxytocin may have similar long term effects on the processes involved in infants' memory for social stimuli. Evidently, this requires further research for more in-depth understanding of the mechanism involved.

This knowledge-dependent effect of oxytocin on infants' representation of social categories may also help integrate the current findings with an additional set of findings on adults, which showed that oxytocin promotes certain intergroup biases. For instance, after inhaling oxytocin – compared to placebo – adults manifested more ingroup favoritism (Dreu et al., 2011), were more willing to lie in order to benefit fellow group members (Shalvi & De Dreu, 2014), and were more willing to collaborate with ingroup members (De Dreu et al., 2010). A crucial point that allows for the integration of these sets of findings is that these effects of oxytocin on adults' intergroup cognition occurred vis-à-vis groups *known* to the adult participants (e.g., based on nationality or ethnicity, or explicitly assigned to them during the experiments). In this respect, the situation is analogous to the one experienced by the infants who were in the placebo condition in their first visit. They too formed racial categories on that visit, and thus in their second visit, the oxytocin boost maintained these previously established racial categories. In turn, for the infants in the oxytocin condition on the first visit, *there were no set groups*. And the revelation here is that, under this naïve knowledge state, oxytocin hindered the discrimination between potential groups; in a sense it led to the formation of a broader social group inclusive of White and Black men. In sum, oxytocin seems to have different effects in group cognition once groups are already represented versus when they are still in the process of being formed.

From a practical perspective, it is not viable to prescribe oxytocin to infants so as to halt the formation of social group representations. Nevertheless, the more general point is that the function of oxytocin is to activate infants' fundamental affiliative drive. It has been previously demonstrated that behaviourally activating this drive increases infants' helping behaviour (Over & Carpenter, 2009), and also dampens their racial categorization (Ferera et al., 2018). Affiliative cues have also been found to improve infant's recognition of other-race faces (Minar & Lewkowicz, 2018; Quinn et al., 2020). The present findings reveal that a biological manipulation of the system indeed has a similar effect. This suggests that triggering an affiliation motivation leads infants to privilege the construal of others as individuals, and thus potential ingroup members. This suggestion is in line with the Perceptual-Social Linkage recently proposed by Quinn et al. (2019). According to this account, exposure to facial stimuli is accompanied by different social and emotional correlates that in turn, may explain social biases. They list a number of mechanisms that may be involved in the process, such as familiarity of stimuli and caregiver emotional reaction to stimuli, to name a few. It seems reasonable to add motivationally-related biological factors (such as Oxytocin) to this complex repertoire.

One question left open by this conclusion is whether the effect of oxytocin found here would hold to other social categories. A recent developmental argument is that the underlying process of category representation is general in nature, not specific to racial categories

(Lee et al., 2017). Further, from an evolutionary point of view, it is argued that humans are prone to detect coalitions in their environment, namely, others with whom they could collaborate and prosper (Kurzban et al.,2001). This presumed activation of infants' "coalitional psychology", may indeed lead them to focus on group cues that are fundamental (e.g., collaboration potential) over more modern and superficial ones (e.g., race; Pietraszewski et al., 2014). Although infants' definition of social groups may be quite malleable, it remains to be seen whether there are limits to the effectiveness of such intervention with regard to other social categories. An additional – related – question is whether oxytocin's putative effects on infants' categorization are limited to social stimuli. It would be interesting to explore this possibility in further studies using non-social stimuli as categorization targets.

A further issue has to do with limitations of the present work. Recent reviews (for example, Mierop et al., 2020; Quintana et al., 2021) raised concerns that research on intranasal oxytocin administration suffers from small sample size and lack of replications. This is evidently a limitation of the present study as well. We hope that the novelty of the paradigm and the findings, will encourage further work to more systematically examine the effects of oxytocin on categorization. Related issues concern, for example, whether intranasal administration reaches the brain or only the periphery. This is clearly beyond the scope of this paper, though it adds to the debate by showing that intranasal intake by mothers, affected their infants' looking behaviour, replicating earlier findings on the transmission process between fathers and their infants (Weisman et al., 2012b). It is worth noting that this transmission process between parent and infant is yet to be fully understood. Many possible mechanisms of psychological and/or chemical communication may be involved: parent-infant interaction, parent breath, body smell, or even simply parents touching their noses post administration, and when interacting with their infant, transferring some residual spray onto their infant. Regardless of the specific mechanism(s) involved, the main point in terms of the present work is that infants' oxytocin levels increased from baseline measurement to post-administration measurement, and that their behavior was affected by these changed oxytocin levels.

5. Conclusions

We conclude by highlighting what we believe is the main contribution of the present work. Very little is known about the effect of oxytocin on young children's social cognition (Horta et al., 2020). The current findings begin to fill this gap by providing promising evidence for the role of an affiliative motivation in general, and oxytocin in particular, in the very formation of social group representation in infants.

Data Availability

I have shared the data as a Supplementary Material file.

Acknowledgements

This work was supported by the Israel Science Foundation [grant #599/13], the Simms/Mann Chair, the Harris Foundation, and the Bezos Foundation. We would like to thank Emily Gerdin for her help with stimuli preparation and data collection.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.infbeh.2023.101824.

References

Anzures, G., Quinn, P. C., Pascalis, O., Slater, A. M., & Lee, K. (2010). Categorization, categorical perception, and asymmetry in infants' representation of face race. *Developmental Science, 13*(4), 553–564.

Anzures, G., Wheeler, A., Quinn, P. C., Pascalis, O., Slater, A. M., Heron-Delaney, M., Tanaka, J. W., & Lee, K. (2012). Brief daily exposures to Asian females reverses perceptual narrowing for Asian faces in Caucasian infants. *Journal of Experimental Child Psychology, 112*(4), 484–495.

Arueti, M., Perach-Barzilay, N., Tsoory, M. M., Berger, B., Getter, N., & Shamay-Tsoory, S. G. (2013). When two become one: The role of oxytocin in interpersonal coordination and cooperation. *Journal of Cognitive Neuroscience, 25*(9), 1418–1427.

Balaban, M. T., & Waxman, S. R. (1997). Do words facilitate object categorization in 9-month-old infants? *Journal of Experimental Child Psychology, 64*(1), 3–26.

Bar-Haim, Y., Ziv, T., Lamy, D., & Hodes, R. M. (2006). Nature and nurture in own-race face processing. *Psychological Science, 17*(2), 159–163.

Bauer, P. J. (2007). Recall in infancy: A neurodevelopmental account. *Current Directions in Psychological Science, 16*(3), 142–146.

Baumeister, R. F., & Leary, M. R. (1995). The need to belong: Desire for interpersonal attachments as a fundamental human motivation. *Psychological Bulletin, 117*(3), 497–529.

Blandon-Gitlin, I., Pezdek, K., Saldivar, S., & Steelman, E. (2014). Oxytocin eliminates the own-race bias in face recognition memory. *Brain Research, 1580*, 180–187.

Borowiak, K., & von Kriegstein, K. (2020). Intranasal oxytocin modulates brain responses to voice-identity recognition in typically developing individuals, but not in ASD. *Translational Psychiatry, 10*(1), 1–12.

Carter, C. S. (2014). Oxytocin pathways and the evolution of human behavior. *Annual Review of Psychology, 65*, 17–39.

Cohen, D., & Shamay-Tsoory, S. G. (2018). Oxytocin regulates social approach. *Social Neuroscience, 13*(6), 680–687.

Damon, F., Quinn, P. C., Heron-Delaney, M., Lee, K., & Pascalis, O. (2016). Development of category formation for faces differing by age in 9-to 12-month-olds: An effect of experience with infant faces. *British Journal of Developmental Psychology, 34*(4), 582–597.

De Dreu, C. K., Greer, L. L., Handgraaf, M. J., Shalvi, S., Van Kleef, G. A., Baas, M., Ten Velden, F. S., Van Dijk, E., & Feith, S. W. (2010). The neuropeptide oxytocin regulates parochial altruism in intergroup conflict among humans. *Science, 328*(5984), 1408–1411.

De Dreu, C. K., Gross, J., Fariña, A., & Ma, Y. (2020). Group cooperation, carrying-capacity stress, and intergroup conflict. *Trends in Cognitive Sciences, 24*(9), 760–776.

De Dreu, C. K., & Kret, M. E. (2016). Oxytocin conditions intergroup relations through upregulated in-group empathy, cooperation, conformity, and defense. *Biological Psychiatry, 79*(3), 165–173.
Declerck, C. H., Boone, C., & Kiyonari, T. (2010). Oxytocin and cooperation under conditions of uncertainty: The modulating role of incentives and social information. *Hormones and Behavior, 57*(3), 368–374.
Diesendruck, G. (2021). A motivational perspective on the development of social essentialism. *Current Directions in Psychological Science, 30*(1), 76–81.
Diesendruck, G., & Deblinger-Tangi, R. (2014). The linguistic construction of social categories in toddlers. *Child Development, 85*(1), 114–123.
Dreu, C.K.W.D., Greer, L.L., Kleef, G.A.V., Shalvi, S., & Handgraaf, M.J.J. (2011). Oxytocin promotes human ethnocentrism. Proceedings of the National Academy of Sciences, 108(4), 1262–1266. https://doi.org/10.1073/pnas.1015316108.
Eckstein, M., Bamert, V., Stephens, S., Wallen, K., Young, L. J., Ehlert, U., & Ditzen, B. (2019). Oxytocin increases eye-gaze towards novel social and non-social stimuli. *Social Neuroscience, 14*(5), 594–607.
Erickson, L. C., Thiessen, E. D., & Estes, K. G. (2014). Statistically coherent labels facilitate categorization in 8-month-olds. *Journal of Memory and Language, 72*, 49–58.
Feldman, R. (2012). Oxytocin and social affiliation in humans. *Hormones and Behavior, 61*(3), 380–391. https://doi.org/10.1016/j.yhbeh.2012.01.008
Feldman, R. (2016). The neurobiology of mammalian parenting and the biosocial context of human caregiving. *Hormones and Behavior, 77*, 3–17. https://doi.org/10.1016/j.yhbeh.2015.10.001
Feldman, R. (2017). The neurobiology of human attachments. *Trends in Cognitive Sciences, 21*(2), 80–99.
Feldman, R.. (2021). The neurobiology of affiliation: Maternal-infant bonding to life within social groups. Encyclopedia of Behavioral Neuroscience: Second Edition (3–3, pp.518–531). Elsevier.
Feldman, R., Gordon, I., & Zagoory-Sharon, O. (2010). The cross-generation transmission of oxytocin in humans. *Hormones and Behavior, 58*(4), 669–676. https://doi.org/10.1016/j.yhbeh.2010.06.005
Ferera, M., Baron, A. S., & Diesendruck, G. (2018). Collaborative and competitive motivations uniquely impact infants' racial categorization. *Evolution and Human Behavior, 39*(5), 511–519.
Ferera, M., Pun, A., Baron, A. S., & Diesendruck, G. (2021). The effect of familiarity on infants' social categorization capacity. *PLoS One, 16*(3), Article e0247710. https://doi.org/10.1371/journal.pone.0247710
Ferry, A. L., Hespos, S. J., & Waxman, S. R. (2013). Nonhuman primate vocalizations support categorization in very young human infants. *Proceedings of the National Academy of Sciences, 110*(38), 15231–15235.
Fischer-Shofty, M., Levkovitz, Y., & Shamay-Tsoory, S. G. (2013). Oxytocin facilitates accurate perception of competition in men and kinship in women. *Social Cognitive and Affective Neuroscience, 8*(3), 313–317.
Fiske, S. T. (2010). Interpersonal stratification: Status, power, and subordination. In D. T. Fiske, Gilbert, & G. Lindzey (Eds.), *Handbook of social psychology* (pp. 941–982). John Wiley & Sons Inc. https://doi.org/10.1002/9780470561119.socpsy002026.
Gamer, M., Zurowski, B., & Büchel, C. (2010). Different amygdala subregions mediate valence-related and attentional effects of oxytocin in humans. *Proceedings of the National Academy of Sciences, 107*(20), 9400–9405.
Guastella, A. J., Mitchell, P. B., & Mathews, F. (2008). Oxytocin enhances the encoding of positive social memories in humans. *Biological Psychiatry, 64*(3), 256–258.
Henrich, J. (2015). *The secret of our success*. Princeton University Press.
Herrmann, E., Call, J., Hernández-Lloreda, M. V., Hare, B., & Tomasello, M. (2007). Humans have evolved specialized skills of social cognition: The cultural intelligence hypothesis. *Science, 317*(5843), 1360–1366.
Horta, M., Pehlivanoglu, D., & Ebner, N. C. (2020). The role of intranasal oxytocin on social cognition: An integrative human lifespan approach. *Current Behavioral Neuroscience Reports*, 1–18.
Jin, K., & Baillargeon, R. (2017). Infants possess an abstract expectation of ingroup support. *Proceedings of the National Academy of Sciences, 114*(31), 8199–8204.
Jost, J. T., Banaji, M. R., & Nosek, B. A. (2004). A decade of system justification theory: Accumulated evidence of conscious and unconscious bolstering of the status quo. *Political Psychology, 25*(6), 881–919.
Kemp, A. H., & Guastella, A. J. (2011). The role of oxytocin in human affect: A novel hypothesis. *Current Directions in Psychological Science, 20*(4), 222–231.
Keverne, E. B., & Curley, J. P. (2004). Vasopressin, oxytocin and social behaviour. *Current Opinion in Neurobiology, 14*(6), 777–783.
Kinzler, K. D., Dupoux, E., & Spelke, E. S. (2007). The native language of social cognition. *Proceedings of the National Academy of Sciences, 104*(30), 12577–12580.
Kosfeld, M., Heinrichs, M., Zak, P. J., Fischbacher, U., & Fehr, E. (2005). Oxytocin increases trust in humans. *Nature, 435*(7042), 673–676.
Kurzban, R., Tooby, J., & Cosmides, L. (2001). Can race be erased? Coalitional computation and social categorization. *Proceedings of the National Academy of Sciences, 98*(26), 15387–15392.
Lee, K., Quinn, P. C., & Pascalis, O. (2017). Face race processing and racial bias in early development: A perceptual-social linkage. *Current Directions in Psychological Science, 26*(3), 256–262.
Leinbach, M. D., & Fagot, B. I. (1993). Categorical habituation to male and female faces: Gender schematic processing in infancy. *Infant Behavior and Development, 16*(3), 317–332.
Liberman, Z., Woodward, A. L., & Kinzler, K. D. (2017). The origins of social categorization. *Trends in Cognitive Sciences, 21*(7), 556–568.
Liu, Y., Li, S., Lin, W., Li, W., Yan, X., Wang, X., Pan, X., Rutledge, R. B., & Ma, Y. (2019). Oxytocin modulates social value representations in the amygdala. *Nature Neuroscience, 22*(4), 633–641.
Maestripieri, D., Hoffman, C. L., Anderson, G. M., Carter, C. S., & Higley, J. D. (2009). Mother–infant interactions in free-ranging rhesus macaques: relationships between physiological and behavioral variables. *Physiology & Behavior, 96*(4–5), 613–619.
Meaney, M. J. (2001). Maternal care, gene expression, and the transmission of individual differences in stress reactivity across generations. *Annual Review of Neuroscience, 24*(1), 1161–1192. https://doi.org/10.1146/annurev.neuro.24.1.1161
Mierop, A., Mikolajczak, M., Stahl, C., Béna, J., Luminet, O., Lane, A., & Corneille, O. (2020). How can intranasal oxytocin research be trusted? A systematic review of the interactive effects of intranasal oxytocin on psychosocial outcomes. *Perspectives on Psychological Science, 15*(5), 1228–1242.
Minar, N. J., & Lewkowicz, D. J. (2018). Overcoming the other-race effect in infancy with multisensory redundancy: 10–12-month-olds discriminate dynamic other-race faces producing speech. *Developmental Science, 21*(4), Article e12604.
Neumann, I. D. (2008). Brain oxytocin: A key regulator of emotional and social behaviours in both females and males. *Journal of Neuroendocrinology, 20*(6), 858–865.
Neumann, I. D. (2009). The advantage of social living: Brain neuropeptides mediate the beneficial consequences of sex and motherhood. *Frontiers in Neuroendocrinology, 30*(4), 483–496.
Oakes, L. M. (2010). Using habituation of looking time to assess mental processes in infancy. *Journal of Cognition and Development, 11*(3), 255–268.
Over, H., & Carpenter, M. (2009). Eighteen-month-old infants show increased helping following priming with affiliation. *Psychological Science, 20*(10), 1189–1193. https://doi.org/10.1111/j.1467-9280.2009.02419.x
Pauker, K., Williams, A., & Steele, J.R. (2016). Children's racial categorization in context. Child Development Perspectives, 10(1), 33–38. https://doi. org/10.1111/cdep. 12155.
Pedersen, C. A. (2004). Biological aspects of social bonding and the roots of human violence. *Annals of the New York Academy of Sciences, 1036*(*1*), 106–127.
Pietraszewski, D., Cosmides, L., & Tooby, J. (2014). The content of our cooperation, not the color of our skin: An alliance detection system regulates categorization by coalition and race, but not sex. *PLoS ONE, 9*(2), Article e88534. https://doi.org/10.1371/journal.pone.0088534
Pun, A., Ferera, M., Diesendruck, G., Hamlin, K. J., & Baron, A. S. (2018). Foundations of infants' social group evaluations. *Developmental Science, 21*(3), Article e12586.
Qian, M. K., Quinn, P. C., Heyman, G. D., Pascalis, O., Fu, G., & Lee, K. (2017). Perceptual individuation training (but not mere exposure) reduces implicit racial bias in preschool children. *Developmental Psychology, 53*(5), 845–859. https://doi.org/doi: doi/10.1037/dev0000290.
Quinn, P. C., Lee, K., & Pascalis, O. (2019). Face processing in infancy and beyond: The case of social categories. *Annual Review of Psychology, 70*, 165–189.
Quinn, P. C., Lee, K., Pascalis, O., & Xiao, N. G. (2020). Emotional expressions reinstate recognition of other-race faces in infants following perceptual narrowing. *Developmental Psychology, 56*(1), 15–27.

Quinn, P. C., Yahr, J., Kuhn, A., Slater, A. M., & Pascalis, O. (2002). Representation of the gender of human faces by infants: A preference for female. *Perception, 31*(9), 1109–1121. https://doi.org/10.1068/p3331

Quintana, D. S., Lischke, A., Grace, S., Scheele, D., Ma, Y., & Becker, B. (2021). Advances in the field of intranasal oxytocin research: Lessons learned and future directions for clinical research. *Molecular Psychiatry, 26*(1), 80–91.

Rilling, J. K., & Young, L. J. (2014). The biology of mammalian parenting and its effect on offspring social development. *Science, 345*(6198), 771–776.

Rimmele, U., Hediger, K., Heinrichs, M., & Klaver, P. (2009). Oxytocin makes a face in memory familiar. *Journal of Neuroscience, 29*(1), 38–42.

Robinson, C. W., & Sloutsky, V. M. (2007). Linguistic labels and categorization in infancy: Do labels facilitate or hinder? *Infancy, 11*(3), 233–253.

Ross, H. E., & Young, L. J. (2009). Oxytocin and the neural mechanisms regulating social cognition and affiliative behavior. *Frontiers in Neuroendocrinology, 30*(4), 534–547.

Sapolsky, R. M. (2018). *Behave: The biology of humans at our best and worst*. Penguin.

Setoh, P., Lee, K. J., Zhang, L., Qian, M. K., Quinn, P. C., Heyman, G. D., & Lee, K. (2019). Racial categorization predicts implicit racial bias in preschool children. *Child Development, 90*(1), 162–179.

Shalvi, S., & De Dreu, C. K. (2014). Oxytocin promotes group-serving dishonesty. *Proceedings of the National Academy of Sciences, 111*(15), 5503–5507.

Sidanius, J., & Pratto, F. (2001). *Social dominance: An intergroup theory of social hierarchy and oppression*. Cambridge University Press.

Singarajah, A., Chanley, J., Gutierrez, Y., Cordon, Y., Nguyen, B., Burakowski, L., & Johnson, S. P. (2017). Infant attention to same-and other-race faces. *Cognition, 159*, 76–84.

Spangler, S. M., Schwarzer, G., Freitag, C., Vierhaus, M., Teubert, M., Fassbender, I., & Keller, H. (2013). The other-race effect in a longitudinal sample of 3-, 6-and 9-month-old infants: Evidence of a training effect. *Infancy, 18*(4), 516–533.

Tajfel, H. (1982). Social psychology of intergroup relations. *Annual Review of Psychology, 33*(1), 1–39.

Tomasello, M. (2016). *A natural history of human morality*. Harvard University Press.

Tottenham, N., Tanaka, J. W., Leon, A. C., McCarry, T., Nurse, M., Hare, T. A., Marcus, D. J., Westerlund, A., Casey, B. J., & Nelson, C. (2009). The NimStim set of facial expressions: Judgments from untrained research participants. *Psychiatry Research*.

Waxman, S.R., & Leddon, E.M. (2011). Early word-learning and conceptual development: Everything had a name, and each name gave birth to a new thought. In U. Goswami (Ed.) The Wiley-Blackwell handbook of childhood cognitive development (pp. 180–208). Malden, MA: Wiley-Blackwell.

Weisman, O., Zagoory-Sharon, O., & Feldman, R. (2012a). Intranasal oxytocin administration is reflected in human saliva. *Psychoneuroendocrinology, 37*(9), 1582–1586.

Weisman, O., Zagoory-Sharon, O., & Feldman, R. (2012b). Oxytocin administration to parent enhances infant physiological and behavioral readiness for social engagement. *Biological Psychiatry, 72*(12), 982–989.

Xiao, N. G., Quinn, P. C., Xiao, W. S., Liu, S., Ge, L., Pascalis, O., & Lee, K. (2017). Older but not younger infants associate own-race faces with positive music and other-race faces with negative music. *Developmental Science*.

Xue, S. W., Wu, H. B., Zhang, L., & Zhang, D. X. (2020). Intranasal oxytocin increases perceptual salience of faces in the absence of awareness. *Psychiatry Investigation, 17*(4), 292–298.

Yan, X., Yong, X., Huang, W., & Ma, Y. (2018). Placebo treatment facilitates social trust and approach behavior. *Proceedings of the National Academy of Sciences, 115*(22), 5732–5737.

Zak, P. J., Kurzban, R., & Matzner, W. T. (2005). Oxytocin is associated with human trustworthiness. *Hormones and Behavior, 48*(5), 522–527.