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Alteration of consciousness via diverse photo-acoustic stimulatory patterns. Phenomenology and effect on salivary flow rate, alpha-amylase and total protein levels

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ABSTRACT

Long-term photo-acoustic stimulation is used for the induction of altered states of consciousness for both therapeutic and experimental purposes. Long-term photo-acoustic stimulation also leads to changes in the composition of saliva which have a key contribution to the efficiency of this technique in easing mucosal symptoms of oral psychosomatic patients. The aim of this study is to find out whether there is any cumulative effect of repeated stimulation and whether there are any detectable differences between diverse stimulatory patterns of long lasting photo-acoustic stimulation on the phenomenology of the appearing trance state and on salivary secretion. There was significant cumulative effect in relation with the appearance of day dreaming as phenomenological parameter, and in relation with protein output and amylase/protein ratio as salivary parameter. Pattern specific effect was detectable in relation with salivary flow rate only. Although our results clearly indicate the existence of certain cumulative and stimulation-pattern specific effects of repeated photo-acoustic stimulation, the absolute values of all these effects were relatively small in this study. Therefore, in spite of their theoretical importance there are no direct clinical consequences of these findings. However, our data do not exclude at all the possibility that repeated stimulation with other stimulatory parameters may lead to more pronounced effects. Further studies are needed to make clear conclusion in this respect.

1. Introduction

1.1. General considerations

Light and sound (tune and rhythm) effects have frequently been used for the induction of altered states of consciousness for long (Heinze, 1993; Hoppál, 1993a, 1993b). Light and sound stimuli can be used for trance induction also nowadays for both research (Fábián et al., 2002, 2004b, 2009b) and therapeutic (Fábián and Fábián, 2000; Fábián et al., 2002, 2004a, 2005, 2006, 2009c) purposes. For such purposes there are numerous stimulatory instruments commercially available recently. In most systems, photic and acoustic stimuli (mixed frequency of 5–10 Hz) are administered via glasses with built-in light emitting diodes (LED) and headphones (Fábián et al., 2005, 2009c). Light stimuli are administered

Abbreviations: ANOVA, analysis of variance; LED, light emitting diodes; ICD-10, International Statistical Classification of Diseases and Related Health Problems 10th Revision; EEG, electroencephalography; EMG, electromyography; PCI, Pekala's Phenomenology of Consciousness Inventory; IgA, immunoglobulin A; HSP70/HSPA, 70 kDa heat shock protein (HSP70) also referred to as heat shock protein A (HSPA); ISN, inferior salivary nucleus; SSN, superior salivary nucleus; VIP, vasoactive intestinal peptide.

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under eye-closed conditions, using LEDs emitting light strong enough to pass through the eyelids. Photo-acoustic stimuli may be administered using 'ready-to-use' available stimulatory programs; however, individually programmed stimulation may be carried out via computers (Fábián et al., 2005, 2009c). Photo-acoustic stimulation may be used individually or in small groups (Fábián et al., 2006). For the latter purposes, signal distributor equipment suitable for up to 5–6 participants is commercially available.

Headphones used for acoustic stimuli are also suitable for barely audible relaxing music with suggestions via a microphone in parallel with stimulation for both experimental and therapeutic purposes (Fábián et al., 2005, 2009c). For therapeutic purposes suggestions, often individualized, of autogenic training, relaxing hypnosis or other more complex hypnotic methods have been used advantageously (Fábián et al., 2005, 2009c; Krause, 1994; Krause et al., 2007). Since photo-acoustic stimulation advantageously leads to a restricted perception of the environment (i.e. wearing the headphones and LED glasses), enhanced hypnotizability and increased susceptibility to suggestions may be facilitated (Barabasz, 1982; Barabasz and Barabasz, 1989).

1.2. Related neuro/psychophysiology

Early studies demonstrated that turning the light or sound on and off induces alpha desynchronization in the EEG (Berger, 1930; Walter et al., 1946), leading to a powerful stimulating effect on the central nervous system for a short time. This phenomenon is called an 'on and off' effect, typified by a prompt decrease of alpha density (Kawabata, 1972). The specificity of sense modality for this effect can be reinforced; and a larger 'on' effect has been found in occipital areas for visual stimulation, and in central areas for auditory stimulation (Arannibar and Pfurtscheller, 1978). The magnitude of the 'on' effect was both roughly related to stimulus intensity, and consistent and reproducible with small inter- and intraindividual variability (Arannibar and Pfurtscheller, 1978). In the case of light stimuli, increased 'on' effects were found using certain colors of the stimulating light, such as violet–blue (453–75 nm), green–yellow (551 nm) and orange–red (615 nm) (Ciganek and Ingvar, 1969). All the above data indicate a powerful phasic stimulating effect of photo-acoustic stimulation on the central nervous system as a short lasting stimulus (Fábián et al., 2005, 2009c).

In contrast, most likely because of habituation to stimuli (Fábián et al., 2005, 2009c), longer lasting (*at least* 5–10 min) stimulation with flash light and tone signals (5–10 Hz frequency) leads to drowsiness and mixed alpha–theta activity (Jin et al., 2003; Williams and West, 1975), and to bodily relaxation with increased skin resistance, decreased EMG activity and a decreased salivary cortisol level (Brauchli, 1993). Significant immunological changes have also been reported following long lasting photic stimulation, including an increase of salivary IgA level (Brauchli, 1993) and increased output of the salivary molecular chaperone HSP70/HSPA (Fábián et al., 2004b), which is an immunoregulator and defense protein of the oral cavity and upper gastrointestinal tract (Fábián et al., 2007, 2008c, 2009a, 2012). A strong trance inducing ability of long lasting photic stimulation has also been demonstrated with the above effects (Fábián et al., 2002). Summarizing the data above it can be concluded that while long run (at least 5–10 min) photo-acoustic stimulation helps to keep the body relaxed, it also strongly activates certain trance inductive psychophysiological functions, resulting in a putatively unique trance state (Fábián et al., 2005, 2009c).

1.3. Phenomenology

As it was mentioned above, a strong trance inducing ability of long lasting photic stimulation has been demonstrated in our previous study (Fábián et al., 2002). In that study mixed photic stimulation (8 Hz mean frequency) was compared to simple relaxation and standardized group hypnosis (Fábián et al., 2002), using three relevant phenomenological scales (altered state of awareness; arousal; and altered experiences) of the Hungarian version (Szabó, 1989, see also Szabó, 1993; Varga et al., 2001) of Pekala's Phenomenology of Consciousness Inventory (PCI; Pekala, 1982, 1991). Photic stimulation induced significantly higher alteration of awareness comparing to relaxation, whereas comparing to group hypnosis the alteration of awareness was also somewhat higher, but the difference was not significant in that case (Fábián et al., 2002). There was also a significantly stronger decrease of arousal level comparing to group hypnosis, whereas comparing to relaxation the decrease of arousal was also somewhat stronger, but the difference was not significant in that case (Fábián et al., 2002). There were also higher values of alteration of experiences in the case of photic stimulation compared to both relaxation and hypnosis; however, the differences were not statistically significant in neither of the cases (Fábián et al., 2002).

1.4. About saliva

Saliva is a major determinant of the oral environment and also serves as an easily available diagnostic tool of systemic conditions and several psychological states (Fábián et al., 2008a, 2008b, 2009a, 2012; Nater et al., 2005; Pramanik et al., 2012) including various states of altered consciousness like hypnosis, relaxation or photo-acoustic stimulation induced trance state (Fábián et al., 2002, 2004b). It is a body fluid secreted by three pairs of major salivary glands (parotid submandibular and sublingual) and by many of minor salivary glands (Fábián et al., 2008a, 2008b; Ferreira and Hoffman, 2013). Saliva is supplemented with several constituents originated from blood serum (i.e. gingival crevicular fluid, mucosal transudate, ultrafiltrate of the salivary glands' acini and oral bleeding), from intact or destroyed oral mucosal and immune cells, and from intact or destroyed oral microorganisms (Fábián et al., 2008a, 2008b, 2012) resulting in a complex mixture of a high variety of molecules (Fábián et al., 2008a, 2008b, 2012).

Saliva plays an important role in acquired pellicle formation on tooth surfaces, in crystal growth homeostasis, in bacterial adhesion and biofilm (plaque) formation, in digestion of polysaccarides (i.e. starch), lubrication of oral mucosal surfaces and taste perception (Fábián et al., 2008a, 2008b, 2015) as well as in maintaining mucosal integrity of the oral and upper gastro-intestinal mucosal surfaces by means of various innate and acquired immune functions, entrapment/agglutination/surface exclusion of microbes, physico-chemical defense mechanisms and wound healing facilitation (Fábián et al., 2008a, 2008b, 2012; Gibbins et al., 2014). A high number of saliva constituents including proteins, carbohydrates, lipids and ions interact under fine regulation to fulfill these important tasks (Fábián et al., 2008a).

1.5. Regulation of salivation

Salivary fluid secretion (flow rate) and protein secretion are primarily mediated by the parasympathetic and sympathetic autonomic innervation (Ferreira and Hoffman, 2013; Ishikawa et al., 2006; Proctor and Carpenter, 2014). Parasympathetic innervations arise from the medulla (inferior salivary nucleus, ISN) and pons (superior salivary nucleus, SSN) regions of the brainstem (Ferreira and Hoffman, 2013). Preganglionic fibers synapse either in the otic ganglion (ISN) or in the submandibular ganglion (SSN) and postganglionic fibers target salivary glands via either the auriculotemporal nerve (ISN) or via the lingual nerve (SSN) both of which are branches of the submandibular division of the V. (trigeminal) cranial nerve (Ferreira and Hoffman, 2013). The