Published in final edited form as:

Brain Res. 2014 September 11; 1580: 180–187. doi:10.1016/j.brainres.2013.07.015.

Oxytocin eliminates the own-race bias in face recognition memory[☆]

Iris Blandón-Gitlin^{a,*}, Kathy Pezdek^b, Sesar Saldivar^a, and Erin Steelman^a

^aCalifornia State University, Fullerton, USA

^bClaremont Graduate University, USA

Abstract

The neuropeptide Oxytocin influences a number of social behaviors, including processing of faces. We examined whether Oxytocin facilitates the processing of out-group faces and reduce the own-race bias (ORB). The ORB is a robust phenomenon characterized by poor recognition memory of other-race faces compared to the same-race faces. In Experiment 1, participants received intranasal solutions of Oxytocin or placebo prior to viewing White and Black faces. On a subsequent recognition test, whereas in the placebo condition the same-race faces were better recognized than other-race faces, in the Oxytocin condition Black and White faces were equally well recognized, effectively eliminating the ORB. In Experiment 2, Oxytocin was administered after the study phase. The ORB resulted, but Oxytocin did not significantly reduce the effect. This study is the first to show that Oxytocin can enhance face memory of out-group members and underscore the importance of social encoding mechanisms underlying the own-race bias.

Keywords

Oxytocin; Other-race bias; Face recognition; Encoding

1. Introduction

The neuropeptide Oxytocin (OT) has been implicated in complex emotional and social behaviors. Human and animal studies show that OT enhances a number of social interactions, reduces anxiety, increases trust, and in some species decreases social avoidance and aggression (Lee et al., 2009; Zak, 2012). More recently the effects of OT on human social cognition have been demonstrated as well (for reviews see Bartz et al., 2011; MacDonald and MacDonald, 2010). Rimmele et al. (2009) reported that pre-encoding intranasal doses of OT make faces more familiar during subsequent recognition tests, and the effect was unique to this social stimulus set; recognition of non-social stimuli (e.g.,

[☆]This research was supported by seed Grants to the first author from California State University, Fullerton. Part of this research served as partial fulfillment of Erin Steelman's honors thesis supported by the California State Fullerton MARC U*STAR Program Grant 2T34GM008612-15 and -16 from the National Institutes of Health.

© 2013 Elsevier B.V. All rights reserved.

*Correspondence to: CSUF, Department of Psychology, P.O. Box 6846, Fullerton, CA 92834-6846, USA. Fax: +1 657 278 7134. iblandon-gitlin@fullerton.edu (I. Blandón-Gitlin).

houses, sculptures, and landscapes) did not show a beneficial effect of OT. Thus, face identification may be facilitated by pre-encoding exposure to OT. In this study we examined the potential effects of this peptide on the own-race bias (ORB). The ORB is a phenomenon characterized by less accurate recognition of other-race than the same-race faces due to encoding failures. We predict that pre-encoding OT exposure will lead to improvements in recognition of other-race faces.

1.1. Social-cognitive factors underlying the own-race bias

The ORB is a robust phenomenon demonstrated in numerous studies in the lab and real-world settings (Brigham et al., 2007). In a typical ORB study, participants view the same- and other-race faces. On subsequent recognition memory tests, the same-race faces are more accurately recognized than other-race faces by a number of groups (see Brigham et al., 2007; Pezdek et al., 2003). A principal explanation of the ORB posits that the effect results from social-cognitive factors that lead to differential processing of the same- and other-race faces (see Levin, 2000; Meissner et al., 2005; Sporer, 2001). When a face is perceived, an automatic social categorization process occurs such that the face is placed into an in-group or an out-group category. Race is one of a number of factors that can cue out-group categorization processes (Levin, 2000; Susa et al., 2010). As demonstrated by studies with ambiguous race faces, changing just one facial feature that stereotypically marks a race (e.g. hair style) can trigger face categorization processes (Maclin and Malpass, 2001). This categorization occurs with other in-group/out-group social categories as well. Shriver et al. (2008) showed that White participants remembered faces of White individuals more accurately if they believed them to be affiliated with their own rather than another university or social economic class.

Cognitively, the categorization of faces can be characterized as an economy of attentional resources. Whereas out-group faces are “cognitively disregarded” (Rodin, 1987) leading to decreased attention and shallow processing, in-group faces receive more attentional resources to individuating features diagnostic of recognition (Meissner et al., 2005). Indeed instructing participants to pay close attention to individual aspects of other-race faces substantially reduces the ORB (Hugenberg et al., 2007). Lebrecht et al. (2009) found that training involving an individuation task (attending to face differentiating cues) but not category tasks (deciding on race of face) reduced both the ORB and implicit racial bias. Thus, it appears that early processing dimensions of social categorization affect attentional allocation and to some extent attitudes toward out-group members. These mechanisms appear to underlie the bias in other-race face recognition memory.

1.2. Influence of Oxytocin on face processing

In humans, the impact of OT on social recognition and behavior appears to be moderated by contextual and individual difference factors (Bartz et al., 2011). Despite this, a recent meta-analysis of the effect of OT on *facial recognition of emotions* showed a modest significant effect size in the direction of OT-treated groups outperforming the placebo group (overall $d=.21$, $p<0.01$; Van IJzendoorn and Bakermans-Kranenburg, 2012). Similarly, four of the five published studies on *face recognition memory* show positive effects in the predicted direction (Di Simplicio et al., 2009; Guastella et al., 2008b; Rimmele et al., 2009; Savaskan

et al., 2008). A reverse effect was reported by Herzmann et al. (2012). Thus, the overall pattern of results shows that OT enhances face processing and recognition.

Although the mechanisms by which OT facilitates face recognition are unknown, it has been suggested that OT may work by reducing social anxiety and stress via attenuation of amygdala activity, which induces autonomic responses to emotional experience (Kirsch et al., 2005). Using functional MRI, Domes et al. (2007a) showed that compared to a placebo group, OT-treated males had less right-sided amygdala activity in response to emotional face stimuli (showing angry, fearful or happy expressions) than neutral stimuli.

Another mechanism by which OT may enhance face memory is by facilitating eye-gaze to face regions conveying important social information. Guastella et al. (2008a) had participants in OT and placebo conditions view neutral faces. They recorded eye-gaze duration and fixation toward three face regions: eye, nose/mouth and forehead/cheek. Based on previous research indicating that the eye region is primary in social face perception, the authors hypothesized this region would be important in eye-gaze patterns. Compared to the placebo group, OT-treated participants gazed significantly longer and more frequently at the eye region of faces compared to other regions. These eye-gaze data, together with the face recognition studies, suggest that OT may facilitate encoding by inducing a face individuation orienting response.

1.3. Influence of Oxytocin on social categorization

Research investigating the influence of OT on social categorization in humans is sparse (de Dreu, 2012). However, recent research shows that OT may moderate socially relevant behaviors toward in-group and to some extent out-group members. Using measures of event-related brain potentials, Sheng et al. (2013) found greater neural response to in-group faces displaying pain expressions than neutral expressions. This empathy bias was enhanced by OT-treatment significantly more when viewing in-group faces than out-group faces. Similarly, de Dreu et al. (2011) reported that OT-treated groups made stronger positive implicit associations (e.g., ascribing words to targets) and benevolent decisions (e.g., reduced readiness to sacrifice targets) about the in-group compared to control conditions. Only in some conditions did OT-treated participants make negative implicit associations toward the out-group, a result that has not been specifically clarified and may be explained by out-group derogation (de Dreu et al. 2011) or a general OT-induced sensitivity to socially important information (Averbeck, 2010; Chen et al., 2011). In these social categorization studies OT had a greater effect on attitudes and behaviors toward in-group than out-group members. The potential effect of OT on face encoding and recognition memory for in-group vs. out-group members remains unexplored. Examining this relationship is a principal goal of the current study.

1.4. Current study

Given that OT can facilitate encoding of faces via a combination of social, neurological and cognitive processes, and the finding that the ORB results from encoding deficits for other-race faces in some of these same processes, the principal prediction in this study is that encoding of other-race faces will be enhanced by the application of OT compared to a

placebo control condition. In two double-blind experiments, participants were randomly assigned to an OT or placebo condition. Using a social orienting task they encoded own-and other-races faces followed by a recognition memory test. In Experiment 1, OT was administered prior to studying the faces to assess the effects of OT at encoding. We predict that OT will enhance face recognition overall. More important, we predict an interaction with greater improvements in recognition accuracy in the OT than the placebo condition for other-race than the same-race faces, effectively reducing the ORB. The application of OT is predicted to reduce the face categorization bias thereby resulting in more similar allocation of attentional resources to the same- and other-race faces. In Experiment 2, OT was administered after encoding faces to determine if OT affects the consolidation of the information processing stage.

2. Experiment 1 results and discussion

This study involves a 2 (Race of face: White or Black) by 2 (Condition: Placebo or Oxytocin), mixed design, with condition as the between-subjects factor. Measures from Signal Detection Theory (SDT; see Banks, 1970; Stanislaw and Todorov, 1999) were used to assess recognition accuracy for the same- and other-race faces (see Section 6 for explanation of stimuli and participants' tasks). The SDT measures were calculated by comparing test responses to previously seen faces ("old") and distractor faces presented only at test ("new"). A hit rate indicates the proportion of correct responses to previously seen faces; a false alarm rate indicates the proportion of incorrect responses to new faces. The d' rate is the standardized difference in accuracy between responses to old and new faces. The C rate, also known as response bias, is a measure of the tendency to respond "old" or "new" independent of accuracy. A C rate of zero indicates relatively equal distributions of "old" and "new" responses and therefore no bias in responding. A C rate smaller than zero indicates more "old" responses, and a C rate larger than zero indicates more "new" responses. A lower C rate is interpreted as a liberal response bias (more likely to respond "old" to both old and new faces), and a higher C rate is interpreted as a conservative bias (less likely to respond "old").

All statistical tests in this study were conservatively conducted as two-tailed. Degrees of freedom for tests vary because some participants did not provide responses in one or more conditions. Analyses of face recognition measures are reported first, followed by analyses of the social encoding task and self-reported perception of anxiety, mood and attention.

2.1. Face recognition

Fig. 1 presents the mean hit rate, false alarm rate, d' rate and C rate as a function of race of target and condition. On the d' data a 2 (Face: White vs. Black) $\times$ 2 (Condition: Control vs. OT) mixed ANOVA revealed a significant main effect of race of face and more important, an interaction with condition. Overall White faces ($M=1.89$, $SE=0.09$) were better recognized than Black faces ($M=1.56$, $SE=0.08$), $F(1, 41)=14.22$, $p=0.001$, $\eta_p^2=0.26$. The significant interaction, $F(1, 41)=4.34$, $p=0.044$, $\eta_p^2=0.10$, showed that whereas in the placebo condition, as predicted, White faces ($M=1.90$, $SE=0.13$) were better recognized than Black faces ($M=1.39$, $SE=0.12$); in the OT condition recognition accuracy for White faces

($M=1.89$, $SE=0.12$) and Black faces ($M=1.74$, $SE=0.11$) did not differ. It was specifically recognition memory for Black faces that was improved in the OT compared to the control condition, $t(41)=-2.19$, $p=0.034$, $d=-0.68$. No other effect was statistically significant on d' (highest $F=1.30$)

The 2×2 mixed ANOVAs on hits and false alarm data showed statistically significant effects of race of face only. Hit rates were significantly lower for White ($M=0.76$, $SE=0.02$) than Black faces ($M=0.81$, $SE=0.02$), $F(1, 41)=6.81$, $p=0.013$, $\eta_p^2=0.14$. However, false alarms were significantly higher with Black ($M=0.28$, $SE=0.02$) than White faces ($M=0.17$, $SE=0.02$), $F(1, 41)=37.12$, $p<0.001$, $\eta_p^2=0.48$. The finding that the ORB was more evident for false alarm than hit rate data is consistent with findings reported elsewhere (e.g., Meissner and Brigham, 2001). No other effect was statistically significant (highest $F=2.44$).

A 2×2 mixed ANOVA on C rates revealed a significant effect of race of face only. Participants were more liberal (more likely to respond “old” to both old and new faces) in their judgment with Black ($M=-0.05$, $SE=0.07$) than White faces ($M=0.16$, $SE=0.06$), $F(1, 41)=12.48$, $p=0.001$, $\eta_p^2=0.23$. No other effect was significant ($F<1$).

A multivariate analysis of confidence ratings in response to the four types of stimuli at test (old-White, old-Black, new-White, new-Black) as a function of condition revealed no significant effects, $F<1$.

2.2. Social engagement during encoding

A 2×2 mixed ANOVA on stimulus approachability ratings during encoding showed no statistically significant effects, $F<1$. The overall mean approachability rating was relatively low (scale 1–10, $M=4.29$, $SE=0.22$), and in all conditions none of the correlations between face approachability rating and d' were significant ($p>0.05$). It is not clear why these results were not significant. Perhaps the task was only effective orienting participants to the faces but not sensitive enough to determine other relationships.

2.3. Wakefulness, calmness, mood, and attention

Two 2 (Condition) $\times 2$ (Time: pre- vs. post-encoding) mixed ANOVAs on wakefulness and calmness ratings were conducted. A significant interaction on calmness ratings resulted, $F(1,35)=8.37$, $p=0.007$, $\eta_p^2=0.19$; whereas in the control condition calmness ratings were lower pre-test ($M=41.44$, $SE=1.58$) than post test ($M=44.94$, $SE=1.83$), ($t(17)=-2.81$, $p=0.012$, $d=-0.482$), in the OT condition pre- ($M=44.63$, $SE=1.19$) and post ($M=43.95$, $SE=1.17$) calmness ratings did not significantly differ, ($t<1$). No other effect was statistically significant (highest $F=3.79$).

The 2×2 ANOVAs on both affect ratings revealed a main effect of time on negative affect only. Negative affect ratings given prior to substance intake ($M=15.58$, $SE=0.78$) decreased after substance intake ($M=14.10$, $SE=0.78$), $F(1,41)=7.62$, $p=0.009$, $\eta_p^2=0.16$. No other effect was significant (highest $F=1.74$). Additionally, no significant effects were found for

the attention measure, $F < 1$. Together these results suggest that for the most part OT did not negatively affect participants' mood, anxiety or attention.

In Experiment 1, the principal analyses involving discrimination accuracy (d') revealed three important findings. First, the predicted interaction was confirmed; whereas in the placebo condition same-race faces were better recognized than other-race faces, in the Oxytocin condition Black and White faces were equally well recognized, effectively eliminating the ORB. Second, the main effect of OT was not significant. Overall better face recognition with OT was predicted from previous findings but did not result. Third, there was an overall ORB effect; the same-race faces were more accurately recognized than other-race faces. Finally, OT did not adversely affect participants' anxiety, mood or attention.

3. Experiment 2

In Experiment 1, pre-encoding of OT significantly improved memory for other-race faces, thus confirming that OT improves face recognition memory at the encoding stage. However, Savaskan et al. (2008) reported that post-encoding of OT also improved face recognition memory, thus suggesting that OT may affect memory consolidation as well as encoding. The results of Experiment 1 and those of Savaskan et al. suggest that pre- and post-encoding OT administration may differentially affect various aspects of face recognition memory.

Experiment 2 was conducted to assess if OT affected the own race bias at the consolidation stage in addition to the encoding stage. If so, the significant interaction of race by condition on d' data reported in Experiment 1 would be replicated in Experiment 2. The procedure of Experiment 2 was similar to that used in Experiment 1 except that the OT and placebo were administered after presentation of the target faces.

4. Experiment 2 results and discussion

Experiment 2 applies the same analytical procedures from Experiment 1.

4.1. Face recognition

Fig. 2 presents mean hit rate, false alarm rate, d' rate, and C rate as a function of the race of target and condition. Various 2 (Face: White vs. Black) $\times$ 2 (Condition: Control vs. OT) mixed ANOVAs on each measure showed statistically significant effects of race of face only; The d' analysis showed that White faces ($M=1.68$, $SE=0.11$) were better recognized than Black faces ($M=1.24$, $SE=0.09$), $F(1, 42)=10.58$, $p=0.002$, $\eta_p^2=0.20$. Consistent with Experiment 1, whereas hit rates were lower for White ($M=.71$, $SE=0.02$) than Black faces ($M=0.76$, $SE=0.02$), $F(1, 42)=6.99$, $p=0.011$, $\eta_p^2=0.14$, false alarms were significantly higher with Black ($M=0.34$, $SE=0.03$) than White faces ($M=0.18$, $SE=0.02$), $F(1, 42)=51.17$, $p<0.001$, $\eta_p^2=0.55$. No other effect on these three measures was statistically significant (highest $F=2.57$). Most critically, the interaction of condition by race of face was not significant on any of the recognition accuracy measures including d' rate ($F=1.50$, $p=0.227$).

A 2×2 mixed ANOVA on C rates revealed significant main effects of face and condition. Participants were more liberal in their judgment of Black ($M=-0.13$, $SE=0.06$) than White faces ($M=0.28$, $SE=0.06$), $F(1, 42)=39.26$, $p<0.001$, $\eta_p^2=0.48$, and participants were more conservative (less likely to choose “old”) in the OT ($M=0.19$, $SE=0.07$) than placebo condition ($M=-0.03$, $SE=0.07$), $F(1, 42)=4.81$, $p=0.034$, $\eta_p^2=0.10$.

As in Experiment 1, a multivariate analysis of confidence ratings in response to the four types of stimuli at test, as a function of condition was not significant, $F=1.37$.

4.2. Social engagement during encoding

A 2×2 mixed ANOVA on stimulus approachability ratings during encoding showed a significant main effect of race of face despite an overall low mean rating (scale 1–10, $M=4.55$, $SE=0.21$). White faces received higher approachability ratings ($M=4.75$, $SE=0.23$) than Black faces ($M=4.36$, $SE=0.23$), $F(1, 42)=5.75$, $p=0.011$, $\eta_p^2=0.12$. The correlations between approachability ratings and d' measures were small; none were significant, $p>0.05$.

4.3. Wakefulness, calmness, mood, and attention

Two 2 (Condition) $\times 2$ (Time: pre- vs. post-encoding) mixed ANOVAs on wakefulness and calmness ratings were conducted. Only a significant main effect of wakefulness resulted; pre-encoding ratings were higher ($M=43.31$, $SE=1.15$) than post-encoding ratings ($M=41.28$, $SE=1.32$), $F(1, 39)=5.42$, $p=0.025$, $\eta_p^2=0.12$. No other effect was significant (highest $F=1.35$).

The 2×2 ANOVAs on both affect ratings revealed a main effect of Time on negative affect only. Negative affect ratings declined from pre-encoding ($M=15.42$, $SE=0.94$) to post-encoding ($M=13.78$, $SE=0.70$), $F(1, 41)=6.13$, $p=0.018$, $\eta_p^2=0.13$. No other effect was significant (highest $F=1.27$) including results on the attention measure, $F<1$.

In Experiment 2 the principal analyses involving discrimination accuracy (d') revealed a significant ORB effect only. Unlike Experiment 1, in Experiment 2, when OT was administered post-encoding, the interaction of condition by race of face was not significant. This nonsignificant interaction in Experiment 2 suggests that OT affects recognition memory for other-race faces only when administered prior to encoding. This is consistent with social-cognitive models of the ORB and underscores the importance of encoding mechanisms involved in the ORB effect.

The main difference between Experiment 1 and 2 is the timing of the substance administration relative to the study phase. This procedure separates the OT encoding effects from consolidation effects. The effect of OT on consolidation processes independent of retrieval processes cannot be assessed in this study. It is likely that the OT substance was still present in the central nervous system at the time of the recognition memory test, as it takes a few hours to wash out of the body. Several studies have used longer delays (e.g., 24 h) for the recognition test (e.g., Guastella et al., 2008b; Rimmele et al., 2009), and Savaskan et al. (2008) used a short (30 min) vs. long (24 h) delay to assess potential interactive effects

of OT with time intervals. Results from these studies showed no significant interactive effects, suggesting that OT did not directly affect retrieval processes. Despite this, it is possible that in the context of our study the lack of significant main effect of OT on face recognition memory may be related to the short delay interval.

5. General discussion

This study is the first to show that the neuropeptide, Oxytocin, reduced the own-race bias. The principal finding involved the significant interaction of condition by race of face in Experiment 1; compared to the placebo condition, pre-encoding intake of OT led to a significant increase in accuracy recognizing other-race faces. This interaction was not significant in Experiment 2 when OT was administered post-encoding of faces. These results suggest that the effect of OT on other-race face processing occurs primarily at the encoding stage and does not affect memory consolidation. These results are consistent with social-cognitive models of the ORB and in line with many behavioral studies demonstrating that the memory impairment of other-race faces occurs because of encoding failures. Contrary to predictions from the OT face recognition research, there was no significant effect of OT on recognition memory for the same-race faces.

In modeling the basic mechanisms underlying the ORB, Meissner et al. (2005) and more recently Susa et al. (2010) concluded that the cognitive processes involved in encoding the same-race faces are qualitatively different from that of other-race faces. Racial categorization plays a significant role in early stages of other-race face processing whereby an out-group label may “disrupt the successful encoding of individuating facial information” (p. 535). With the same-race faces a deeper processing involving the encoding of individuating features diagnostic of recognition occurs and can result in better memory. Our results are consistent with a differential processing of faces framework of the ORB. Given that OT facilitates attention to more socially significant face regions such as the eyes, it is possible that OT induced an orienting response to individuating encoding of other-race faces in our participants. Di Simplicio et al. (2009) reported that OT induced a slower processing speed for fearful facial expressions compared to other basic expressions. Thus it is possible that OT works to facilitate greater attention allocation to particular aspects of important stimuli and thereby strengthening encoding.

Emotions may play an important role as well. The emotional salience of Black faces to White participants was shown by Cunningham et al. (2004) with functional MRI. These researchers showed that during a fast-paced perception interval, amygdala activity increased more in response to Black than White faces, and this difference in activation was stronger in participants who exhibited greater racial bias toward out-group members. Because OT dampens amygdala activity in males (Domes et al., 2007a; Kirsch et al., 2005) it is possible that in our study, OT attenuated amygdala activity in response to emotion likely triggered by Black faces. This is possible given that the social group for most of our participants involved mainly Whites. Further research is needed to directly assess these potential relationships and importantly, female participants should be included. A different pattern of results may emerge or elucidate on the current findings, as in some cases female participants' amygdala activation differs from that of men. For example, Domes et al. (2010) found that compared

to a control group, OT-treated females showed an increase in left amygdala activation in response to faces displaying a fearful expression. This increase in amygdala activation in females followed by OT treatment may reveal additional relationships between OT and the ORB. Perhaps the ORB will increase in females due to OT-induced activation of the amygdala. Alternatively, gender might moderate the relationship between OT and ORB when faces displaying emotions are shown, but not when neutral faces (like the ones in the current study) are shown. Any of these findings would further our understanding of OT effects on the ORB.

Together, these explanations help clarify the OT effect on memory for other-race faces, however, they do not account for the absence of an effect of OT on the same-race faces. Several contextual and individual difference factors have been noted to account for some inconsistent findings in studies of OT and social cognition (Bartz et al., 2011). One of those factors is task difficulty. Domes et al. (2007b) reported that participants in an OT condition performed better than controls on a difficult version of a mind reading task, however, the two groups performed equally well on the easy version of this task. Similarly, in the verbal memory domain, Heinrichs et al. (2004) showed that pre-encoding OT significantly impaired memory when the recall task was difficult (word generation) but not when it was easy (word-stem completion). Together these findings suggest that stimuli type, task type, and task difficulty may moderate the effect of OT on the same-and cross-race faces. Specifically, it is possible that in our study, OT had a greater influence on the more difficult other-race face memory task but not on the relatively easier same-race face memory task.

This study demonstrated that Oxytocin can enhance the encoding of out-group faces, a class of stimuli that typically receives less attention, is “cognitively disregarded” and processed at a shallow level. The mechanisms underlying these encoding effects need to be clarified in future studies, including the investigation of possible motivational factors driving attention allocation to out-group faces. This study also demonstrates the feasibility of a new methodology to test models of the ORB. Imaging studies have shed light on the neural structures associated with the same- vs. other-race face processing, behavioral studies have investigated the social-cognitive mechanisms involved in processing these two categories of faces, and the current study contributes to the understanding of the ORB from a neurochemical perspective. This furthers our understanding of the ORB and provides a more complete picture of its underlying mechanisms.

6. Experiment 1 method

6.1. Participants and design

Forty-three non-Hispanic Caucasian males (age $M=19.86$, $SD=1.68$) meeting criteria were included. They received \$20 and course credit. Similar to other studies (e.g., Rimmele et al., 2009; Savaskan et al., 2008) participants' inclusion criteria were: no physical or mental illness, not taking prescription medication, non-smokers, and a normal heart rate and blood pressure at the time of the study. Participants reported normal sleep–wake cycle the day preceding the study, and no heavy consumption of alcohol or caffeinated drinks, or use of illegal drugs prior to testing. Three participants who showed deviant scores on hits or false alarm measures ($z>3.29$) were not included in analyses. A double-blind placebo-control

design was used with 23 participants in the OT condition and 20 in the control condition. The main design is a 2 (Race of face: White or Black) by 2 (Condition: Placebo or Oxytocin), mixed design, with condition as the between-subjects factor.

6.2. Materials and procedure

There were three phases, illustrated in Fig. 3. In phase 1, participants completed a questionnaire assessing their prior days' activities, followed by assessments of heart rate and blood pressure. Next, questionnaires assessing wakefulness, calmness (Steyer et al., 1997), mood (Positive and Negative Affect Scale, PANAS; http://ir.uiowa.edu/psychology_pubs/11) and attention (Brickenkamp and Zillmer, 1998) were completed self-paced. Immediately afterward, participants self-administered intranasally, either 24 IU of Oxytocin (Syntocinon Spray by Novartis; three puffs of 4-IU in each nostril) or the placebo (saline) solution.

Using procedures similar to Rimmele et al. (2009) we allowed 45 min to ensure OT central nervous system effects. During this time participants completed distractor tasks. In phase 2, participants viewed 50 neutral-expression faces (25 Black, 25 White, in random blocks) for 2.5 s each, with instructions to study each face and indicate the extent to which they would like to approach the person (rating: 1=not at all; 10=very much). This orienting task (a) ensured that participants were attending to stimuli in a social manner, and (b) determine if OT has a greater effect than placebo on subjective perception of stimuli at encoding. Practice trials familiarized participants with the task. The face stimuli for both experiments were selected from the database of male faces with neutral expressions used by Meissner et al. (2005) and others.¹

Immediately following, in phase 3, participants again completed the wakefulness, calmness, mood and attention questionnaires. They were then instructed on the test procedure and given practice trials. The test consisted of 50 old and 50 new face stimuli (50 Black and 50 White faces) presented for 2.5 s each and organized in blocks shown in random order. Participants' task was to decide if each face was old or new and rate their confidence in that assessment (1=not at all confident; 10=very confident).

Participants then reported their contact with the same-and other- race groups; the majority (73%) reported that their social group included mostly Whites. Finally, they were asked to guess which condition they were assigned to. Only 17 provided a guess response. The proportion of those guessing correctly (47%) was not significantly different from those guessing incorrectly (54%), $Z=.34$, $p>0.05$.

7. Experiment 2 method

7.1. Participants and design

Forty-four non-Hispanic Caucasian males (age $M=19.57$, $SD=1.45$) participated. They received \$20 and course credit. The same design, inclusion criteria, and prescreening used in Experiment 1 were used in Experiment 2.

¹See: <http://iilab.utep.edu/stimuli.htm>.

7.2. Materials and procedure

In phase 1, all procedures followed in Experiment 1 were used except that participants studied the face stimuli in phase 1 rather than phase 2 (see Fig. 3). Similar to Savaskan et al. (2008), immediately following presentation phase, in phase 2, participants self-administered the substance and waited 45 min. In phase 3, participants again completed the wakefulness, calmness, mood and attention questionnaires and were then presented the face recognition memory test.

Next participants reported on their contact with the same-and other-race groups; 63% reported their social group to include mostly Whites. Finally participants were asked to guess which condition they were assigned to. Only 20 participants provided a guess response. The proportion of those guessing correctly (35%) was not significantly different from those guessing incorrectly (65%), $Z=1.90$, $p>0.05$

REFERENCES

- Averbeck BB. Oxytocin and the salience of social cues. *Proc. Natl. Acad. Sci. USA*. 2010; 107:9033–9034. <http://dx.doi.org/10.1073/pnas.1004892107>. [PubMed: 20448196]
- Banks WP. Signal detection theory and human memory. *Psychol. Bull.* 1970; 74:81–99. <http://dx.doi.org/10.1037/h0029531>.
- Bartz JA, Zaki J, Bolger N, Ochsner KN. Social effects of oxytocin in humans: context and person matter. *Trends Cogn. Sci.* 2011; 15:301–309. <http://dx.doi.org/10.1016/j.tics.2011.05.002>. [PubMed: 21696997]
- Brigham, JC.; Bennett, LB.; Meissner, CA.; Mitchell, T. The influence of race on eyewitness memory. In: Lindsay, R.; Ross, D.; Read, J.; Toglia, M., editors. *The Handbook of Eyewitness Psychology: Memory for People*. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers; 2007. p. 257–281.
- Brickenkamp, R.; Zillmer, EA. *d2 Test of Attention*. Germany: Hogrefe & Huber, Göttingen; 1998.
- Chen FS, Kumsta R, Heinrichs M. Oxytocin and intergroup relations: goodwill is not a fixed pie. *Proc Natl. Acad. Sci.* 2011; 108:E45. <http://dx.doi.org/10.1073/pnas.1101633108>. [PubMed: 21441109]
- Cunningham WA, Johnson MK, Raye CL, Gatenby JC, Gore JC, Banaji MR. Separable neural components in the processing of Black and White faces. *Psychol. Sci.* 2004; 15:806–813. [PubMed: 15563325]
- de Dreu CKW. Oxytocin modulates cooperation within and competition between groups: an integrative review and research agenda. *Horm. Behav.* 2012; 61(3):419–428. <http://dx.doi.org/10.1016/j.yhbeh.2011.12.009>. [PubMed: 22227278]
- de Dreu CKW, Greer LL, Van Kleef GA, Shalvi S, Handgraaf MJJ. Oxytocin promoted human ethnocentrism. *Proc. Natl. Acad. Sci. USA*. 2011; 108:1262–1266. <http://dx.doi.org/10.1073/pnas.1015316108>. [PubMed: 21220339]
- Di Simplicio M, Massey-Chase R, Cowen P, Harmer C. Oxytocin enhances processing of positive vs. negative emotional information in healthy male volunteers. *J. Psychopharmacol.* 2009; 23:241–248. <http://dx.doi.org/10.1177/0269881108095705>. [PubMed: 18801829]
- Domes G, Heinrichs M, Gläscher J, Büchel C, Braus DF, Herpertz S. Oxytocin attenuates amygdala response to emotional faces regardless of valence. *Biol. Psychiatry*. 2007a; 62:1187–1190. <http://dx.doi.org/10.1016/j.biopsych.2007.03.025>. [PubMed: 17617382]
- Domes G, Heinrichs M, Michel A, Berger C, Herpertz S. Oxytocin improves “mind-reading” in humans. *Biol. Psychiatry*. 2007b; 61:731–733. <http://dx.doi.org/10.1016/j.biopsych.2006.07.015>. [PubMed: 17137561]
- Domes G, Lischke A, Berger C, Grossmann A, Hauenstein K, Heinrichs M, Herpertz SC. Effects of intranasal oxytocin on emotional face processing in women. *Psychoneuroendocrinology*. 2010; 35:83–93. <http://dx.doi.org/10.1016/j.psyneuen.2009.06.016>. [PubMed: 19632787]

- Guastella AJ, Mitchell PB, Dadds MR. Oxytocin increases gaze to the eye-region of human faces. *Biol. Psychiatry*. 2008a; 63:3–5. <http://dx.doi.org/10.1016/j.biopsych.2007.06.026>. [PubMed: 17888410]
- Guastella AJ, Mitchell PB, Mathews F. Oxytocin enhances the encoding of positive social memories in humans. *Biol. Psychiatry*. 2008b; 64:256–258. <http://dx.doi.org/10.1016/j.biopsych.2008.02.008>. [PubMed: 18343353]
- Heinrichs M, Meinlschmidt G, Wippich W, Ehlert U, Hellhammer DH. Selective amnesic effects of oxytocin on human memory. *Physiol. Behav.* 2004; 83:31–38. <http://dx.doi.org/10.1016/j.physbeh.2004.07.020>. [PubMed: 15501488]
- Herzmann G, Young B, Bird CW, Curran T. Oxytocin can impair memory for social and non-social visual objects: a within-subject investigation of oxytocin's effects on human memory. *Brain Res.* 2012; 1451:65–73. <http://dx.doi.org/10.1016/j.brainres.2012.02.049>. [PubMed: 22424787]
- Hugenberg K, Miller J, Claypool H. Categorization and individuation in the cross-race recognition deficit: toward a solution to an insidious problem. *J. Exp. Soc. Psychol.* 2007; 43:334–340. <http://dx.doi.org/10.1111/j.1751-9004.2008.00090.x>.
- Kirsch P, Esslinger C, Chen Q, Mier D, Lis S, Siddhanti S, et al. Oxytocin modulates neural circuitry for social cognition and fear in humans. *J. Neurosci.* 2005; 25:11489–11493. <http://dx.doi.org/10.1523/JNEUROSCI.3984-05.2005>. [PubMed: 16339042]
- Lebrecht S, Pierce L, Tarr MJ, Tanaka J. Perceptual other-race training reduces implicit racial bias. *PLoS One*. 2009; 4(1):e4215. <http://dx.doi.org/10.1371/journal.pone.0004215>. [PubMed: 19156226]
- Lee H-J, Macbeth AH, Pagani JH, Young WS. Oxytocin: the great facilitator of life. *Prog. Neurobiol.* 2009; 88:127–151. <http://dx.doi.org/10.1016/j.pneurobio.2009.04.001>. [PubMed: 19482229]
- Levin DT. Race as a visual feature: using visual search and perceptual discrimination tasks to understand face categories and the cross-race recognition deficit. *J. Exp. Psychol.* 2000; 129:559–574.
- Meissner CA, Brigham JC, Butz DA. Memory for own-and other-race faces: a dual-process approach. *Appl. Cogn. Psychol.* 2005; 19:545–567. <http://dx.doi.org/10.1002/acp.1097>.
- Meissner CA, Brigham JC. Thirty years of investigating the own-race bias in memory for faces: a meta-analytic review. *Psychol. Public Policy Law*. 2001; 7:3–35. <http://dx.doi.org/10.1037/1076-8971.7.1.3>.
- MacDonald K, MacDonald TM. The peptide that binds: a systematic review of oxytocin and its prosocial effects in humans. *Harv. Rev. Psychiatry*. 2010; 18:1–21. <http://dx.doi.org/10.3109/10673220903523615>. [PubMed: 20047458]
- Maclin OH, Malpass RS. Racial categorization of faces: the ambiguous race face effect. *Psychol. Public Policy Law*. 2001; 98:112–113. <http://dx.doi.org/10.1037/1076-8971.7.1.98>.
- Pezdek K, Blandón-Gitlin I, Moore C. Children's face recognition memory: more evidence for the Cross-Race Effect. *J. Appl. Psychol.* 2003; 88:760–763. <http://dx.doi.org/10.1037/0021-9010.88.4.760>. [PubMed: 12940414]
- Rimmele U, Hediger K, Heinrichs M, Klaver P. Oxytocin makes a face in memory familiar. *J. Neurosci.* 2009; 29:38–42. <http://dx.doi.org/10.1523/jneurosci.42600-8.2009>. [PubMed: 19129382]
- Rodin. Who is memorable to whom: a study of cognitive disregard. *Soc. Cogn.* 1987; 5:144–165.
- Savaskan E, Ehrhardt R, Schulz A, Walter M, Schachinger H. Post-learning intranasal oxytocin modulates human memory for facial identity. *J. Psyneuen*. 2008; 33:368–374. <http://dx.doi.org/10.1016/j.psyneuen.2007.12.004>.
- Sheng F, Liu Y, Zhou B, Zhou W, Han S. Oxytocin modulates the racial bias in neural responses to others' suffering. *Bio Psycho*. 2013; 92:380–386.
- Shriver ER, Young SG, Hugenberg K, Bernstein MJ, Lanter JR. Class, race, and the face: Social context modulates the Cross-Race Effect in face recognition. *Pers. Soc. Psychol. Bull.* 2008; 34:260–278. <http://dx.doi.org/10.1177/0146167207310455>. [PubMed: 18212334]
- Sporer SL. Recognizing faces of other ethnic groups: an integration of theories. *Psychol. Public Policy Law*. 2001; 7:36–97. <http://dx.doi.org/10.1037/1076-8971.7.136>.

- Stanislaw H, Todorov N. Calculation of signal detection theory measures. *Behav. Res. Methods Instrum. Comput.* 1999; 31:137–149. <http://dx.doi.org/10.3758/BF03207704>. [PubMed: 10495845]
- Steyer, R.; Schwenkmezger, P.; Notz, P.; Eid, M. Der Mehrdimensionale Befindlichkeitsbogen MDBF. Hogrefe, Göttingen; 1997. Retrieved from University of Jena, Professor Steyer's Web site: <http://www.metheval.uni-jena.de/mdbf.php>.
- Susa KJ, Meissner CA, de Heer H. Modeling the role of social-cognitive processes in the recognition of own- and other-race faces. *Soc. Cogn.* 2010; 28:519–533.
- Van IJzendoorn MH, Bakermans-Kranenburg MJ. A sniff of trust: meta-analysis of the effects of intranasal oxytocin administration on face recognition, trust to in-group, and trust to out-group. *J. Psyneuen.* 2012; 37:438–443. <http://dx.doi.org/10.1016/j.psyneuen.2011.07.008>.
- Zak, P. The source of love and prosperity. New York: Penguin Group; 2012. The moral molecule.

Fig. 1.

Experiment 1 (pre-encoding substance intake). Four dependent measures presented as a function of race of face and condition. Errors bars represent standard errors of the means. The principal finding on the d' rate shows the predicted interaction; whereas in the placebo condition the same-race faces were better recognized than other-race faces, in the Oxytocin condition the same- and other-race faces were equally well recognized, effectively eliminating the own-race bias.

Fig. 2.

Experiment 2 (post-encoding substance intake). Four dependent measures presented as a function of face and condition. Errors bars represent standard errors of the means. The principal finding on the d' rate shows a main effect of face but not a significant interaction. This indicates that the typical own-race bias occurred in both treatment conditions and post-encoding OT did not have a significant effect on recognition memory.

Events and Behavioral Tasks:

1. Health questionnaire and BP/Heart Rate reading.
2. Psychological processes questionnaires.
3. Exp 1: OT or Saline administration. Exp 2: Study face stimuli.
4. Exp 1: Study face stimuli. Exp 2: OT or Saline administration.
5. Psychological processes questionnaires.
6. Test of face stimuli.
7. Contact and Knowledge questionnaires.
8. Debrief.

Fig. 3.

Events and behavioral tasks completed in each phase of Experiments 1 and 2.