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The Recording of Observational Behaviors in Virtual Immersion: A New Research and Clinical Tool to Address the Problem of Sexual Preferences with Paraphiliacs

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Abstract: *A new method to assess and treat deviant sexual preferences based on the combined usage of virtual reality, eye-tracking devices and penile plethysmography is presented. This method tries to answer some of the shortcomings undermining current methods used in research and clinical practice of forensic psychology and rehabilitation. Among these shortcomings, threats to internal validity caused by non compliance and faking normal sexual responses are the most important ones. The victimization of actual photographed models (adults and children) to prompt sexual arousal is also ethically problematic. Hence the use of sexual avatars depicting various age periods and secondary sexual characteristics. These are used to elicit oculomotor behaviors and physiological responses expressing esthetic interest, approach and genital responses which are continuously monitored via video-oculography and penile plethysmography. Preliminary results of the avatars' validation process are also presented.*

THEORETICAL BACKGROUND

It is on sexual preference assessment's premises that an effective treatment of sexual deviancy relies first. Sexual preferences are usually assessed either by resorting on sexual responses recorded with a penile plethysmograph or by using visual reaction time from stimuli with sexual content[1,2,5,7,9,16,25]. However, numerous shortcomings come with penile plethysmography and visual reaction time, and most notably not conscientiously paying attention to stimuli and/or exerting a misleading voluntary erectile control, which are important threats to the internal validity of these assessment procedures (do not forget that these patients are generally not eager for being assessed for such reasons, and in such ways[6,13,14].The victimization of children is another major weakness with assessment procedures using pictures of real children, either to arouse deviant sexual response or deviant interest as indexed by visual reaction time.

In order to get round these limitations, we developed a method that controls gazing activity relative to sexual avatars. We had already used a similar logic in the past to assess behavioral avoidance with arachnophobics[20] and to assess sexual preferences with normal subjects[23].This method counts on the possibility to literally get inside a patient's subjective viewpoint by simultaneously considering the momentary scene displayed to him in virtual immersion as well as his punctual oculomotor activities, as these latter largely contribute to the content of his attentional focus (Figure 1; [18,24,21,22]). Coupling this new method with classic penile plethysmography allows indeed, *prima facie*, a far better internal validity to sexual preference assessment, considering the aforementioned first two shortcomings inherent to classic methods.

Regarding the stimulus part peculiar to this new assessment method, avatars depicting naked characters of both genders and of clinically significant age phases are required to prompt sexual attraction and arousal. It is usually theorized that sexual attraction and arousal sequentially unfold with the aesthetic, the approach and the genital responses[7,18,24]. As a major asset, the resort to these synthetic characters guards against the victimization of real models that are used with classic methods[18].

Figure 1. Inside the patient's vantage point of view; the crosshair depicts the momentary point of regard of the immersed subject shown in the upper right corner photo; the avatar personifies a female child of 8 years old; on the right hand side, a photo of the monocular infrared eye-tracking system combined within the binocular HMD

METHODS

In a more technical fashion, our method relies upon a technological setting including what is usually necessary to present virtual environments in immersion plus equipments dedicated to eye-movement tracking from within a Virtual Research V8 head mounted display (HMD). A special mounting built from an ASL monocular infrared eye-tracking system combined within the binocular HMD is used to track eye-movements in immersion (see figure1). Head-movements are recorded from an Intersense IS-900 tracking system rendering the 6 degrees-of-freedom (DOF) of translation and rotation.

Our method performs gaze analysis by the way of virtual measurement points (VMP) placed over virtual objects for the analysis of eye-movements in relation to specific features of these objects. These VMPs are placed over meaningful areas such as the simulated erogenous zones depicted over an avatar. Gaze radial angular deviation (GRAD) from a VMP is given by the combination of the 6 DOF developed by head-movements and the 2 DOF (*x* and *y* coordinates) rendered by the eye-tracking system[21-22].

While variations in the 6 DOF developed by head-movements define momentary changes in the global scene presented through the HMD, the 2 DOF given by the eye-tracking device allow the computation of the line of sight's positioning relative to VMPs (Figure 1 and 3). The closer this measure gets to zero, the closer the gaze dwells in the vicinity of the selected VMP. Moreover, VMPs are locked onto virtual objects and move jointly with them which allows analysis of visual pursuit with dynamic virtual objects.

As other measurements ensuing from this method, the subject's distance from the VMPs (which is a reliable index of social proxemics; figure 5), the pupil size diameter (which may be indicative of preferences) and the blinking response (which is a good index of a defensive state) are also obtainable[27-28].

These oculomotor measures are sampled in synchronicity with the erectile response which is recorded from a Limestone technology penile plethysmograph. The erectile response in question is expressed as the penile circumference recorded from the stretching a strain gauge placed around the penis of the assessee while he is in immersion with a sexual avatar (Figures 1 and 4).

Another version of this system works with a standard computer flat screen combined with a pan-tilt mobile infrared camera installed below. This mobile infrared camera, fine-tuned by a head-tracking system (IS-900 from Intersense), captures the assessed individual's eye movements. However, with this particular version of the system, the assessee's inherent tridimen-

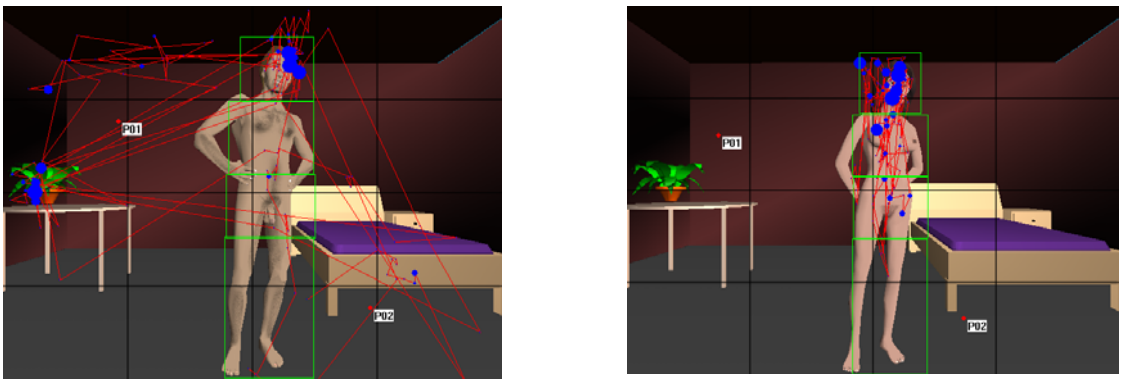

Figure 2 Ocular saccades (lines) and fixations (dots) patterns as superimposed over a male adult avatar (right) and a female adult avatar (left); 2 minutes data sampling coming from one male heterosexual subject.

sional visual perspective is not grasped as such like with full immersive video-oculography as described above. With this pan-tilt mobile infrared camera method, measurements are limited to the recording of eye movements as expressed by ocular saccades and fixations mapped over a 2D plane. Saccades are the most common eye movements, they involve rapid jumps of the eyes from one position to another while fixation, i.e. the steady gaze holding over stationary objects, can be considered as a special case of visual pursuit in which the target is at zero velocity; fixation time ranges from 150ms to 600ms with an average of 300ms; jumps observed in major saccadic eye movements are usually larger than 1.2 degree[28]. Figure 2 presents two examples of ocular saccades (lines) and fixations (dots) patterns as superimposed over a male adult avatar (right) and a female adult avatar (left).

The virtual stimuli that we use to prompt sexual attraction and arousal are animated naked avatars. These have been designed, developed and validated in order to make sure that they would be perceived as representing the required sexual properties to assess sexual preference with pedophile patients[23,18]. Other paraphilias will of course require the development of other specific virtual environments and avatars. See section 3 for statistical results.

You can get access to online video and Power point documents presenting this method as well as the avatars that we developed (http://w3.uqo.ca/cyberpsy/atsa2004vid.avi; http://w3.uqo.ca/cyberpsy/atsa2004pdf.pdf; [18].

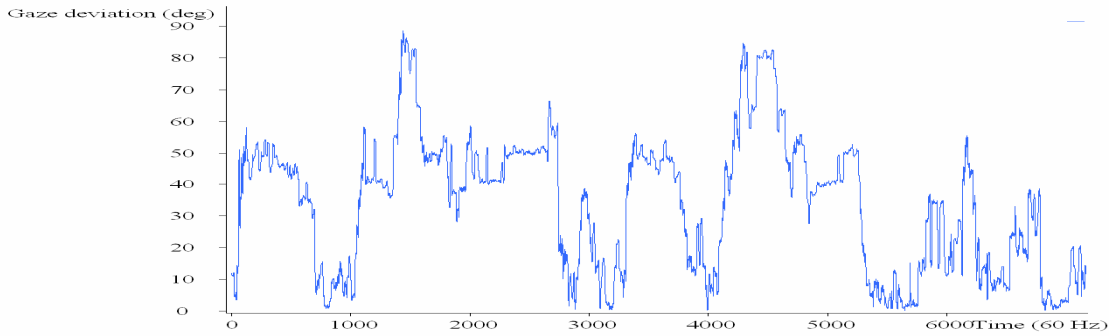

Figure 3. Gazing response as expressed in angular deviation from a virtual measurement point (VMP) marking out the avatar's head; 2 minutes data sampling coming from one subject (expressed in degree).

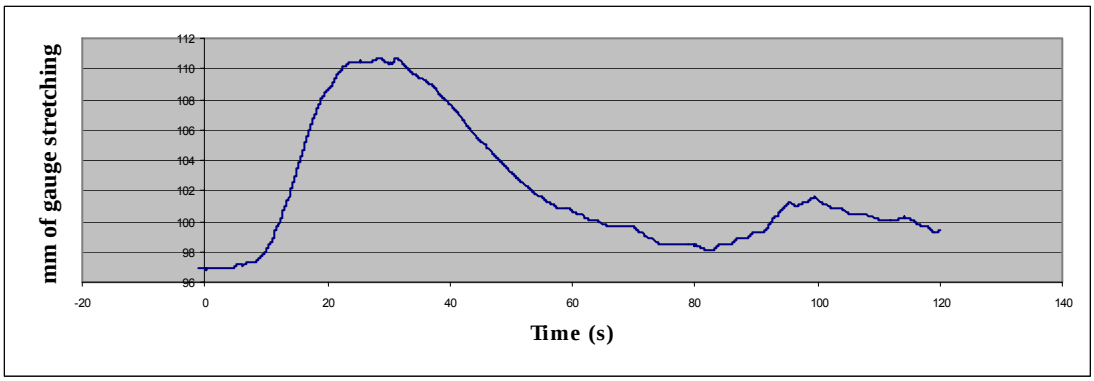

Figure 4. Erectile response as expressed in millimeters of penile gauge stretching, in function of time; 2 minutes data sampling coming from one subject.

ASSESSMENT OF THE AVATARS' PERCEIVED AGE AND LEVEL OF REALISM

As mentioned in section 2, the avatars the we use have been designed, developed and validated in order to make sure that they would be perceived as representing the required sexual properties and the required age to assess sexual preference with pedophile patients. We also developed a sexually neutral avatar for control purposes; all avatars are animated in a similar fashion, that is following the same general way but with slight adaptations to fit each age period and gender behavioural properties. Figure 5 presents snapshot images of the seven categories of avatars, male and female adults, male and female adolescents and male and female children, and the sexually neutral avatar. These were developed to respectively emulate the following age periods : between 25 and 35 years old for the adult, between 13 and 17 years old for the adolescent, and between 6 and 10 years old for the children. All prototypes (except the sexually neutral) were presented to a sample a 63 subjects, 20 males and 43 females, that had to estimate their age and level of realism (Question: *On a scale ranging from 1 to 7, to what extent do you consider this character realistic?*). Descriptive statistics for the age and level of realism results are displayed respectively in table 1 and 2.

Repeated measures analyses of variance and pairwise comparisons confirmed that avatars are perceived as representing members of distinct age groups (adults, adolescents and chlidren), with slight differences between pairs in each group ($F(5,58)=383.27$, $p<.0001$): for

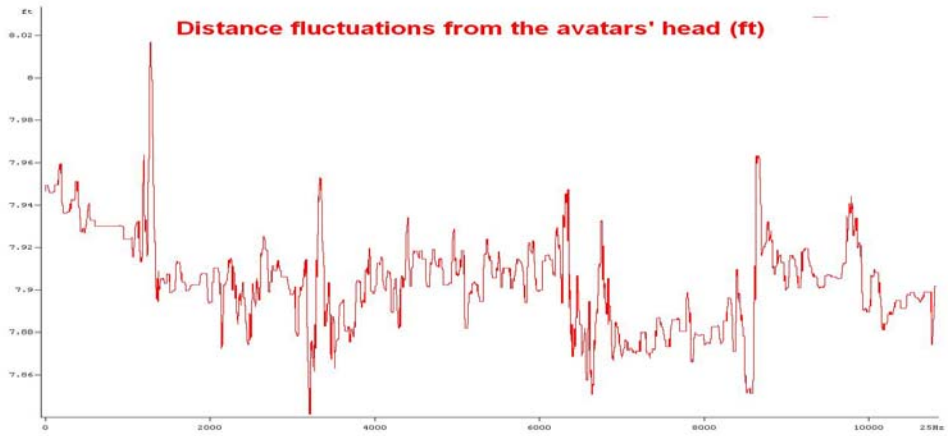

Figure 5. Measures of social proxemics: distance fluctuations from one of the VMP edited over the avatar's head; 2 minutes data sampling coming from one subject (expressed in feet).

Figure 5. Snapshot images of the avatars' prototypes: male and female adults, male and female adolescents, male and female children and a sexually neutral avatar for control purposes.

instance, the male adult avatar is perceived as 1.9 years older than the adult female avatar and the male child avatar is perceived as 0.635 year older than the female child avatar. The same kind of analyses also confirmed that the overall level of realism is acceptable and would need improvements ($F(5,58)=16.251$, $p<.0001$). We also found differences between categories: the adolescent avatars are perceived as the least realistic of all, and even more so for the female adolescent avatar, the male adult avatar is perceived as slightly more realistic than the female adult avatar and the children avatars are perceived as the most realistic, tied with the male adult avatar. These results will guide further improvements of these stimuli.

APPLICATIONS

First, the method put forward in this paper is about controlling the attentional content of the assessee through the minute examination of his observational behavior. To know if the assessee's eyes are open or not is the very first requisite that our method answers to. To pinpoint the gaze location relatively to the morphological layout of sexual avatars is a second crucial aspect of the method that can significantly increase the internal validity of the sexual preference assessment procedure based on penile plethysmography. By knowing how and when the assessee avoids visual contact with the avatar's features being able to arouse his sexual interest, approach and genital responses,

Avatars (gender and age): Perceived age	Min value	Max value	Average	SD
Age Male adult	15.00	40.00	26.5714	5.27842
Age Female adult	16.00	36.00	24.6508	3.98853
Age Male adolescent	10.00	30.00	14.5397	3.35446
Age Female adolescent	9.00	40.00	14.4286	4.47831
Age Male Child	4.00	9.00	6.8413	1.23401
Age Female Child	4.00	9.00	6.2063	1.23339

Table 1. Descriptive statistics for the avatars perceived age (N=63).

Avatars (gender and age):	Min value	Max value	Average	SD
M adult	3.00	7.00	4.7619	1.16001
F adult	2.00	7.00	4.5238	1.30578
M adolescent	2.00	7.00	4.1746	1.39746
F adolescent	1.00	6.00	3.5873	1.32756
M child	2.00	7.00	4.8889	1.24578
F child	2.00	7.00	4.8730	1.15692

Table 2. Descriptive statistics for the avatars estimated level of realism on a scale ranging from 1 to 7 (N=63).

the internal validity of the erectile response measurement is indeed boosted.

Secondly, this method is also about the possibility to develop an original index of sexual preference whose basis would be visual scanpath's parameters in themselves. Preliminary results tend to incline toward the relative time spent on and off the sexually prompting areas displayed on the avatars (as tagged by the VMPs), as well as the gaze moving sequence from one area to another, as good candidates to diagnose properly sexual attraction, deviant or not[23,18]. The inherently dynamic properties of the oculomotor signal, that is how this latter fluctuates in time, its velocity, acceleration or dynamic properties of higher level, could also be indicative of sexual interests[21,22-18]. The latter measurement potentials could be combined as well with measures of proxemics, pupillometrics and ocular defensive response to yield a composite index of sexual preference.

Mediated biofeedback and operant conditioning of sexual behavior and perception

Sexual deviation is treated in various ways but mainstream therapies for paraphilias rely essentially on cognitive-behavioral techniques notably with the use of aversive therapy and covert sensitization to alter deviant sexual arousal, behavior and interest[8]. Penile biofeedback, with and without signaled punishment, has also been tried with interesting results to help sex offenders gain control over their deviant behaviors[15,8].

Classically, feedback stimuli in biofeedback have been mostly audio or visual signals sent continuously and monotonously in proportion to physiological parameters (e.g. amplitude and frequency[3,27]). More recently however, biofeedback applications have been used through video games and virtual reality set-ups, opening new windows on more complexly mediated interactions between patients and their to be controlled physiological responses. In the same vein, we developed a mediated oculomotor biofeedback prototype that allows the interacting subject to be immersed with virtual objects whose kinematical and textural properties change in real-time in function of gazing responses and pupillometric inputs[19].

We propose here a device to deliver specifically a combined penile/oculomotor biofeedback in order to help paraphiliacs be attuned to their physiological, behavioral and perceptual processes otherwise not directly perceptible to them and that engage their sexuality into reprehensible actions. This biofeedback device would mediate its feedbacks through virtual objects' behaviors. For instance, a patient showing signs of interest and/or sexual arousal when doing a virtual stroll nearby a simulated schoolyard could be continuously kept in resonance with his physiological reactions by the delivering of proportional changes in the ambiant sound and luminosity of the scene in which he would be immersed.

As for aversive conditioning, the coupling of aversive or sensitizing contingencies with sex-

ual responses could be done automatically, in a discrete fashion, when a preset criterion would be reached. For instance, a patient exceeding a preset criterion equivalent to 10% of his maximum erectile response and displaying at the same time a critical visual sampling pattern with regard to potential simulated victims would see himself provided with an aversive or sensitizing stimulus that could take the form of a virtual policeman entering the precinct; alternatively, the stimulus could be purely and simply a drastic removal from the scene to an other environment designed to be aversive, eg: a virtual cell or a virtual arrest situation or any event that would be particularly aversive to that individual.

CONCLUSION

Concrete applications of virtual reality in mental health are becoming more and more common. However, virtual reality applications for forensic science and correctional rehabilitation are still not very numerous. With the method put forward in this paper we tried to bring solutions to real and important psychological and social problems by using the immersive properties of virtual reality together with the analytical potential of eye-tracking technologies.

REFERENCES

1. Abel, G.G., Huffman, J., Warberg, B.W., & Holland, C.L. (1998). Visual reaction time and plethysmography as measures of sexual interest in child molesters. *Sexual Abuse: A Journal of Research and Treatment, 10,* 81-95.
2. Abel, G.G., Lawry, S.S., Karlstrom, E.M., Osborn, C.A. and Gillespie, C.F. (1994). Screening tests for pedophilia. *Criminal Justice and Behavior, 21 (1)*, 115-131.
3. Basmajian, J. V. (1989). Biofeedback: Principles and Practice for Clinicians (3rd ed.), William & Wilkins, Baltimore.
4. Cho, B. H., Jang, D. P., Lee, J. M., Kim, J. S., Kim, S. I., Ku, J. H., Kim, I. Y., & Lee J. H. (2002). Attention Enhancement System using Virtual Reality and EEG Biofeedback. *IEEE Virtual Reality Conference 2002*, March 24-28, 2002, Orlando, Florida.
5. Harris, G.T., Rice, M.E., Quinsey, V.L. & Chaplin, T.C. (1996). Viewing time as a measure of sexual interest among child molesters and normal heterosexual men. *Behaviour Research and Therapy, 34*, 389-394.
6. Harris, G. T., Rice, M. E., Quinsey, V. L., & Chaplin, T. C. (1999). Dissimulation in phallometric testing of rapists' sexual preferences. *Archives of sexual behavior, 34*, 223-232.
7. Kalmus, E., & Beech, A.R. (2005). Forensic assessment of sexual interest: A review. *Aggression and Violent Behavior, 10*, 193-217.
8. Laws, D.R. (2001). Olfactory aversion: Notes on procedure, with speculations on its mechanism of effect. *Sexual Abuse: A Journal of Research and Treatment, 13,* 275-287.
9. Marshall, W. L., & Fernandez, Y. M. (2000). Phallometric testing with sexual offenders: Limits to its value. *Clinical Psychology Review, 20*, 807–822.
10. Palsson, O.S., & Pope, A.T. (1999). Stress counter-response training of pilots via instrument functionality feedback. Abstract, *Proceedings of the 1999 Association for Applied Psychophysiology and Biofeedback Meeting,* Vancouver, Canada.
11. Palsson, O.S., Pope, A.T., Ball, J.D., Turner, M.J., Nevin, S., & DeBeus, R. (2001). Neurofeedback videogame ADHD technology: Results of the first concept study. *Proceedings of the 2001 Association for Applied Psychophysiology and Biofeedback Meeting,* Raleigh-Durham, NC.
12. Palsson, O.S., & Pope, A.T. (2002). Morphing Beyond Recognition: The Future of Biofeedback Technologies. *Biofeedback, 30 (1),* 14-18.
13. Proulx, J., Cote, G., & Achille, F.J. (1993). Prevention of Voluntary Control of Penile Response in Homosexual Pedophiles During Phallometric Testing. *The Journal of Sex Research, 30,*140-147.
14. Quinsey, V.L., & Chaplin, T.C. (1988b). Preventing faking in phallometric assessments of sexual preference. In R. Prentky and V.L. Quinsey (Eds.), *Human sexual aggression: Current perspectives* (pp. 49-58). Annals of the New York Academy of Sciences, Vol. 528.
15. Quinsey, V.L., Chaplin, T.C., & Carrigan, W.F. (1980). Biofeedback and signaled punishment in the modification of inappropriate sexual age preferences. *Behavior therapy, 11*, 567-576.
16. Quinsey, V.L., & Lalumière, M. (1992). *The assessment of sexual offenders against children*. *The APSAC study guide*. California: Sage.
17. Renaud, P. (2004). Moving assessment of sexual interest into the 21st century : the potential of new information technology. Invited

speaker at *The 23rd Annual Research and Treatment Conference (Association for the Treatment of Sexual Abusers)*, Albuquerque, 27-30 October 2004.
18. Renaud, P., Albert, G., Sauvé, L., Renaud, L., Décarie, J., & Bouchard, S. (2004). Assessing perceptual learning dynamics during visual search in virtual immersion using eye-tracking technologies. *Proceedings of the IADIS International Conference on Cognition and Exploratory Learning in Digital Age*, Lisbon, Portugal: IADIS Press, pp. 413-418.
19. Renaud, P., Bernier, S., Décarie, J., Gourd, S.-P., & Bouchard, S., (2003a). Oculomotor biofeedback mediated in virtual immersion. *Proceedings of the Ninth International Conference on Virtual Systems and Multimedia : Hybrid Reality : Art, Technology and the Human Factor 2003 (VSMM)*, Montréal, pp. 732-740.
20. Renaud, P., Bouchard, S., & Proulx, R. (2002a). Behavioral avoidance dynamics in the presence of a virtual spider. *IEEE (Institute of Electrical and Electronics Engineers). Transactions in Information Technology and Biomedecine, 6 (3)*, 235-243.
21. Renaud, P., Cusson, J.-F., Bernier, S., Décarie, J., Gourd, S.-P., & Bouchard, S. (2002b). Extracting perceptual and motor invariants using eye-tracking technologies in virtual immersions. Proceedings of *HAVE'2002-IEEE (Institute of Electrical and Electronics Engineers) International Workshop on Haptic Virtual Environments and their Applications,* Ottawa, pp. 73-78.
22. Renaud, P., Décarie, J., Gourd, S.-P., Paquin, L.-C., & Bouchard, S. (2003b). Eye-tracking in immersive environments : a general methodology to analyze affordance-based interactions from oculomotor dynamics. *Cyberpsychology and Behavior, 6 (5),* 519-526.
23. Renaud, P., Rouleau, J.-L., Granger, L., Barsetti, I., & Bouchard, S. (2002c). Measuring sexual preferences in virtual reality: A pilot sudy. *Cyberpsychology and Behavior, 5 (1)*, 1-10.
24. Renaud, P., Singer, G., & Proulx, R. (2001). Head-tracking fractal dynamics in visually pursuing virtual objects. In Sulis W., Trofimova I. (Eds.), *Nonlinear Dynamics in Life and Social Sciences* (NATO Science series, Vol. 320), Institute of Science Press (IOS Press), Amsterdam, pp 333-346.
25. Rouleau, J.-L., Renaud, P., & Barsetti, I. (2001). Le traitement des agresseurs sexuels. In Séguin, M., Leblanc, L. (Eds.), *La relation d'aide* (pp 251-282). Montréal : Éditions Logiques.
26. Singer, B. (1984). Conceptualizing sexual arousal and attraction. *The Journal of Sex Research, 20 (3)*, 230-240.
27. Schwartz G.E., & Beatty J. (1977). *Biofeedback: Theory And Research*, Academic press, New York.
28. Stern, J.A, Walrath, L.C., & Goldstein R. (1984). The endogenous eyeblink. *Psychophysiology, 21*, 22-33.
29. Stern, J.A. & Dunham, D.N. (1990). The ocular system. In Caccioppo, J.T. & Tassinary, L.G. (eds.), *Principles of psychophysiology:physical, social and inferential elements* (pp. 513-553). Cambridge, U.K.: Cambridge University Press.

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