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COMMENTARY

Neuroelectrical Activity and Sexual Stimulation: Deconstructing a Tower of Babel

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Doing sex research sometimes feels like stumbling into a Kafka novel where unlocking heavily guarded secrets of the sexual universe are a subversive act met with resistance, deterrence, and retribution. In addition to roadblocks put in place by risk averse granting agencies and downright terrified academic administrators and their media minions, sometimes the subject itself eludes capture by a plethora of perfectly reasonable experiments that, when taken together, overwhelm us with conflicting information. Nowhere is this kind of sexual Tower of Babel cast in a clearer light than the Target Article review and meta-analysis conducted by Ziogas et al. (2020) on neuroelectric correlates of human sexual arousal and orgasm.

To say this, we must have a labor of love against all odds is an understatement. With uncommon and admirable scholarship and technical sophistication, Ziogas et al. (2020) scoured 150 years of literature on the electrical properties of the human brain in response to sexual stimulation to arrive at 255 papers published between 1936 and 2017 that met rigorous inclusion criteria. These studies spanned different recording methods like electroencelphalography (EEG) and event-related potentials (ERPs) with their early, middle, and late components that reflect different cognitive processes in response to visual sexual stimulation and direct genital stimulation. Ziogas et al. also examined the largely subjective sexual effects of different electrical stimulation methods, including deep brain stimulation (DBS), paying particular attention to the groundbreaking but notorious work of Robert G. Heath at Tulane University in the 1960s and 1970s, electroconvulsive therapy (ECT), transcranial direct current stimulation (tDCS), and recent studies using transcranial magnetic stimulation (TMS). What they did not do was include the burgeoning literature on brain activation using functional magnetic resonance imaging (fMRI) or positron emission tomography (PET), although regions of activational confluence between methods were noted. And why not? In addition to likely doubling the size of the article, the methods differ importantly in temporal and spatial resolution. What EEG, ERPs, and the electrical/magnetic stimulation methods possess as temporal resolution in real time they lack in spatial resolution, especially regarding subcortical regions. PET and fMRI have relatively good spatial resolution (especially PET superimposed on MRI images) but lack temporal specificity. This makes it extremely difficult to relate findings even from the same brain regions. But to make matters worse, the 255 studies that made the grade for their review all differed in experimental procedures. In fact, a decisive take-home message from the paper is that there are no agreed-upon basic methodologies in the brain activation or stimulation studies they reviewed, no standardized set of cognitive tests, no standardized pictures or videos to present as visual sexual stimuli (other than the IAPS pictures which were validated in the 1970s), and no standardized way to provide genital stimulation to participants other than to do whatever is possible to bring them to orgasm, albeit without the use of any validated subjective measures of orgasm (e.g., the Orgasm Rating Scale of Mah & Binik, 2002) to relate their cognitive, emotional, and/or physiological experiences. It is remarkable, then, that there are *any* commonalities in the findings, which the authors summarize at the end of the paper:

1. Neuroelectricity, genital stimulation, and orgasm. Turns out that local EEG field potentials correspond to fMRI findings in which the genital sensory "homunculus" (clitoral and penile) in both deep and superficial layers of somatosensory cortex is activated by electrical and tactile stimulation of the genitals. Likewise, EEG responses during orgasm indicate that it involves epileptiform signals, and there appears to be commonality in both seizure activity and orgasm-like feelings, especially in the experience of temporal lobe seizures, with both hyper- and hyposexual responses reported. However, regarding orgasm, EEG

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signals are interpreted with caution given the overwhelming contamination by body movements. In contrast, deep electrical stimulation of the lateral septum induced consistent pleasurable orgasm-like feelings in Heath's patients, and such stimulation was used by Heath and colleagues (e.g., Heath, 1963; Heath & Gallant, 1964; Moan & Heath, 1972) as a treatment for depression. Indeed, the pleasure from septal stimulation was so powerful that both humans and rats would press buttons and levers for it, to the exclusion of other primary needs (Olds & Milner, 1954; Pliskoff et al., 1965; Routtenberg & Lindy, 1965).

2. Cognition and sexual arousal. EEG and ERP recordings reveal a specific pattern of activity in the appraisal of arousing visual sexual stimuli relative to other emotional or cognitive tasks. These generally include higher amplitude spikes in the left and right parietal lobe (from electrodes P3–P4, respectively), late positive potentials (LPPs) and early posterior negativity (EPN), and higher frontal alpha wave asymmetry (generally lower left than right, though sometimes the opposite) to visual sexual stimuli relative to other stimuli. Thus, it can be concluded that visual sexual stimuli are high on the hierarchy of motivational variables that are salient and grab attention quickly. However, Ziogas et al. (2020) note that pictures are typically a mix of salient cues such as attractive faces and naked bodies posed provocatively, in addition to the particular sexual activity portrayed. Indeed, faces may be processed unconsciously for emotion, erotic valence, or both, which remains unclear if the participants are not asked subjective questions. And if a picture is worth a thousand words, then videos are worth thousands of pictures and are likely to be far more stimulating in terms of the sexual interaction. This makes it nearly impossible to delineate the salient features of a video that might lead to differences in genital arousal and cognitive/brain processing. Moreover, videos that depict different sexual activities are presented for variable lengths of time (e.g., 2–15 min) which makes it difficult to compare their effect on EEG or ERPs without a common cognitive measure before, during, or after the video.

3. Sex and gender differences. Women and men have long been known to display different patterns of genital and subjective arousal to depictions of heterosexual and homosexual activity (Chivers et al., 2010; Spape et al., 2014). Men are generally category specific (e.g., heterosexual men show greater and concordant genital and subjective arousal to depictions of naked women and heterosexual activity between men and women and homosexual men show greater genital and subjective arousal to depictions of naked men and homosexual activity between two or more men). Heterosexual women appear to be more fluid in their genital arousal patterns, showing greater arousal to sexual activity in general, regardless of orientation, but discordant subjective arousal responses that are consistent with their self-appraised orientation. Women who self-appraise as exclusively homosexual, on the other hand, are more consistent in their pattern of genital and subjective arousal and preferences for depictions of exclusively lesbian sexual activity (Suschinsky et al., 2017). Although it is rare that EEG and ERP data are collected for the purpose of examining gender differences, such differences emerged in the meta-analysis that were generally consistent with fMRI findings. For example, men show greater activation of inferior temporal cortex, amygdala, and hypothalamus than women do in response to visual sexual stimuli involving naked women and heterosexual activity and EEG and ERP patterns are consistent with this. Much of this, however, appears to be related to the processing of attractive faces and bodies, with men showing enhanced ERP and EEG responses compared to women. Ziogas et al. (2020) conclude that much of the early, automatic, and fast cortical responses might link genital and subjective sexual arousal in men, whereas less immediate and automatic cortical functions "might allow for some independence between genital and mental sexual arousal in women". Ziogas et al. cite Chivers et al. (2010) to support an evolutionary hypothesis for this difference (i.e., for reproductive purposes, men need to respond quickly and directly to their penile erections, whereas for the purposes of choosiness, women need time to make a decision regarding the "right" mate). But another, perhaps more proximate argument could be made that men wearing underwear and pants have their penises tightly bound in a single position, making them sensitive to small increases in penile blood flow due to resistance against erection. Women do not generally wear indwelling devices in their vaginas or around their clitorises that provide pressure against engorgement, which may make them less sensitive to blood flow relative to men. One wonders how sensitive men might be to their penile blood flow if the penis was free floating with no pressure against erection.

The problems raised by Ziogas et al. (2020) about the lack of standardized, much less consistent, methodology ring true for almost all studies that utilize visual sexual stimuli, regardless of whether brain activation or cognitive assessments are key dependent measures. It is difficult to find pictures or videos of the same couples doing different things or different couples doing exactly the same things. It is difficult to find videos that have the same duration of different sexual activities and with the same couples doing them. It is less difficult to equate them for luminance, though the quality of the photos and videos taken from the public domain off the internet may well be sub-standard.

Another, perhaps latent, variable is the experience and expectation of the participant of what constitutes sexually arousing visual cues. The availability of erotic and pornographic pictures and videos has changed dramatically in the past two decades with the advent of the internet. And the types of dress, hair styles, presence or absence of body or pubic hair, dialogue, and background sounds or music have created almost identifiable "eras," from silent nudist films and Playboy centerfolds of the 1950s, to more centerfolds and poorly filmed Super 8 mm hardcore loops found in sex shops of the 1960s, to "art" porn of the 1970s and more risqué centerfolds, to manicured pubic patches of the 1980s with "male centric" and "female centric" themes, hairless bronzed bodies of the 1990s, to more and more depictions of fetish activities and fantasies in the 2000s.

With the advent of the internet, what had been the mainstream porn industry fell apart just like the recording industry did; the internet provided people with direct access to homemade or small group-made pictures, videos, and live action. What this means then is that several generations of people grew into their sexuality during these different eras, and the type of porn depicted in those different eras became, much like the music of those eras, a familiar and even preferred style (e.g., the presence or absence of pubic hair is one of several "generation gaps" that can engender vociferous debate). Up to the advent of the internet, hardcore porn was available only in sex or porn shops that were frequented mostly by men; after this, porn was freely available to anyone with a computer or cell phone. It is clear that more and more women in the past 20 years have been watching porn and using it as an adjunct to masturbation and sex play, just as men had been doing in previous generations. What researchers are discovering is that what was highly arousing for college-age young adults in the 1970s is only mildly arousing for college-age young adults in the 2010s, and indeed, this impact may be greater for women than men (D'Amours, et al., 2013; Jacob et al., 2011). Stimuli that were validated have become dated, which stymies attempts at replication because the experiences and expectations of the participants have changed. Perhaps, our field needs to take a page from cognitive neuroscientists that study drug addiction in humans and have the participants in the scanner or fitted with EEG electrodes rate different visual sexual stimuli according to subjective arousal, positive or negative valence, etc., or even choose preferred stimuli from menus with different possibilities.

But as if that were not enough, most of the data to date have been derived from people of European descent. Not that the physiological sexual responses of humans of other ethnicities are going to be any different, but expectations and experiences may well be different enough to turn hardcore mainstay findings about genital arousal, desire, preference, and brain activation in response to visual sexual stimulation on their heads. Likewise, different types of auditory sexual stimulation in blind individuals may activate neural pathways similar to those activated by visual sexual stimulation in sighted individuals. Such a finding would be a powerful demonstration of neural plasticity in the human adult and would mirror findings that "babbling" in the verbal or manual mode for hearing and deaf babies, respectively, coalesces into the activation of similar language-related brain structures (Bellugi, Poisner, & Klima, 1989; Petitto & Marentette, 1990). It is possible that TMS technology mixed with high resolution MRI brain maps of individual participants will be able to stimulate different brain regions that are critical for sexual excitation or inhibition (Pfaus, 2009). Mixed with the right kind of visual and/or auditory sexual stimuli, and perhaps also the right kind of cognitive task (e.g., dot-probe, sexual Stroop using tinted pictures), TMS could help reveal critical regions for the distributed processes of sexual arousal and desire, and/or how those regions impact the quality of orgasm. The promise of such findings could translate into the ability of TMS as a therapeutic tool to restore the feelings of sexual arousal, desire, and orgasm to individuals with sexual dysfunctions or individuals with spinal cord lesions.

In July 2003, the Kinsey Institute hosted a controversial conference on sexual psychophysiology in Bloomington, Indiana. The meeting was incredibly productive and individual papers presented there became chapters in a book edited by former IASR President Erick Janssen. It was the first meeting of its kind, and its primary goals were to "…present up-to-date reviews, discuss commonalities and differences in conceptual and methodological approaches, and generate ideas and suggestions for future research." A second goal was to "… work toward increased standardization and consensus in measurement and analysis procedures in psychophysiological sex research" (Janssen, 2007, p. xi). Perhaps, it is time for another meeting, this time to tackle the similarities and differences that brain activation studies have provided and to distill methodologies and variables, both independent and dependent, into a core of consensus-driven "gold standards" that could not only help to deconstruct this current sexual Tower of Babel, but also help to set a focused direction for the next 20 years of sexual neuroscience and the unlocking of more heavily guarded secrets of the sexual universe.

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Declarations

Conflicts of interest The author declares that he has no conflicts of interest.

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