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Effects of oxytocin in humans: Impact on the basic psychological processes of cognition, emotions and behavior. Role for the autonomic functions

P. Angelova[1], E. Petrova[1], T. Vladimirov[1]

[1] *Medical Faculty of Sofia University "St. Kliment Ohridski"*
palmena.angelova@gmail.com

Abstract. *Emotional intelligence enables individuals to be more effective in their personal and social life. The neural structures that support emotional and social intelligence overlap with the structures involved in autonomic functions and decision-making, i.e. ventromedial prefrontal cortex, amygdala and insular regions. Oxytocin (OT) facilitates social bonding by enhancing cognitive control from prefrontal regions to amygdala in order to regulate emotionality. It inhibits excitatory flow from the amygdala to brainstem sites mediating fear response and reduces social anxiety that results in a greater willingness to trust and bond to other people. OT has empathogenic properties and it`s agonists may be a useful therapy in enhancing socially motivated learning and emotional empathy in disorders such as autism and schizophrenia. This neuropeptide may promote mother–infant attachment. OT levels are associated with interactive synchrony between parent and child and appear to play an important role in promoting responsive parental caregiving. Increased values of heart rate variability (HRV) are associated with positive emotions such as cheerfulness and tranquility. Heart rate variability is a reliable indicator of the psychological background, of approach-related motivation and hence of the autonomic nervous system balance.*

Key words: oxytocin, prosocial behavior, anxiety, heart rate variability.

Background

Emotional intelligence is a type of social intelligence that determines the capacity of a person for creating sustainable and flexible social relationships. The main features of emotional intelligence are the following: the ability to be aware of one's own emotions and to express them, to be aware of others' feelings and to establish interpersonal relationships, to manage and regulate emotions, to cope with the immediate situations and solve problems of a personal and interpersonal nature and to generate positive affect in order to be sufficiently self-motivated to achieve personal goals (Salovey, P., Mayer, J.D., 1990). Emotional intelligence enables individuals to cope with daily demands and be more effective in their personal and social life (Mayer, J., Salovey, P., 1993). Emotional intelligence marks the intersection between two fundamental components of personality: the cognitive and the emotional systems. Together with cognitive intelligence, emotional and social intelligence form important components of general intelligence. One of the major differences between the two is that the former is thought to relate primarily to higher order mental processes like reasoning, while the latter focuses more on perceiving, immediate processing and applying emotional and social content. Cognitive intelligence is more cortically based, while emotional and social intelligence involve the limbic system for immediate behavior suited for survival and adaptation (Bar-On, R., 2001: 82-97).

The neural systems that support emotional and social intelligence overlap with the structures subserving autonomic activation and decision-making, i.e. ventromedial prefrontal cortex (VM), amygdala and insular regions. Two of the most important emotional intelligence competencies – self-regard (accurate self-awareness) and assertiveness (self-expression) are affected by brain injury in this neural circuitry. Patients with lesions to the VM prefrontal cortex manifest some autonomic disbalance and tend to exercise poor judgment in decision-making, which is displayed in the disadvantageous choices they make in their personal lives and in the ways in which they relate with others. There are a number of alterations of emotional experience, social functioning (Bechara, A., Tranel, D., Damasio, A.R., 2000: 192-214) and the ability to effectively cope with daily demands in these patients. Furthermore, lesions to the amygdala or insular cortices, especially on the right side, also compromise the same functions.

The process of judgment and decision-making depends on systems involved in: memory, which is supported by high-order association cortices as well as the dorsolateral prefrontal cortex; emotions, which are mediated by subcortical limbic structures and feelings which are supported by limbic system as well as the insula, surrounding parietal cortices and the cingulate cortex. Therefore, damage to the systems that impact emotions, feelings or memory usually compromise the ability to make advantageous decisions (Bar-On, R., Fund, S., Handley, R., 2003). The VM prefrontal cortex links these systems together. To perform well and be successful in one's professional and personal life apparently requires the ability to make emotionally and socially intelligent decisions more than just having a high IQ. One of the factors determining the emotional intelligence and the psychological state of humans is oxytocin that is the subject of our review.

Oxytocin receptors in the brain structures and in the periphery tissues

Oxytocin (OT) is a neuropeptide that is produced in the structures of the hypothalamus. It has many central effects mediated by the receptors in the brain and peripheral effects on the target organs.

The OT receptors are widely distributed in brain regions implicated in cognition and emotion (Hein, G., Singer, T., 2008) as well as in several central autonomic nuclei, including the dorsal motor nucleus of the vagus, nucleus ambiguus and nucleus tractus solitarius (Higa, K.T., Mori, E., Viani, F.F., Morris, M., Michelini, L.C., 2002). OT may also impact the autonomic control through its influence on neural structures such as the amygdala – a structure expressing high-density OT receptors (Tribollet, E., Dubois-Dauphin, M., Dreifuss, J.J., Barberis C., Jard, S., 1992) and orchestrating complex autonomic functions (Davis, M., Whalen, P., 2001).

The amygdala is referred to as a neural hub because of its high degree of connectivity, which is critical for the flow and integration of information between regions (Pessoa, L., 2008). It is strongly connected with other brain regions involved in emotional processing such as the orbitofrontal cortex (OFC), the supra- and subgenual parts of the anterior cingulate cortex (ACC), the brainstem and the thalamus (Pessoa, L., 2008). Several studies have shown that modulating amygdala activity can shift neural output towards other brain regions within this network. For example, Kirsch et al. (Kirsch, P., Esslinger, C., Chen, Q., Mier, D., Lis, S., Siddhanti, S., Gruppe, H., Mattay, VS., Gallhofer, B., Meyer-Lindenberg, A., 2005) established that OT reduces amygdala-brainstem coupling that is important for fear and arousal. Van Wingen et al. (van Wingen, G., Mattern, C., Verkes, R.J., Buitelaar, J., Fernández, G., 2010) showed that OFC-amygdala coupling was reduced after testosterone administration. The OFC is involved in reward and hedonic processing (Kringelbach, ML, Lehtonen, A., Squire, S., Harvey, A.G., Craske, M.G., Holliday, I.E., Green, A.L., Aziz, T.Z., Hansen, P.C., Cornelissen, P.L., Stein, A., 2008).

OT receptors have been identified in cardiac tissue (Jankowski, M., Danalache, B., Wang, D., Bhat, P., Hajjar, F., et al., 2004) , allowing a direct site of action for this peptide to regulate cardiac function.

Less well appreciated is the production of OT in the body, namely in the gastrointestinal tract, heart, testes, uterus, corpus luteum, placenta and amnion. OT is also present in the kidney, pancreas, thymus and in adipocytes (Kiss, A., Mikkelsen, J.D., 2005).

When human subjects receive social stimuli, this causes reactions in the heart and the gut that may themselves contribute to OT plasma levels (Yu Q, Ji R, Gao X, Fu J, Guo W, Song X, Zhao X, Burnstock, G., Shi X, He C, Xiang, Z., 2011). Visceral signals are picked up by the afferent branches of the vagus nerve and other visceral afferents and are registered as emotional signals in the brain. The motor vagus may then respond with signals to the viscera. Moreover, both OT and vasopressin hormones are released in the brain following vagal stimulation (McEwen, B.B., 2004).

Expression of OT and its receptors in the brain and in the periphery is upregulated by high levels of estrogen in combination with progesterone withdrawal(Numan, M.; Insel, T.R., 2003).

Effects of oxytocin on integrative brain functions and its role for the psychological health

The fundamental ability to form attachment is indispensable for human social relationships. Attachment security is characterized as the individuals' confidence to rely on attachment figures to achieve care, safety and protection and, when alone, to have access to internalized attachment relationships. Attachment insecurity contributes to a wide spectrum of mental disorders (Maunder, R.G., Hunter, J.J., 2001).

The intranasal application of OT enhances cooperation in response to social cues (Declerck, C.H., Boone, C., Kiyonari, T., 2010), facial emotion recognition (Marsh, A.A., Yu HH, Pine, D.S., Blair, R.J., 2009), eye gaze (Gamer, M., Zurowski, B., Büchel, C., 2010), trust (Baumgartner, T., Heinrichs, M., Vonlanthen, A., Fischbacher, U., Fehr, E., 2008) and attachment, but appears to reduce some aspects of cognitive functioning, such as recall performance (Heinrichs, M., Baumgartner, T., Kirschbaum, C., Ehlert, U., 2003) and memory storage (Bruins, J., Hijman, R., Van Ree, J.M., 1992). Other studies have demonstrated that OT enhances perception and processing of positive social cues (Unkelbach, C., Guastella, A.J., Forgas, J.P., 2008) and sensitivity to biological (but not non-biological) motion(Kéri, S., Benedek, G., 2009). The middle temporal gyrus and precuneus are part of a network involved in the perception of speech and prosody and in aspects of social cognition such as mentalizing and emotion understanding (Leitman, D.I., Loughead, J., Wolf, D.H., Ruparel, K., Kohler, C.G., Elliott, M.A., Bilker, W.B., Gur, R.E., Gur, R.C., 2008) . Pessoa (Pessoa, L., 2008) suggested that the high degree of connectivity between the amygdala and other regions involved in emotional processing might contribute to the integration of emotion and cognition and the evaluation of sensory information. OT might facilitate evaluation of and responding to emotional stimuli by modulating neural connectivity. This is supported by a study of Gamer et al. (Gamer, M., Zurowski, B., Büchel, C., 2010), who showed that OT increased functional coupling between the amygdala and the superior colliculus as well as gaze changes towards the eyes of an emotional stranger in order to recognize its emotions.

The "reading the mind in the eyes" test (RMET) requires subjects to infer internal emotional state of another individual from subtle differences in the eyes and it activates the amygdala. Eye gaze monitoring is amygdala dependent (Adolphs, R., Tranel, D., Buchanan, T.W., 2005). OT increases the amount of time looking at the eyes in faces(Guastella, A.J., Mitchell, P.B., Dadds, M.R.., 2008) and this may contribute indirectly to improved performance on the RMET.

Frontal asymmetries assessed by the EEG activity of both hemispheres reflect a general tendency for approach versus withdrawal, with greater left activity reflecting greater approach motivation and greater right activity reflecting greater withdrawal motivation (Huffmeijer, R., Alink, L.R., Tops, M., Bakermans-Kranenburg, M.J., van IJzendoorn, M.H., 2012). Dorsolateral prefrontal cortex is involved in the processing of reward-related information in goal-directed behavior. Differential effects of positive and negative emotional stimuli both on left and right dorsolateral prefrontal brain activity and on working memory performance, point toward the integration of cognitive and emotional material in this brain region (Herrington, J.D., Mohanty, A, Koven, N.S., Fisher, J.E., Stewart, J.L., Banich, M.T., Webb, A.G., Miller, G.A, Heller, W., 2005) . The lateral prefrontal areas influence the approach–withdrawal motivation. It was recently argued that increasing approach motivation may be one of the mechanisms through which OT achieves its prosocial effects (Kemp, A. H., Bos, P.A., Panksepp, J., Bluthe, R-M, Honk, J.V., 2011). Substantial evidence implicates OT in facilitating human bonding and trust. OT may influence the very core mechanisms of belief formation (Rubin, L.H., Carter, C.S., Drogos, L., Pournajafi-Nazarloo, H., Sweeney, J.A., Maki, P.M., 2010). Bos et al. (Bos, P.A., Panksepp, J., Bluthe, R-M, Honk, J.V., 2011) suggested that OT facilitates social bonding by enhancing cognitive control from prefrontal regions to regulate emotionality, as well as by its effects on the experience of reward during social interaction.

It has been claimed to have both promnestic (Guastella, A.J., Mitchell, P.B., Mathews, F., 2008) and amnestic (Heinrichs, M., Meinlschmidt, G., Wippich, W., Ehlert, U., 2004) effects. One hypothesis reconciling these contradictory findings is that OT may specifically promote learning that is socially reinforced.

OT enhances inference of emotional states as well as generosity toward others (Zak, P.J., Stanton, A.A., Ahmadi, S., 2007), suggesting that OT has empathogenic properties and could influence behavior in the context of social bonding. Furthermore studies have shown that OT reduces both social anxiety and amygdala responses to fearful faces (Kirsch, P., Esslinger, C., Chen, Q., Mier, D., Lis, S., Siddhanti, S., Gruppe, H., Mattay, V.S., Gallhofer, B., Meyer-Lindenberg, A., 2005), implying an inhibitory effect of OT on the amygdala responsivity and in turn a greater willingness to trust and bond to other people.

OT facilitates social recognition memory. This confirms that social reinforcement of learning is important. Studies reporting amnestic effects of OT (Heinrichs, M., Meinlschmidt, G., Wippich, W., Ehlert, U., 2004) often involve highly aversive and stressful experimental contexts. It is possible that OT may facilitate amygdala activity under positive, prosocial and empathy-provoking conditions and inhibit it under more aversive and stressful conditions where stimuli are avoided (Petrovic, P., Kalisch, R., Singer, T., Dolan, R.J., 2008).

People with damaged amygdala were not compromised in cognitive empathy, but showed an impairment in emotional empathy. They seem quite capable of identifying facial emotions by cognitive strategies, but are impaired in processing and responding to the emotional consequences of this recognition (Hurlemann, R., Patin, A., Onur, O.A., Cohen, M.X., Baumgartner, T., Metzler, S., Dziobek, I., Gallinat, J., Wagner, M., Maier, W., Kendrick, K.M., 2010).

One critical question is whether OT effects on social behavior reflect its influences on specialized high-order social cognitive processes (e.g. trust, generosity, suspiciousness, mentalizing) or on underlying states and inclinations (e.g. general anxiety, affiliative motivation, global saliency of social cues). After intranasal OT administration, humans display more trust in economic game involving allocating money to a stranger (Kosfeld, M., Heinrichs, M., Zak, P.J., Fischbacher, U., Fehr, E., 2005), receive higher “mind-reading” scores in a task that involves interpreting strangers’ eyes and show more in-group favoritism and ethnocentrism (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). All these effects involve high-order psychological processes ("trust", "mentalizing", "cooperation") and hence OT selectively targets circuitry involved in sophisticated social-cognitive computations (Churchland, P.S., Winkielman, P., 2012).

The emotional empathy intensity ratings of the women were considerably higher than those of the men and only when the men received OT treatment did they become equivalent to untreated women. This fact may reflect enhanced release of OT in women as compared with men.

OTR agonist may be a useful therapy in enhancing socially motivated learning and emotional empathy in men. Hurleman (Hurlemann, R., Patin, A., Onur, O.A., Cohen, M.X., Baumgartner, T., Metzler, S., Dziobek, I., Gallinat J., Wagner, M., Maier, W., Kendrick, K.M., 2010) shows that OT treatment has rather minor effects in improving cognitive empathy. Augmenting the effectiveness of socially reinforced learning and levels of emotional empathy could, however, benefit the treatment of a number of disorders in which social emotional responsivity is aberrant, such as autism, schizophrenia (Derntl, B., Finkelmeyer, A., Toygar, T.K., Hülsmann, A., Schneider, F., Falkenberg, D.I., Habel, U., 2009) and psychopathy.

The oxytocin anxyolitic and prosocial effects

Social stressors and the absence of positive social interactions have been associated with several detrimental consequences, including disrupted mood and emotion, increased reactivity of the hypothalamic-pituitary-adrenal (HPA) axis, autonomic imbalance and central nervous system dysfunction (Norman, G.J., Cacioppo, J.T., Morris, J.S., Malarkey, W.B., Berntson, G.G., Devries, A.C., 2011). Previous evidence suggests that negative social experiences may mediate the development and maintenance of affective disorders and cardiovascular diseases (Grippo, A.J., Trahanas, D.M., Zimmerman, R.R. 2nd, Porges, S.W., Carter, C.S., 2009). In humans feelings of loneliness are associated with behavioral and cardiovascular alterations including increased ratings of hopelessness, reduced self-esteem and increased diastolic blood pressure (Steptoe, A., Owen, N., Kunz-Ebrecht, S.R., Brydon, L., 2004). The neurohormones OT, vasopressin and corticotropin-releasing hormone (CRH) play an important role in these associations(Pierrehumbert, B., Torrisi, R., Laufer, D., Halfon, O., Ansermet, F, Beck Popovic, M., 2010). Increased hypothalamic CRH, circulating cortisol, hypothalamic vasopressin and central and circulating OT levels have been observed in praire voles after exposure to short- or long-term social stressors (Ruscio, M.G., Sweeny, T., Hazelton, J., Suppatkul, P., Sue Carter, C., 2007).

Exogenous OT may have the capacity to decrease CRH during chronic stress and to down-regulate the HPA axis and HR responses in humans (Heinrichs, M., Baumgartner, T., Kirschbaum, C., Ehlert, U., 2003).

Both complex social behavior and basic emotional processing functions such as anxiety and fear extinction critically depend on the amygdala. The lateral nucleus of the amygdala receives and integrates sensory, prefrontal and limbic inputs and excites neurons in the central nucleus that evoke fear responses via their projections to brainstem regions including periaqueductal gray and reticular formation (LeDoux, J.E., 2000). In humans fearful faces potently activate the amygdala and lesions of the amygdala impair their recognition which leads to social disinhibition (Salovey, P., Mayer, J.D., 1990).

Any social inference and especially positive inference depends on the subject's willingness to engage in social interaction and this willingness is anxiety-sensitive. Trust studies reveal the general mechanisms of anxiety down-regulation, mediated by the amygdala (Baumgartner, T., Heinrichs, M., Vonlanthen, A., Fischbacher, U., Fehr, E., 2008). Other recent works also suggest that complex mental state inferences in the mind-in-the-eye tasks depend on the general willingness to look into strangers' eyes, which in turn is anxiety-dependent (Evans, S., Shergill, S.S., Averbeck, B.B., 2010).

Looking at pictures of significant others showed marked overlap with regions that show high densities of OT receptors (e.g. striatum) (Bartels, A., Zeki, S., 2004). Interestingly, intranasal OT has been shown to attenuate amygdala responses to social stimuli (emotional faces), suggesting a key role of OT in reducing the uncertainty about the predictive value of social stimuli (Domes, G., Heinrichs, M., Gläscher, J., Büchel, C., Braus, D.F., Herpertz, S.C., 2007).

OT acts on the amygdala to reduce fear and modulate aggression (Bosch, O.J., Meddle, S.L., Beiderbeck, D.I., Douglas, A.J., Neumann, I.D., 2005). It acts on the central amygdala to inhibit excitatory flow from the amygdala to brainstem sites mediating fear response (Kirsch, P., Esslinger, C., Chen Q, Mier, D., Lis, S., Siddhanti, S., Gruppe, H., Mattay, V.S., Gallhofe,r B., Meyer-Lindenberg, A., 2005). Autonomic response to aversive pictures has been reported to be reduced under OT (Pitman, R.K., Orr, S.P, Lasko, N.B., 1993), compatible with the effect on amygdala activation. In autism, in which plasma OT is reduced, abnormal amygdala activation occurs during the face processing (Dalton, K.M., Nacewicz, B.M., Johnstone, T., Schaefer, H.S., Gernsbacher, M.A., Goldsmith, H.H., Alexander, A.L., Davidson, R.J., 2005). Most likely anxiolytic effects of OT reflect a complex interaction of central and peripheral mechanisms.

The role of oxytocin in parenting and family interactions

OT is released during key pair-bonding events like sexual climax or childbirth. Its levels at early pregnancy and the postpartum period are related to a clearly defined set of maternal bonding behaviors. Plasma OT concentrations measured during early pregnancy and one month after delivery predict positive and adaptive maternal behaviors, such as affectionate touch, motherese vocalization and mother-to-infant gaze (Feldman, R., Weller, A., Zagoory-Sharon, O., Levine, A., 2007). They are also related to the mother's own adult attachment capacity (Strathearn, L., Fonagy, P., Amico, J., Montague, P .R., 2009). A further study has shown that OT levels are associated with interactive synchrony between parent and child (Feldman, R., Gordon, I., Zagoory-Sharon, O., 2011). OT therefore appears to play an important role in promoting responsive parental caregiving. In addition, OT levels were also associated with bonding to one's own parents in young adults (Gordon, I., Zagoory-Sharon, O., Schneiderman, I., Leckman, J.F., Weller, A., Feldman, R., 2008).

Mothers who showed an increased OT response when interacting with their infant rated themselves as being more sensitive of moods, emotions and physical sensations, but less compulsive, schedule driven and task oriented (Kéri, S., Benedek, G., 2009). OT is only one of several neuroendocrine systems – such as vasopressin, dopamine and prolactin – which may contribute to parenting behaviors (Swain, J.E., Lorberbaum, J.P., Kose, S., Strathearn, L., 2007). Dopamine plays a role in reward signaling and reinforcement learning and OT appears to interact with the mesocorticolimbic dopamine system to reinforce maternal caregiving in response to infant cues. One model of adult attachment proposes that secure attachment is based on an integration of both affective and cognitive information processing in the brain. Optimal maternal caregiving responses may involve both sensitive attunement to infant cues, via OT-mediated mechanisms, and decision making and planning to meet the temporal needs of a family, as mediated by the nigrostriatal dopaminergic system (Strathearn, L., 2011).

New mothers who are more cognitively focused on task performance and executing plans may be less responsive to their infants' affective cues. "Orienting sensitivity" refers to one's responsiveness to sensory cues, moods and emotions. During the stages of pregnancy, childbirth and breastfeeding, new mothers gradually learn to relinquish control of their external environment, while attending more to internal sensory cues from their own body (such as during labor and delivery) and then from their new infant (such as during breastfeeding). Maternal OT response during interactive mother–infant play appears to be positively associated with this important capacity.

Endogenous opioids also affect maternal attachment to infants, including maintenance of contact, grooming and responses to separation.

OT has anxiolytic and stress-reducing effects in breastfeeding mothers and this might increase mothers' sensitivity to infant signals including infant crying but also infant smiling and laughing. Taylor (Taylor, S.E., Gonzaga, G.C., Klein, L.C., Hu, P., Greendale, G.A., 2006) also suggested that OT modulates stress responses and is implicated in the seeking of affiliative contact in response to stress. Riem et al. (Riem, M.M., van IJzendoorn, M.H., Tops, M., Boksem, M.A., Rombouts, S.A., Bakermans-Kranenburg, M.J., 2012) found that OT reduces amygdala responses to infant laughter and crying, whereas it increases activation of the insula and inferior frontal gyrus (IFG), brain regions important for empathy, emotion understanding and maternal bonding. The OFC exhibits a specific neural response to infant stimuli (Kringelbach, M.L., Lehtonen, A., Squire, S., Harvey, A.G., Craske, M.G., Holliday I.E., Green, A.L., Aziz ,T.Z., Hansen, P.C., Cornelissen, P.L., Stein A., 2008). Strathearn et al. (Strathearn, L., Fonagy, P., Amico, J., Montague, P.R., 2009) found that mothers with a strong increase in peripheral OT release while interacting with their infants show more activation in neural reward systems, such as the OFC and the ventral striatum, during the perception of their smiling infant than mothers with lower OT levels.

OT increases functional connectivity between the amygdala and neural reward regions, the OFC and the caudal ACC (Riem, M.M., van IJzendoorn, M.H., Tops, M., Boksem, M.A., Rombouts, S.A., Bakermans-Kranenburg, M.J., 2012). These centers are important for emotional regulation, in particular for the reduction of anxiety, by their inhibitory influence on the amygdala. Increased functional connectivity between the OFC, ACC and amygdala may promote mother–infant attachment by enhancing cognitive control over negative emotionality and at the same time increasing the incentive salience of infant laughter (Bos, P.A., Panksepp, J., Bluthe, R-M, Honk, J.V., 2011).

OT also enhances the functional connectivity between the amygdala and the hippocampus, middle temporal gyrus and precuneus during infant laughter (Riem, M.M., van IJzendoorn, M.H., Tops, M., Boksem, M.A., Rombouts, S.A., Bakermans-Kranenburg, M.J., 2012) . Amygdala-hippocampus interactions are crucial for emotional memory, an important factor in parenting (Guastella, A.J., Mitchell, P.B., Mathews, F., 2008).

Feldman et al. (Feldman, R., Gordon, I., Schneiderman, I., Weisman, O., Zagoory-Sharon, O., 2010) showed that fathers with high levels of OT displayed more stimulatory contact during play with their child. In a complementary study, Naber et al. (Naber, F., van Ijzendoorn, M.H., Deschamps, P., van Engeland, H., Bakermans-Kranenburg, M.J., 2010) found that intranasally administered OT enhances paternal playful interaction.

Oxytocin and the autonomic functions. Application of the heart rate variability method

The polyvagal theory focuses on the phylogenetic shift from reptiles to mammals involving specific changes to the vagal pathways regulating the heart (Porges, S.W., 2009). Only mammals have a myelinated vagus – originating from the nucleus ambiguus – and through the process of evolution, the brainstem nuclei became integrated with the mimic muscles of the face and head that express facial emotions. The polyvagal theory proposes an automatic, subcortical mechanism – neuroception – that is capable of identifying environmental and visceral features that are safe, dangerous or life-threatening. Neuroception is triggered by feature detectors in the temporal cortex, which respond to voice prosody, facial expressions and hand movements. OT may serve to increase ones sensitivity to such cues. Neuroception may also be triggered by afferent feedback from the viscera. This visceral feedback represents a major factor for the extent to which social engagement will take place.

There exists an important distinction between approach-motivated states that increase capacity for action versus a quiescent state associated with positive feelings of warmth and calm in which motivation to act is absent (McCall, C., Singer, T., 2012). Approach motivation would be associated with increased sympathetic activity, while quiescence would be associated with parasympathetic activity.

OT has a key role in the regulation of approach- and withdrawal-related social behaviors. It increases one's capacity for approach-related motivation but this capacity need not be a conscious process. While social behavior is associated with the motivation to approach or withdraw, this motivation may not always lead to overt, observable behavior. OT may upregulate parasympathetic and/or reduce sympathoadrenal responses through a number of mechanisms. One candidate psychophysiological marker of approach-related motivation is heart rate variability (HRV) that is the variability in consecutive heartbeats. Reduced HRV is associated with an increased risk of cardiovascular disease and sudden cardiac death (Thayer, J.F., Yamamoto, S.S., Brosschot, J.F., 2010).

Increased values of HRV are associated with positive emotions such as cheerfulness and calmness (Geisler, F.C.M., Vennewald, N., Kubiak, T., Weber, H., 2010), thus highlighting the specific role of HRV as indicator of social engagement. Reductions in HRV are displayed in unmedicated patients with depression and anxiety disorders characterized by reductions in approach and increases in withdrawal-related behaviors (Kemp, A.H., Quintana, D.S., Felmingham, K.L., Matthews, S., Jelinek, H.F., 2012) and compromised capacity to detect positive social cues and engage with others. OT and its receptors are present in cardiac tissue (Jankowski, M., Danalache, B., Wang, D., Bhat, P., Hajjar, F., et al., 2004). It alters cardiovascular reactivity via its actions on the heart itself, but also centrally – via nucleus of the solitary tract (NTS), which integrates and relays incoming peripheral visceral inputs with central influences (Norman, G.J., Cacioppo, J.T., Morris, J.S., Malarkey, W.B., Berntson, G.G., Devries, A.C., 2011).

Exogenous OT administration to isolated prairie voles prevented several detrimental cardiac consequences of depression including altered HR and HR variability and autonomic imbalance (Grippo, A.J., Trahanas, D.M., Zimmerman, R.R. 2nd, Porges, S.W., Carter, C.S., 2009). OT increases HRV (Kemp, A.H., Quintana, D.S., Felmingham, K.L., Matthews, S., Jelinek, H.F., 2012) and high frequency (HF) – HRV (reflecting the parasympathetic activity) while participants are engaged in a variety of non-stressful activities. That leads to increased flexibility and adaptiveness to the environment. Attentional demand decreases HRV (Marsh, A.A., Yu H.H., Pine, D.S., Blair, R.J., 2009) and OT may either attenuate or reverse these effects.

Oxytocin affects psychological health through interactions with the brain structures involved in cognitive functions, emotional processing and behavioral disposition. The integrative brain centers are connected with the subcortical autonomic centers – the amygdala and the brainstem nuclei of the cranial nerves, which, in turn, control the physiological processes of the organs. The higher and lower brain structures interact with various endocrine factors and determine the somatic state. This sophisticated system could be easily evaluated by means of the heart rate variability method. HRV is an indicator of the psychological state and of the psychosomatic effects on organs mediated via the autonomic nerve system.

(Marsh, A.A., Yu H.H., Pine, D.S., Blair, R.J. 2009)

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Ефекти на окситоцина върху когнитивните процеси, емоциите, поведението и върху вегетативните функции при хора

Палмена Ангелова, Екатерина Петрова, Тим Владимиров

Резюме. *Емоционалната интелигентност е от значение за функционирането на личностно и социално ниво. Нервните структури, които определят емоционалната и социална интелигентност, участват също в регулацията на вегетативните функции и в някои когнитивни процеси като вземането на решения. Това са вентромедиалната префронтална кора, амигдалата и инсуларната кора. Окситоцинът улеснява създаването на социални връзки, като усилва контрола от префронталната кора върху амигдалата. По този начин се потенцира когнитивният контрол върху емоционалните реакции. Окситоцинът подтиска и възбудните влияния от амигдалата към мозъчния ствол, като намалява реакциите на страх, тревожността в социална среда и усилва доверието към другите хора. Свързан е с проявите на емпатия и социално мотивираното обучение, поради което може да подпомогне лечението на заболявания като аутизъм и шизофрения. Участва в създаването на емоционалната връзка между майката и бебето и на отговорното родителско поведение. Повишените стойности на вариабилността на сърдечната честота са свързани с наличието на позитивни емоции като щастие и спокойствие. Вариабилността на сърдечната честота е надежден показател за базалното психоемоционално състояние, за просоциалната нагласа и за вегетативния баланс.*

***Ключови думи*:** окситоцин, просоциално поведение, тревожност, вариабилност на сърдечната честота.

Палмена Ангелова – доктор, магистър – лекар, главен асистент в катедра „Физиология и патофизиология“ в Медицински Факултет на Софийски Университет “Св. Климент Охридски”. Защитила дисертация на тема „Влияние на физическите натоварвания върху скоростта на провеждане на възбуждането по мускулните влакна“ при НСА „Васил Левски“ със съдействието на Института по биофизика при БАН. Научните интереси са в областите: спортна физиология, нервно-мускулна физиология, мускулна умора, вегетативна сърдечна регулация, вегетативна дистония, ендокринна регулация, психосоматични явления, психоемоционален стрес.

Palmena Angelova – Ph. D., MD. The dissertation “Impact of physical training on muscle fiber conduction velocity” has been accomplished at the National Sports Academy “Vassil Levski” in collaboration with the Institut of Biophysics – BAS. Her research interests are focused on sports physiology, neuro-muscular physiology, muscle fatigue, vegetative regulation of the heart, vegetative dystonia, endocrine regulation, psychosomatic events, psychoemotional stress.

Екатерина Петрова – студент по медицина. Научни интереси в областта на ендокринната и вегетативна регулация, стреса, психосоматичните явления, сърдечно-съдовата адаптация.

Ekaterina Petrova – medical student. Research interests in the field of endocrine and vegetative regulation, stress, psychosomatic events, cardio-vascular adaptation.

Тим Владимиров – студент по медицина. Научни интереси в областта на вегетативна регулация, стреса, психосоматичните явления, сърдечно-съдовата адаптация, вирусологията.

Tim Vladimirov – medical student. Research interests in the field of endocrine and vegetative regulation, stress, psychosomatic events, cardio-vascular adaptation.