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The role of oxytocin in implicit personal space regulation: An fMRI study

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ABSTRACT

Personal space, defined as the distance individuals choose to maintain between themselves and others, is an indicator of affiliation and closeness. Most paradigms that measure personal space preferences involve explicit choice and therefore fail to examine the implicit aspects of such preferences. In the current study, we sought to investigate an implicit form of interpersonal space that is more closely related to real-life situations involving affiliation. We studied the effects of oxytocin (OT) on neural networks that involve affiliation and tested the impact on personal space preferences. In a double-blind placebo-controlled study, we asked participants to choose between two rooms that differed only in the distances between two stimuli. The stimuli were either social stimuli (two chairs) or non-social stimuli (table and plant). The behavioral results showed that OT caused participants to choose a closer space in social blocks but did not affect their choices in non-social blocks. Imaging results revealed an interaction between stimulus and treatment (OT/PL) in the dorsal striatum, an area that is related to approach motivation and is part of the reward circuitry. Specifically, OT increased activity in the dorsal striatum in the social blocks and decreased this activity in the non-social blocks. The results of the study strengthen the social salience theory regarding OT, indicating that OT does not uniformly affect all social responses and that context has a determining impact on our behavior.

1. Introduction

Personal space refers to the physical space immediately surrounding us, into which encroachment can feel threatening or uncomfortable. The way in which we maintain our interpersonal space represents a form of nonverbal communication indicting how close we prefer to sit or stand relative to another person. Our interpersonal space preferences can vary depending on situation and context. For example, when we speak to a stranger in public we may choose to maintain a greater distance than when we speak to a close friend (Hall, 1966). Indeed, research has shown that differential space preferences are observed at different levels of relationships. These differential space preferences may signal responsiveness and feelings of comfort, degree of intimacy and degree of safety individuals feel with others (Birtchnell, 1996; Feeney, 1999; Kaitz et al., 2004; Meisels and Guardo, 1969; Roberts, 1997).

Although personal space preferences are a strong predictor of our level of affilation with other individuals, for the most part we determine this space implicitly without being aware that we are doing so. In social situations we interact with familiar and unfamiliar protagonists without being consciously aware of the space we choose to maintain between ourselves and the other. Nonetheless, most research on personal space has focused on explicit forms of personal space regulation (Duke and Nowicki, 1972; Kennedy et al., 2009; Perry et al., 2013; Scheele et al., 2012). The paradigms developed to test interpersonal space preferences require participants to indicate explicitly where they choose to stand relative to another by stopping an approaching protagonist whenever they begin to feel uncomfortable (Duke and Nowicki, 1972; Kennedy et al., 2009; Perry et al., 2013; Scheele et al., 2012). For example, in a seminal study S.M., a patient with bilateral amygdala damage, was asked to indicate explicitly whenever she felt uncomfortable standing in someone else's space (Kennedy et al., 2009). Other paradigms use a similar version of testing the limits of personal space by showing participants pictures or animated figures that appear to grow bigger ("zoom in") or by having participants observe interactions with others in order to simulate an intrusion of personal space (Baldassare and Feller, 1975). Thus, it appears that most available paradigms to date focus on examining participants' responses to explicit threats of intrusion into personal space rather than measuring this space implicitly, as occurs in real-life situations.

Social psychologists using implicit measures of interpersonal space have shown that one's implicit choice of where to sit relative to others may be affected by attachment style (Kaitz et al., 2004) and ingroup-outgroup contexts (e.g., Novelli et al., 2010). Yet because most

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neuroimaging paradigms assessing personal space regulation involved explicit choice of space, it is not surprising that regions related to threat signaling were found to be involved in interpersonal space regulation. Indeed, several studies found the amygdala to be a key brain region for personal space regulation (Kennedy et al., 2009; Scheele et al., 2012).

In addition to its role in threat signaling, personal space regulation also includes the need to be close to another and to feel social connectedness. Thus, paradigms of implicit personal space regulation may induce activity in networks related to social affiliation, social reward and social approach. Personal space regulation may also involve the reward circuitry, including the striatum, the caudate and the dorsal striatum, which are core regions shown to play a major role in social affiliation and social reward (Aron et al., 2005). Therefore, these regions may be relevant to personal space regulation, especially when someone chooses to approach another person. Indeed, studies have posited that the reward system is important in social situations, especially in positive approach behaviors and the processing of emotional information (Critchley et al., 2000). Given the role of the reward circuitry—including the ventral striatum and dorsal striatum—in social reward and approach motivations (Tomer et al., 2014), this circuitry may also mediate personal space regulation.

Research has shown that the neurohormone oxytocin (OT) also plays an important role in regulating the reward circuitry (Dölen et al., 2013; Guastella et al., 2008; Scheele et al., 2013), particularly when social reward is involved (Dölen et al., 2013; Scheele et al., 2013; Liu and Wang, 2003). Scheele et al. (2013) found that intranasal administration of OT regulates the activity of the reward mechanism, including the ventral striatum. OT administration was also found to affect other systems in the brain. For example, OT was found to reduce amygdala responses to fearful faces and threatening scenes in healthy men (Kirsch et al., 2005; Striepens et al., 2012).

Given the role of OT in social reward and affiliation, we hypothesized that OT would also mediate personal space regulation. According to the recent framework for understanding the role of OT in social behavior, the effects of OT are not monolithic but rather depend on context (Bartz et al., 2011). In a situation that involves threat, OT may increase the salience of threat signals, while in contexts involving positive cooperation OT may increase the salience of safety signals (Shamay-Tsoory and Abu-Akel, 2016). Indeed, Scheele et al. (2012) showed that OT intake generally caused participants to choose to maintain greater distances. This effect was especially strong among men who were in exclusive relationships compared to those who were single. Similarly, in a paradigm that involved approaching protagonists, Cohen et al. (2017) showed that OT intake increases the distance maintained between individuals, particularly if they are strangers, and that this effect is mediated by regions that mediate social behavior, including the dorsomedial prefrontal cortex (dmPFC). Thus it appears that in the context of threat OT may increase social space, but when the social context does not involve threat OT may reduce the amount of space individuals need to maintain.

The difference between implicit and explicit processes is evident in various functions. For example, Schuwerk et al. (2015) showed that there are two forms of theory of mind (TOM) abilities—implicit and explicit—and that the behaviors derived from these two forms differ. Other studies reveal differences in implicit and explicit knowledge (Dienes and Perner, 1999). Moreover, neuroimaging studies point to marked differences in neural activation between implicit and explicit processes (Critchley et al., 2000; Voss and Paller, 2008). For example, these processes were found to play differential roles in memory tasks and priming testing. We therefore hypothesized that implicit and explicit personal space preferences may also be mediated by different mechanisms.

The current study used a pharmacological-functional magnetic resonance imaging (fMRI) approach to examine the neural correlates of the effects of OT on personal distance in an implicit task. in a neurofunctional scan performed after administration of OT or placebo (PL): two types of blocks a social stimulus (distance between two chairs) and a non-social stimulus (distance between a table and a plant) were used. The way chairs are positioned in a room may represent the nature of a social relationship (Brand, 2009; Dabbs, 1971; Holland et al., 2004). Therefore, this positioning was considered to be the social stimulus, while the position of the table and plant was considered to be the non-social stimulus. Moreover, chairs are regarded as “social” because they are usually the type of furniture people move when they want to position themselves closer or further away from another person in a room. Indeed, previous studies have shown that the placement and arrangement of chairs in a room may affect social interaction between individuals (e.g., Kéri and Benedek, 2009; Sommer and Ross, 1958). Tables and plants are not likely to be moved in social situations. Therefore, for both types of stimuli participants were instructed to choose between two rooms, thus creating a room in which they would feel most comfortable sitting and discussing personal topics based on the chosen distance between the variables.

We hypothesized that the choice of a smaller space between the chairs in the social condition represents a preference for the social approach, as compared to the choice of a smaller space between table and plant in the non-social condition (hereinafter referred to as the “tables” condition). In addition, according to the social salience hypothesis, OT affects decision-making depending on context. We therefore hypothesized that in a positive intimate context OT would affect personal space preferences differently for social stimuli than for non-social stimuli. We expected that in the social stimuli blocks participants would choose smaller personal spaces more often after OT administration than they would after PL intake. Because the task is implicit and, unlike explicit tasks of personal space, does not involve interaction with another person, we further hypothesized that OT would modulate the activity of the reward system. We reasoned that observation of neutral pleasant rooms should evoke no stress, so that activations within the amygdala should not be expected. With regards to the implicitness of the task, it should be noted that during the debriefing of the experiment we asked participants whether they could guess what the task was about. Finally, given that previous studies (e.g., Cohen et al., 2017) showed that the dorsomedial prefrontal cortex (dmPFC) is activated during explicit personal space regulation following OT administration, we examined whether this region also plays a role in implicit personal space pReferences

2. Methods

2.1. Participants

Twenty-four (male) participants were recruited for the experiment. One participant was removed from the behavioral analysis due to deviating data (outlier of more than three standard deviations), so that a total of 23 participants were analyzed in the behavioral results. One participant was removed from analysis of the scanning data due to head movements exceeding six millimeters. A total of 22 participants were included in the imaging analysis.

The participants ranged in age from 19 to 30 (M = 28.02, SD = 2.69). All participants were fluent in Hebrew, right-handed, and did not report any history of psychiatric or neurological disorders, as confirmed by a screening questionnaire and interview. Participants were asked to refrain from alcohol, nicotine and caffeine during the evening and morning before the scanning.[2] Participants received 200 New Israeli Shekels (approx. $50) for their participation. The study was approved by the Institutional Review Board (IRB) of the Tel-Aviv Sourasky Medical Center and conformed to all ethical guidelines.

[2] All participants were part of an ongoing investigation regarding OT and interpersonal space.