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Effect of arousal on perception as studied through the lens of the motor correlates of sexual arousal

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Abstract: Sexual arousal's study is at the interface of affective and social neurosciences. Recent results regarding the motor correlates of sexual arousal demonstrating an early freezing response are in perfect accordance with the GANE model sustaining the double role of the arousal dimension on emotional processing.

During the last decades, sexual affiliation has been an exponentially explored functional context within socioaffective neuroscience, especially to explore the motivational component of *inter-attraction, which* can be either positive or negative within social relationships. As appearing in international databases, sexual visual stimuli are often reported as the most arousing stimuli and are there ideal to increase knowledge about the influence of the arousal dimension on the neural (central and peripheral) and psychological correlates of emotional information processing which is at the center of the theory presented in the target paper. Here, we focus on recent results regarding the motor correlates of visual sexual information corroborating the complex modulatory role of arousal as developed in the GANE theory.

Within the framework of sexual behavior, emotion can be partly conceptualized as an action-disposition characterized by a context-dependent (e.g. approach *vs* avoidance)

behavioral component, which may be and mediated by automatic responses (Campbell et al., 1997; Panksepp and Biven, 2012). In that sense, emotion should influence several steps of the motor response (Bradley et al., 1992; H_lbig et al., 2011; Williams et al., 1996) by inducing an *approach-behavior* to what promotes our well-being and our survival and an *avoidance-behavior* in response to painful experiences (Elliot and Covington, 2001). Albeit recent, most neuroimaging studies of sexual arousal made central in their theorethical model a motivational component. Several incentive motivation theories state that approach behavior is activated by appropriate incentives (Agmo, 1999; Bindra, 1974; Singer and Toates, 1987. This theoretical framework is supported by recent results showing in sexual condition increased behavioral responsiveness and interest (Both et al., 2004) as well as increased spinal tendon reflexes linearly with the arousal's level of the stimuli (Both et al., 2005).

Posture is a good index of motor correlates of emotional information processing and can be quantified by determining the body's Center Of Pressure's (COP ; Gurfinkel, 1973) displacements. Previous studies demonstrated the influence of emotion on decision-making processes (Damasio et al., 1996) through an emotional biasing of action selection, which might indicate the functioning of a Pavlovian system that innately regulates specified responses to reward - or punishment predictive stimuli (Ly et al., 2014). This is supported by numerous studies reporting respectively a behavioral activation *vs* inhibition in response to reward *vs* punishment (Guitart-Masip et al., 2011, 2012, 2014; Crockett et al., 2009; Cavanagh et al., 2013).

Contrary the primary hypothesis of an approach-type behavior, our recent study (Mouras et al., 2015) demonstrated a freezing-type response in response to sexually explicit stimuli (Figure 1).

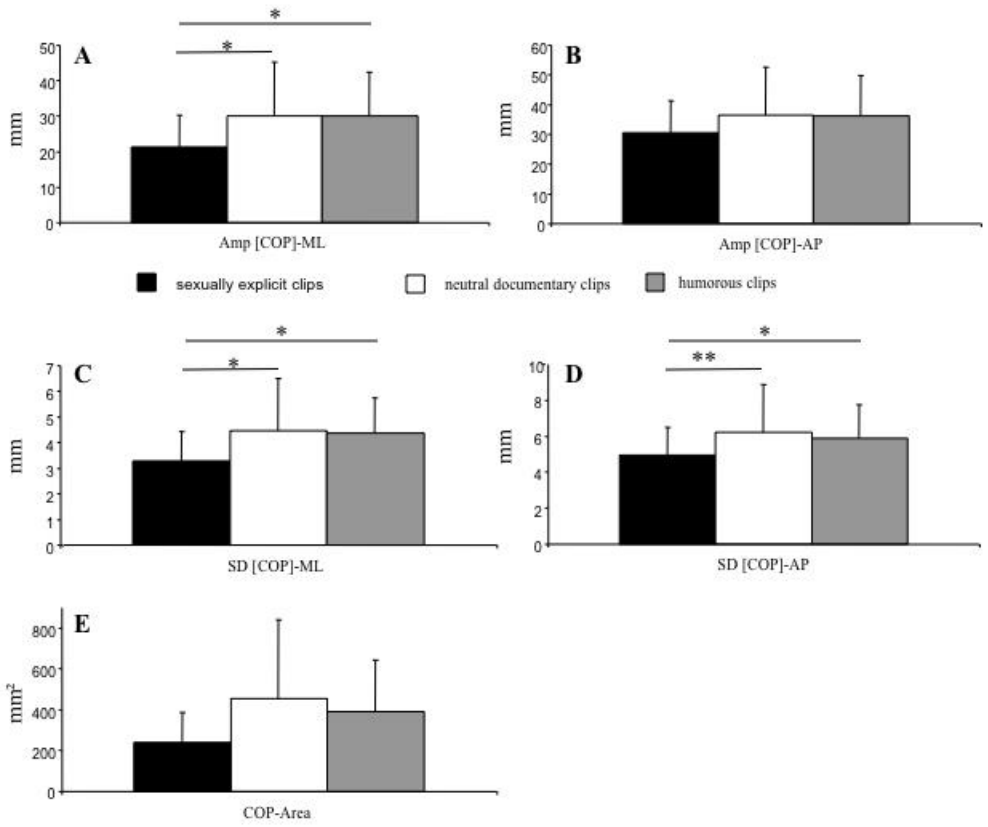

Figure 1: Mean-SD for postural indices as a function of the stimulus (A) Amplitude of the sway of the COP in the mediolateral direction (Amp [COP]-ML) (B) Amplitude of the sway of the COP in the anteroposterior direction (Amp [COP]-AP) (C) Standard displacement of the COP in the mediolateral direction (SD [COP]-ML) (D) Standard displacement of the COP in the anteroposterior direction (SD [COP]-AP) (E) Area encompassed by displacements of the COP (COP-Area) Significant differences are indicated as follows: * $p < 0.05$, ** $p<0.01$ when comparing stimulus. Figure from Mouras et al. (2015).

These results were quite surprising and in accordance with the GANE theory interpreting the effect of arousal on perception and memory. Previous studies reported a freezing strategy in response to aversive visual images (Facchinetti et al., 2006; Stins and

Beek, 2007; Hillman et al., 2004) or a defense-type response to unpleasant compared to both pleasant and neutral videos (Hagenaars et al., 2014b). Interestingly, Horslen and Carpenter (2011) argued that arousal only modulated the freezing strategy and Hagenaars et al. (2014a) report that freezing (i) is usually considered as a threat-related defense strategy; (ii) could be similar to immobility occurring in orienting or behavioral inhibition. The temporal dimension of the motor correlates may be central as demonstrated by an early (1-2 s after stimulus onset) freezing behavior in response to unpleasant films (Hagenaars et al., 2014a) that would be associated with an optimal body's position for concealment from the predator (McNaughton and Corr, 2004). Therefore, sexual arousal could be partly associated not only with positive emotions but also with a certain anxiety in accordance with a freezing response to angry faces and related to anxiety (Roelofs et al., 2010). Facchinetti et al. (2006) reported that body sway reductions were observed in response to both unpleasant and pleasant pictures and suggested that " baby and family pictures may have elicited (for subjects) a predisposition to social bonding and that the pre-activation of muscles involved in the anterior-posterior displacement could reflect preparation for processes like attachment and reduction of social distance".

References

Agmo, A. (1999). Sexual motivation: an inquiry into events determining the occurrence of sexual behavior. *Behavioural Brain Research*, 105(1):129–150.

Bindra, D. (1974). A motivational view of learning, performance, and behavior modification. *Psychological review*, 81(3):199.

Both, S., Boxtel, G., Stekelenburg, J., Everaerd, W., and Laan, E. (2005). Modulation of spinal reflexes by sexual films of increasing intensity. *Psychophysiology*, 42(6):726–731.

Both, S., Spiering, M., Everaerd, W., and Laan, E. (2004). Sexual behavior and responsiveness to sexual stimuli following laboratory-induced sexual arousal. *Journal of Sex Research*, 41(3):242–258.

Bradley, M. M., Greenwald, M. K., Petry, M. C., and Lang, P. J. (1992). Remembering pictures: pleasure and arousal in memory. *J Exp Psychol Learn Mem Cogn*, 18(2):379–90.

Campbell, B. A., Wood, G., and McBride, T. (1997). Origins of orienting and defensive responses: An evolutionary perspective. *Attention and orienting: Sensory and motivational processes*, pages 41–67.

Cavanagh, J. F., Eisenberg, I., Guitart-Masip, M., Huys, Q., and Frank, M. J. (2013). Frontal theta overrides pavlovian learning biases. *The Journal of Neuroscience*, 33(19):8541–8548.

Crockett, M. J., Clark, L., and Robbins, T. W. (2009). Reconciling the role of serotonin in behavioral inhibition and aversion: acute tryptophan depletion abolishes punishment-induced inhibition in humans. *The Journal of neuroscience*, 29(38):11993–11999.

Damasio, A. R., Everitt, B., and Bishop, D. (1996). The somatic marker hypothesis and the possible functions of the prefrontal cortex [and discussion]. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 351(1346):1413–1420.

Elliot, A. J. and Covington, M. V. (2001). Approach and avoidance motivation. *Educational Psychology Review*, 13(2):73–92.

Facchinetti, L. D., Imbiriba, L. A., Azevedo, T. M., Vargas, C. D., and Volchan, E. (2006). Postural modulation induced by pictures depicting prosocial or dangerous contexts. *Neurosci Lett*, 410(1):52–6.

Guitart-Masip, M., Duzel, E., Dolan, R., and Dayan, P. (2014). Action versus valence in decision making. *Trends in cognitive sciences*, 18(4):194–202.

Guitart-Masip, M., Fuentemilla, L., Bach, D. R., Huys, Q. J., Dayan, P., Dolan, R. J., and Duzel, E. (2011). Action dominates valence in anticipatory representations in the human striatum and dopaminergic midbrain. *The Journal of Neuroscience*, 31(21):7867–7875.

Guitart-Masip, M., Huys, Q. J., Fuentemilla, L., Dayan, P., Duzel, E., and Dolan, R. J. (2012). Go and no-go learning in reward and punishment: interactions between affect and effect. *Neuroimage*, 62(1):154–166.

Gurfinkel, E. (1973). Physical foundations of stabilography. *Agressologie: revue internationale de physio-biologie et de pharmacologie appliquees aux effets de l'agression*, 14(Spec No C):9–13.

Hagenaars, M. A., Oitzl, M., and Roelofs, K. (2014a). Updating freeze: aligning animal and human research. *Neuroscience & Biobehavioral Reviews*, 47:165–176.

Hagenaars, M. A., Roelofs, K., and Stins, J. F. (2014b). Human freezing in response to affective films. *Anxiety, Stress & Coping*, 27(1):27–37.

Helbig, T. D., Borod, J. C., Frisina, P. G., Tse, W., Voustianiouk, A., Olanow, C. W., and Gracies, J.-M. (2011). Emotional processing affects movement speed. *Journal of Neural Transmission*, 118(9):1319–1322.

Hillman, C. H., Rosengren, K. S., and Smith, D. P. (2004). Emotion and motivated behavior: postural adjustments to affective picture viewing. *Biological psychology*, 66(1):51–62.

Horslen, B. C. and Carpenter, M. G. (2011). Arousal, valence and their relative effects on postural control. *Experimental brain research*, 215(1):27–34.

Insel, T. R. and Fernald, R. D. (2004). How the brain processes social information: Searching for the social brain*. *Annu. Rev. Neurosci.*, 27:697–722.

Ly, V., Huys, Q. J., Stins, J. F., Roelofs, K., and Cools, R. (2014). Individual differences in bodily freezing predict emotional biases in decision making. *Frontiers in behavioral neuroscience*, 8.

McNaughton, N. and Corr, P. J. (2004). A two-dimensional neuropsychology of defense: fear/anxiety and defensive distance. *Neuroscience & Biobehavioral Reviews*, 28(3):285–305.

Mouras, H., Lelard, T., Ahmadi, S., Godefroy, O., and Krystkowiak, P. (2015). Freezing behavior as a response to sexual visual stimuli as demonstrated by posturography. *PLoS One*, 10(5):e0127097.

Panksepp, J. (2003). At the interface of the affective, behavioral, and cognitive neurosciences: Decoding the emotional feelings of the brain. *Brain and cognition*, 52(1):4–14.

Panksepp, J. and Biven, L. (2012). *The Archaeology of Mind: Neuroevolutionary Origins of Human Emotions (Norton Series on Interpersonal Neurobiology)*. WW Norton & Company.

Roelofs, K., Hagenaars, M. A., and Stins, J. (2010). Facing freeze social threat induces bodily freeze in humans. *Psychological Science*.

Singer, B. and Toates, F. M. (1987). Sexual motivation. *Journal of Sex Research*, 23(4):481–501.

Stins, J. F. and Beek, P. J. (2007). Effects of affective picture viewing on postural control. *BMC neuroscience*, 8(1):83.

Stins, J. F., Roelofs, K., Villan, J., Kooijman, K., Hagenaars, M. A., and Beek, P. J. (2011). Walk to me when i smile, step back when i_m angry: emotional faces modulate whole-body approach–avoidance behaviors. *Experimental brain research*, 212(4):603–611.

Williams, J. M. G., Mathews, A., MacLeod, C., et al. (1996). The emotional stroop task and psychopathology. *Psychological bulletin*, 120(1):3–24.