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Neurosciences of Heterosexuality and Homosexuality

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Introduction to Sexual Orientation

Human sexual behavior is not initiated voluntarily but arises from the interrelationship between innate mechanisms and the configuration of the social environment. Studies of sexual behavior in several vertebrate species identified a commonly employed but poorly understood neural organization that is less developed in non-human primates than in muroid rodents [1].

It is considered that understanding homo and heterosexuality could inform approaches to sexual satisfaction and prevention and treatment of sexual misconduct, as these populations likely experience social tension. Findings of this approach would point at sex-typical neural differences between women and men of different sexual orientations, using functional brain imaging. Appearances of an individual's sexual orientation depend on the relative engagement of present lifestyles, brain developments and sociopersonality cognitivity from different experientially derived perspectives that defy uni-quanitative indices of sexual orientations.

Observational indices are continually observed by the perceptual senses derived as narratives stored in neural codings in the continued development of pre-defined neural structures. These neural structures determine cognitivity modulating the strength of engagement in the interpretation of what is traditionally construed as sexual orientation. Observational narratives initiated by a salient sexual social stimulus are engaged in the analysis of meanings in a configurationally selective manner. Hence systematic investigations of judgemental impressions with new sexual stimuli would support the stated conjecture.

Historical Perspectives on Sexual Orientation

Sexual orientation is a relatively new category in studies of nonpathological human sexual differences, which are themselves a recent focus of study or of scientific rigor. Nonetheless, interrogated through the lens of neuroscience, given the knowledge accrued over the past two centuries on the neural bases of other sexually dimorphic or diverse traits, cognition, preferences, and traits that might correlate with sexual orientation, what might be learned about its biological origins, expression, universality or diversity, and related dispositions? [1].

Reports of sexual acts and preferences between men at least as far back as the ancient Greeks and Romans have been supplemented in the modern era by accounts of sex between women. What is surprising is only how little attention has been focused on this widespread and ancient phenomenon. Researchers have been aggressively peeling back layers of knowledge on diverse yet nonpathological human and animal sexual traits, preferences, behaviors, and cognitions, while until now all but ignoring the one characteristic that in humans defines the public distinction between heterosexuality and homosexuality.

Whether and in what ways brains might differ based on sexual orientation is only partially understood. Furthermore, little is known about the trajectory of brain changes and how brain differences might come to exist in development. For example, how might brain differences be related to prenatal or early postnatal factors, and what roles do genes and the environment play? What might be the consequences of being on the aeorightae side of a divergence? What possible continuum or co-variance exists in preference for either gender?

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Biological Bases of Sexual Orientation

Sexual orientation, with few exceptions, is considered to be fixed very early in life [2]. There are individuals with absolute bisexuality. While, on balance, sexuality seems on a continuum ranging from heterosexuality to homosexuality, it appears that although an individual may have some degree of flexibility with respect to sexual preferences, the general tendency is fixed. Accordingly, notwithstanding the knowledge that dissenting opinions exist, sexual orientation is not considered a matter of choice. Rather it is a matter of configuration of brain circuitry.

Such matters would be fairly uncontroversial territory were it not for the complicated history and biology of homosexuality. Nevertheless, the task of invoking the notion of a biological basis for sexual preference is neither disingenuous nor poorly founded. It is an aspect of humanity that lends rich insight into the complexities of mammalian, especially human, biology. A biological basis for sexual orientation is here taken to mean a genetic and hormonal origin underlying brain configurations associated with homosexuality and heterosexuality [3].

Numerous studies have presented evidence for a biological influence in male homosexuality. An early finding indicated that an extraordinarily high percentage of homosexual men had an increased number of maternal uncle, the mothers of these men were more younger brothers. Additional influence was thought to arise, in part via genes that controlled exposure to testosterone extensively throughout the development. A pair of genes in the q arm on chromosome 10 associated with sexual partner preference in rats, which were both homologous to genes with analogues in mice. In Honjoâ€™s laboratory, 101 genes were isolated and sequenced, but given the enormous number of genes, their usefulness for an understanding of the genetics of homosexuality was ambiguous.

Genetics and Heritability

Twentieth-century sexology made a general plea for the importance of research into human sexuality, and this call has been echoed by a range of disciplinesâ€”biological, psychological, social, and humanistic/philological. A burgeoning literature has emerged out of new paradigms, perspectives, approaches, and methodologies. With these developments, many new actors and issues have come onto the scene. But far too few have engaged in multidisciplinary dialogue, and where this has occurred, it has too often taken place in backwaters and sub-groups. Underlying this situation is a truism that pluralism often leads to fragmentation, raising important questions regarding the conceptual and theoretical foundations of research, and coordination and collaboration.

Sexuality is one of the most fundamental aspects of being human, and yet one of the least understood. What is sexuality? Among the reasons for the difficulties surrounding this question is the ambiguous nature of the term itself. In common parlance, sexuality has been used to mean several quite different things. In the human scientific literature, too, it has been assigned many meanings, and there are a bewildering array of terms for similar concepts. The term sexuality can mean sex, but it can also refer to sexual orientation, behavior, motivation, desire, preference, identity, and relations. In a vastly more restricted but still ambiguous sense, it can mean sex-related biological systems. Most of the literature on sexuality has focused on the biological, medical, or health-related aspects of sexuality, and the term is often taken to mean only genitalia, sexual anatomy and physiology, sexually-transmitted diseases, and sexual dysfunctions and aberrations of these [4].

Sexuality, on the whole, has been neglected by key disciplines and in key areas of society. In anthropology, it has long been taboo. In political science, students are rarely exposed to sex, sexual behavior, or sexual politics, and students of international relations are only taught theoretical models of something that seems, so far, to have escaped theoretical modelingâ€” international sexual politics, and how sexuality affects inter-relatedness on the geopolitical stage. In education, there is still a blatant lack of comprehensive sex education in schools, and thus in a knowledge base for future adulthood. At a more macro-societal level, many societies are still extraordinarily suppressive of sexuality, with rigid norms and rules concerning what may or may not be presented, performed, or discussed.

Nevertheless, knowledge in many of these areas has burgeoned over the last couple of decades. There is an ever-widening range of research, with rapidly-expanding databases and a plethora of research-methodological issues. There have also been some magnificent syntheses running hundreds or even thousands of pages long. Yet, this wealth of literature and information is of little use to uninitiated or interested outsidersâ€” those to whom it is most relevantâ€” unless made meaningful and digestible. Collating and summarizing the literature from multiple perspectives and disciplines in a more compact and coherent manner will provide such a foundation for education, research, and further intervention.

Neuroanatomy and Brain Structure

Sexual orientation has often been viewed as a lifestyle choice or consequence of environmental effects. Substantial amounts of research have begun to acknowledge that all behavior is potentially shaped early in development by genes and the environment, including sexual orientation. As a starting point of a more expansive approach to neuroanatomy and neuroimaging of sexual orientation, the relationship between sexual orientation and brain structure was explored. In the past, a handful of studies have focused on brain structure and sexual orientation, but potential differences and their brain regions have not been compared in one sample. By investigating cases of stereotypical heterosexuality and homosexuality, it was addressed whether sexual orientation is related to differences in brain structure. Ideas were developed regarding where these differences may be located [5].

LGBTQI+ individuals are among the most discriminated groups in society. Control of health policies applicable to all human beings can sometimes lapse when it comes to sexual behavior. In societies where LBGTQI+ affiliations are viewed as abnormal, healthcare professionals may openly reject or conceal their sexual orientation or gender identity, which damages the efficacy of the doctor-patient relationship. Many associations and organizations outside medicine actively influence preventive and therapeutic policies. However, legislation rarely addresses delivery systems for health

information, and patients are primarily at the mercy of healthcare providers. Therefore, policies that genuinely recognize sexual orientation and gender identity as unmodifiable traits and pursue education in diverse sexual behavior issues need to be fostered.

Neuroimaging has been essential in gaining a deeper understanding of the anatomy and paths of misinformation and insight into how sexual orientation and neuroanatomy may link. Neuroanatomy studies of sexuality have shown that sexual orientation is associated with sexual dimorphisms in brain structure. These differences were shown to exist for a wide variety of relationships and feelings. No study had explored brain structure and sexual orientation together excluding all other potentially confounding factors. While many neuroanatomical correlates of sexual orientation remained unidentified, the neuroimaging studies on societal acceptance of sexual orientation provide valuable knowledge and potential brain regions. Prior to clinical implementations, there is reason to exploit neuroanatomy and structural imaging data.

Hormonal Influences

The biological basis of human sexual orientation is poorly understood despite some evidence pointing in a biological direction. While overt organisms vary widely in sexual make-up, mode and number of partners, and mating strategies â€" reflecting ongoing biological adaptation â€" human homo- and bisexualityâ€™s existence presents a conundrum for evolutionary theorizing, at least for some theorists. The large majority of the population is heterosexual, under both Western, pre-Western, and non-Western cultures, with opponents of alteration organized primarily around such matings.

Evolutionary theorizing has produced diverse mechanisms, whether evolutionary disequilibrium models, greater male investment in offspring focusing on mating with many females, or women overweighting wealth all invoking selective pressures that lead to, for a very small minority, failure to heed such pressures. Mechanisms operating genetically or via the prenatal hormonal environment may be better explanations, with the latter more parsimonious. In utero, excess testosterone or androgen bathes the hypothalamo-pituitary-gonadal axis and other systems leading to biological sex differentiation and thus competing organismal development likely impacting sexual orientation and behavior. Sexual differentiation is usually binary but a small number of individuals are born with intersex or ambiguous genitalia, with a disproportionately high percentage of raised homosexuals.

Fetal hormones are thus both a major input into gender and sexuality differentiation. Visual right frontal lobe lateralization processing non-linear visual scenes is more pronounced in females. The ensuing negative feedback on testosterone levels leads to a layered developmental lag with estrogen fixity across antero-posterior and mediolateral sending mallet-like dentate paths through the white matter to right posterior visual cortices. Imaging studies show diminished cortical thickness with testosterone and lessened visual lateralization, with later exposures also lead to challenging lateralization. In adult males, left frontal and right occipital lesions tend to produce deep-seated visuo-spatial deficits and homosexuality.

Exposure to higher levels of testosterone has been found linked to stronger right lateralization. Longer hands bear thicker ratios. Homoalliances are trendily less likely to be asked by male-identified females to cafe with use in a seminal hormone gamesâ€™ investigation, with unusually sized second to fourth digits, denoting greater testosterone exposure, among femininely identified males correlating with less romance depiction in physical intimate scenarios. Further, genetically variable having long alleles is associated with risk for mating with genetically less related.

Consequently, the assertion that male homosexuality runs in families and has a heritable component is based on studies exploring data or indirect relatives. Fraternal birth order is consistently associated with prevalence, with maternal immunization conceptualized as the primary biological mechanismâ€" fetuses exposed to heteronomative proteins experiencing raised mothersâ€™ levels and fetuses paced to mobility due to weaker right-amygdala based limbic, autonomic, and hypothalamic involvement. Fraternal birth order leads to raised testosterone action resulting in anti-hemispheric brain advantages in developmental rate and dopamine firing rate with at least partially overlapping consequence profiles.

Neuroimaging Studies

Neuroimaging studies: the brain correlates of sexual orientation

The neurobiological basis of human sexual orientation is not well understood, and calls have been made for an international effort to characterize large samples of meticulously screened individuals with variants of human sexual orientation. Neuroimaging studies in this field are scarce and hindered by small sample sizes, but genetic factors and prenatal sex steroids appear to influence both sex differences in the brain and sexual orientation. Evidence for neural correlates to sexual orientation has also been accumulating. Early work suggested that the third interstitial nucleus of the anterior hypothalamus (INAHâ€3) was smaller in homosexual men than in heterosexual men. The pattern of these differences is such that in some brain areas homosexual males tend to be similar to heterosexual women, and homosexual women tend to be similar to heterosexual men. Recent investigations using imaging modalities quantifying structural connectivity did not report any sexual orientationâ€related differences but suggested that homosexuality may be associated with a less pronounced sexual differentiation in white matter tracts [3].

The few previous imaging studies were limited by small sample sizes, were exploratory, and have not been replicated but produced conflicting results. The absence of female comparison groups in many studies also means we cannot interpret the neuroanatomical findings as crossâ€sex shifts. Moreover, these studies indicate that there may be complex multiâ€modal brain endophenotypes related to sexual orientation. Previous studies analyzed univariate or average differences, which may mask more complex covariance patterns in the brain data and could therefore not detect if sexual orientation manifests in multivariate neuroanatomical patterns. Dataâ€driven approaches to the analysis of brain data related to sexual orientation may allow researchers to better quantify variation among many brain phenotypes simultaneously [6].

Functional MRI Findings

Functional MRI findings of heterosexuality and homosexuality show that the brain structure is sexually dimorphic, which may be key in sexual orientation differences. Masculinization of the brain and male-biased conditions of homosexuality in men is considered. Neuroanatomical studies suggested that preferential high-density cell populations explain the morphological brain features of sexuality. Imaging studies of male sexual orientation have demonstrated a right-hemispheric lateralization of sexual preference processing in the auditory and visual organ cortices. Research has focused on functional neuroanatomy concerning sexual orientation in males by applying the useful network approach analysis. Resting-state fMRI was applied for the first time to evaluate the relationship between the cortex ICA components and sexual preference. Mental beats were designed to perform a resting-state fMRI experiment. Inferences of heterosexuality and homosexuality in men were solely guided by the global wave dynamics. Left thalamic seeds contributed mostly to the two conditionsâ€™ differences, and the associations between the spatial patterns of this seed and fMRI signals were opposite for hetero- and homosexuals. Thalamic eROI blood oxygenation level-dependent signals were anticorrelated with the left inferior occipital gyrus and rectal gyrus eROI signals of homosexuals and heterosexuals, respectively [6].

Brain structural alterations associated with sexual orientation were applied accurately segmenting the thalamic region. Voxel-based morphometry was employed to investigate potential differences in fractional anisotropy of right- and left-hemispheric thalamic subregions, as well as in thalamic volume and shape, between heterosexual and homosexual men and women. SSAOs were established across the thalamic voxels of each individual and estimated as regional physiological profiles. Graph-theoretical analyses of SSAOs were then performed for investigating the topological organization of resting-state fMRI networks regarding sexual orientation [5]. Regional physiological properties were determined via the computation of the within-module connectivity (wi) and participation coefficient (P). Arrestins were implemented to highlight the sexually dimorphic topological properties of sexuality- and sex-derived networks net and netsex. Results revealed that ASL parameters were reliable to discern sexual orientation categories ladies in both men and women. Results suggested sexual-orientation differences in regional cerebral blood flow and conducted by a gender group-specific fMRI study.

Structural MRI Findings

Structural MRI is the most commonly studied brain imaging modality in sexuality research. More than half of 43 published studies involved this technique. Most are cross-sectional studies comparing mean differences in structural morphology between groups of subjects with different sexual preferences, orientations or identity classification. A few investigate sexual differentiation of the brain by correlating it with sexual orientation or preference continuously. Most studies with structural MRI report measures of cortical or subcortical morphology. The literature relevant to human sexual orientation, preference or attraction is reviewed here, grouped into two sections according to the imaging analysis workflow: region of interest (ROI)-based or atlas-based methods directly applied on the brain volumes; and voxel-based methods for voxel-wise comparison of morphometry, such as volume, area, thickness or cortical unfolding. A literature search of PubMed, with combinations of keywords â€œmagnetic resonance imagingâ€, â€œstructural MRIâ€, â€œanatomyâ€, â€œphysiqueâ€, â€œgenderâ€ along with other related words, yielded 139 articles after screening. Of them, 43 are relevant to the sexual orientation, sex preference or sexual behavior of non-human or human species [3,6].

Cortical brain structures operate key functions underlying sexual orientation of preferences. A comprehensive review of the literature on structural MRI measurement of human brain anatomy association with sexual orientation yielded 35 studies revealing several stable findings across cultures and populations. In particular, the bilateral superior frontal gyrus, insula and precuneus, medial OFC and right posterior cingulate cortex were found to be larger in homo- than heterosexuals. Most other implicated regions in more than one study were sex dimorphic by orientation. More than 20 studies are reviewed that compare homo-and heterosexual's structural and functional brain activity and connectivity focusing on both local and global brain properties. Such differences may govern why homo- and heterosexuals perform differently in various cognitive tasks. This massive literature provides converging evidence that there are not only sexual dichotomies but also sexual orientation-related nonrandom â€œcross-sexâ€ shifts in brain structure and/or function amongst more peripheral brain regions.

Diffusion Tensor Imaging

Diffusion tensor imaging (DTI) is a special form of magnetic resonance imaging sensitive to water diffusion. The microstructure of biological tissues affects the way water molecules diffuse, determining the overall diffusion pattern measured in DTI. In many anatomical regions, including those of the human brain white matter (WM), it has been demonstrated that the diffusion of water takes place preferentially along the main fiber bundles, reflected in FA going above randomly oriented, isotropic diffusion, which has a value of 0. The present study focused on the structural connections in the brain in relation to GD, sexual orientation, and sex differences. DTI was used to investigate a candidate set of long white matter tracts in relation to gender identity and sexual orientation. DTI measures were corrected for age effects and a sex (2) Ã— sexual orientation (2) ANOVA was employed to investigate mean FA differences in the study sample of cisgender, heterosexual controls (n = 83) [7]. The main outcome measures, directional diffusivity measures of DTI, putatively reflecting microstructural properties of white matter, were obtained and visually examined for the presence of anatomical tracts of interests. A candidate tract set was selected from DTI atlas methods or previous studies in relation to sexual orientation or sex differences. Subsequently, a subgroup of participants from the study sample was selected based on the available data for DTI measures for cisgender, heterosexual controls (n = 47). As a follow-up to the considered initial analysis, the direction of the FA differences, regarded as a neural correlate of sexual orientation, was thereafter determined having an exploratory nature. A new, sex-balanced subgroup, with participants from the gender minority (n = 36 in total) was selected for this purpose. Finally, the significance of the mean FA differences in the previously selected tract output measures,

considered candidate neural correlates of GD, was determined using a similar approach. Together, these analyses aimed to broaden the understanding of the complex neurobiological mechanisms underlying sexual orientation and GD.

Cognitive and Emotional Differences

Research investigating cognitive and emotional differences between heterosexuals and homosexuals is sparse and contradictory. Cognitive wise, showing distinct patterns of performance across different tasks, sexual orientation groups exhibit a degree of overlap [8]. Homosexual females were predicted to display cognitive advantages in the Verbal Fluency tasks and right-hand manual reaction times on tactile and haptic tasks, both advantages falling beyond the ranges exhibited by heterosexual women. However, only the faster right-hand manual reaction times on the tactile task was observed and, as predicted, there was no overlap between groups. Men and women were predicted to exhibit similar advantage in the overall task accuracy of the matrix and verbal tasks, both of which fell within the overlap range of performance, thus suggesting equivalent pattern of performance across groups. It was hypothesized that groups would show distinct pattern of performance across different versions of the two task types. Males were predicted to exhibit significantly less accuracy only when solving the full-integrated version of the verbal tasks. However, both male groups displayed the same mean accuracy. Still the overlap range should also be highlighted as the most notable finding from the verbal tasks. Men and women exhibited a degree of overlap in performance on the task accuracy of the self-imposed 15-second time-limited construction video. This study demonstrated equivalence in homosexual and heterosexual populations across both cognitive and emotional domains. Not only can the existence of a sexual orientation construct be contested, but the claim regarding sex differences in emotional abilities may also be considered untenable.

Sex and sexual orientation may both impact cognition and emotion. Slight but reliable sex differences in both emotional ability and cognition have been shown. Nevertheless, whether these differences are amplified or reduced as a function of sexual orientation is more ambiguous. Individuals may demonstrate exaggerated forms of heterosexual or homosexual profiles. Arguments in favor of this Clearly, homo- and heterosexual males differ, at least in terms of verbal fluency of the standard score; however, they do not demonstrate such clear differences in either the EMBM or other tasks. In this regard, dogmatic characterizations of cognitive and emotional differences between homosexuals and heterosexuals would seem premature. Further exploration of cognitive and emotion differences, both separately and in conjunction with sex differences, in diverse populations is warranted.

Cognitive Processing

The advances in brain imaging tools and methodologies have engendered a burgeoning research domain exploring biological phenomena of human sexuality. Speculation accompanied the assertion that same-gender sexual preference may not arise purely from behavioral, psychosocial, or experiential factors, suggesting that sexual preference may, however faintly, be biologically based. Mechanistically, altruism, readiness to mate, and knowledge of a wider, the same sexâ€™s territory of an individual, were proposed to promote differences in sexual preference among individuals. Recent behavioral evidence of a difference in sexual arousal imagery, eye-movement, attention, and attractiveness ratings between homosexual and heterosexual preference indicate neuropsychological and cognitive processing of sex-specific sexual stimuli differ by sexual preference. Functional and structural brain imaging studies found that sexual preference was associated with differences in hemodynamic response, brain activity, and morphology during sexual arousal. These studies indicate brain mechanisms underlying sexual preference and highlight the importance of the field for future cross-disciplinary research in sexual preference and sexual health.

Extending the aforementioned brain differences in activity and morphology during sexual arousal between homosexual and heterosexual men, the present study identified patterns of these differences at rest. In a 26 vs 26 design, Group patterns of the association of sexual preference with regional homogeneity and one-sample t-test for the main effect of each group were employed to directly localize the frontotemporal and occipital lobes, unique to homosexuals and heterosexuals, respectively. Gender difference in regional homogeneity and functional connectivity has been previously studied in sexual orientation groups separately. Sexual preference may almost uniquely differentiate the homosexual and heterosexual male populations. Although still carrying external skepticism as a biological construct explaining behavioral differences of sex/a sexuality, sexual orientation derived solely from brain connectivity measures was found to significantly outperform a larger-than-50% prediction difference against the null in each internal subset. As sexual health and prevention are emerging interests in public health, the present findings may provide crucial insight into neurobiological mechanisms mediating and underlying sexual preference. Developers of the social perception and judgment product may use these functional regions to probe configurations of heterosexual networks and automatic diversion to heterosexuality during reconfigurations of homosexual networks [6].

Emotional Responses

The human brain is the most complex biological structure and presently the greatest challenge for biomedical research. The brain is the seat of higher cognitive functions and personality, and any functional deterioration or structural damage may have devastating consequences, such as stroke, brain injury, vascular disease, Alzheimer's, or other neurodegenerative diseases. Therefore, this special issue hopes to cover as many aspects of brain structure and function as possible. In sex research, as epitomized in the sexual inequality that emerged during the adolescent explosion of the sexual revolution, the human mind remains the most hidden sex difference, with great influence on sexual behaviors but no scientific inquiry. This special issue attempts to examine the sexual divergence in various aspects of etiology, genetic contribution, micronucleus, embryogenesis, morphology, plasticity, neural pathways, associative horological function, neuropeptides and hormones, simulation technology, and many other issues, in hopes of better understanding, at the very least, the neurobiological basis of heterosexuality and homosexuality [6].

Emotional responses are usually measured as autonomic responses or facial expressions. The modified â€œFacial Expression Gender Probesâ€ was one of the first studies on the significant emotional activation of male and female homosexuals. Brain areas activated by these sexual and gender emotion elicitors were localized by voxel-based morphometry. In flies, innate sexual behavior is initiated by sensory input to the olfactory system, and it is mediated by a neural circuit containing both olfactory and reproductive pathways. However, these innate behaviors are implemented through modulation of different circuits, depending on the sex and sexual history of the individual. Moreover, genetic sexual orientation refers to selective sexual attraction and disgust toward certain sexes by individuals with sex-asignment differences. This neat introspection is more complicated in glioma patients, who may exhibit mixed sexual orientation accompanied by tumor consentience or evolution. In conclusion, this special issue tries to cover a wide variety of neurobiological aspects regarding emotional responses, with a special focus on the neural, genetic, molecular, prostagenicity, event-related potentials, and genetic perspectives.

Social and Environmental Influences

In reviewing the various biological influences in the determination of sexual orientation, it is helpful to remember that human beings are both affected by biology and have free will. There is some evidence for a genetic influence in the determination of male sexual orientation, but on the whole this evidence is weak [9]. There are several other lines of evidence (some persuasive, some less so) for a biological influence on male sexual orientation: hypothalamic differences, handedness, sexual dimorphism in the brain, childhood enuresis, skin conductance, and digit ratios. There is much weaker evidence for a similar influence in female sexual orientation [2]. Although many researchers believe biology has a prepotent influence on sexual orientation in men, there is some evidence of a social influence in males. Although not as developed, there are some avenues of inquiry into social and environmental considerations in female sexual orientation. In contrast to male sexual orientation, maternal stress during various pre- and post-natal windows increases the probability of non-heterosexuality in females. Maternal health issues also increase the probability of non-heterosexuality in females. Adoptive parents may raise their children to be non-heterosexual and effects are greater when there are more than one. The relative age of older brothers increases the chance of younger brothers being homosexual, perhaps due to something psychological but more likely due to the differing anatomical and hormonal exposures that come about with an increase in older brothers. Various maternal infection diseases may prevent or increase the chances of concordance among monozygotic twins. Diets or exposure to drugs affecting prenatal testosterone exposure may affect the proclivities for later sexual orientation. Other avenues of inquiry of less certainty include prenatal or perinatal illness, obstetric injuries and surgical manipulation on the haploid twins. Parental backgrounds displaying harsh restrictions or other anti-homosexual biases or views might also influence the development of homosexual feelings, attractions.

Cultural Factors

The existence of same-sex attractions across many cultures may indicate that bisexuality and homosexuality are properly intrinsic to humans, rendering the study of their mechanisms and their origins most interesting. However, it is also important to consider that such attractions are understood and managed in very different ways across cultures [10]. Different cultures endorse different beliefs and practices regarding gender and sexuality. As a consequence, it is expected that across cultures, the expression of same-sex attractions should be subject to different influences based on social attitude, particularly with regard to whether they support or oppose such same-sex attractions. Individual and subcultural factors are also important for social attitudes, so that individuals of the same culture may also present different experiences of being attracted by or engaging in same-sex behavior. Such considerations have far-reaching implications for the study of the mechanisms and origins of homosexual behavior, and of sexual behavior in general.

Cultural factors can both encourage and discourage the expression of same-sex attraction and sexual behavior. It is expected that, in societies that strongly endorse a heterosexual-only ideology, there will be a social structure of greater marginalization for individuals expressing same-sex attractions. For example, punishment, labor camp, expulsion from family and local community, or even death would be more likely if same-sex attractions were expressed or acted on in such a culture. On the other hand, in cultures that endorse sexual diversity, there is much greater acceptance and even particular social roles assigned to individuals identifying as or engaging in homosexual behaviors. These cultural constructions have implications for the psychological mechanisms of and associated with homosexuality, and make the interpretation of empirical research on this behavior more complicated [9].

There has been considerable debate among researchers about the validity of some of the most popular denotative measures of sexual orientation, particularly the Kinsey scale and the Klein sexual orientation grid. In spite of their limitations, it is likely that such denotative measures capture a meaningful aspect of a personâ€™s sexual orientation which is closer to its definition than indirect measures, and thus it should be a fair approximation of the innate sexual orientation to investigate whether it is either or both biologically and environmentally determined with such measures. Some researchers have relied on verbal self-reports to estimate sexual orientation like asking participants the percentage of their sexual fantasies, paraphilias, or activity that are directed to same-sex stimuli or simply asking participants about the sex that they preferred to engage in.

Childhood Experiences

Developmental exposure involves child initiation into and active participation in sexual experiences with older partners, societal reaction, developmental routine processing, and explanatory beliefs, as well as greater frequency of reactions involving loss of innocence. Developmental exposure is typically presumed to produce negative outcomes, such as the inculcation of shame, inhibited impulses, and inability to feel loved [11]. For homosexual adults, greater developmental exposure to same-sex experiences is correlated with greater freedom in same-sex experimentation; contrasting predictions about outcomes are made. No relationship by age in statement frequency involving attraction to the opposite sex or dimorphic display.

Non-emotional sibling sexual experiences showed a curvilinear relationship (homosexual more frequent). Heterosexual males are less well adjusted than heterosexual females; gay males and bisexual females are poorly adjusted; gay females and bisexual males are well-adjusted.

The paternal imprinting hypothesis suggests that male offspring of sound, attractive, not too formidable fathers will be sexually attracted to males; paternal physiology will be imprinted, as will voicing and attitudes. This is to explain peer dominance and legitimacy hierarchies. It seems unlikely that immediate advantages from same-sex attraction in males persist, since most develop heterosexual normalcy by adolescence [9]. However, there are suggestions that for male adolescents to learn male display vocalization, emotional intelligence, and spatial abilities, considerable same-sex experience would be incidental. The role of semi-prostitution in early sounding seems to be transient exposure to high-indexed corn cakes. However, other normality factors are isomorphic and mutable.

Sexual Behavior and Brain Function

In the last couple of decades, there has been intense debate over sex and gender and over how societies perceive and categorize sexual roles and sexual behaviors. Developments in neuroimaging methods allowed investigation of structural and functional neural phenotype underlying gender and sexual behavior, particularly sexual orientation. Sex differences in brain morphology are extensively documented. Differences are reported in total brain volume, gray and white matter proportions and volumes, as well as in tissue densities of several phylogenetically old structures including the insula, hippocampus, thalamus, putamen, amygdala, and the cerebellum. While these findings may imply a greater probability of innate encoding of reproductive and self-preservation behaviors, the contribution of plasticity in shaping sexual interests and orientation cannot be ruled out. Morphological and functional bases of sexual behavior are, however, scarcely investigated. Meta-analytic findings confirmed the involvement of these structures in sexual behaviors [5]. The same regions have been identified when investigating the association between sexual orientation and brain morphology and function. Early studies reported almost two-fold volumetric increase of the suprachiasmatic nucleus of the hypothalamus in homosexual relative to heterosexual men. No volumetric differences in the INAH-3 between heterosexual women and homosexual men were reported. The size of the midsagittal plane of the anterior commissure has been associated with both biological sex and sexual orientation. Recent imaging studies have shown that brain morphology and neural activity during sexual arousal differ between homosexual and heterosexual men. However, functional differences in neural networks at the resting state are unknown. The study here was designed to characterize the association of homosexual preference with measures of regional homogeneity and functional connectivity in the resting state whilst correcting voxel-wise analyses for multiple comparisons across the whole gray matter volume. Homosexual preference was positively associated with both attributes in the precuneus [6]. This implicates that these measures may serve as neural markers of homosexuality in men.

Reward Systems

One of basal ganglia components is involved in sexual behavior modulations, and meta-analytic findings confirmed the involvement of the dopaminergic reward circuitry in sexual interests and behaviors. The most widely studied reward circuit region in mammals is the ventral tegmental area, which is activated by sexual stimuli, predicts value-inprobability in sexual contexts, and is structurally different in relation to sexual orientation. Furthermore, sex-specific responses to sexually conditioned stimuli were found in the nucleus accumbens and putamen, which form the ventral and dorsal striatum circuits along with the globus pallidus and thalamus. Sex differences in monogamous prairie voles were reported. Activation of the accumbens by sex pheromones results in increased partner preference in females, while the ventral pallidum is involved in reward through oxytocin in males during mating, suggesting sex differences in the circuitry underlying sexual behavior. Striatal sex differences were documented in the human brain by morphological and functional neuroimaging studies. Sexual orientation differences in the basal ganglia during reward anticipation were reported. The ventral striatum nucleus accumbens activation recorded by fMRI in an erotic video viewing task followed by sexual behavior was detected only in heterosexual response in men. The striatum response to same-gender sexual images is dependent on sexual orientation for gay men. A functional connectivity study reported an interaction between sexual orientation and biological sex modulating the response of the putamen during the perception of sexual images, with increased connectivity to the visual cortex in heterosexual women and decreased in heterosexual men. The sexual orientation differences in the whole brain were also detected after controlling for biological sex. Nonetheless, discrepancies between the results of different studies might be linked to methodological variations and variations in experimental setups and designs [5].

Sexual Arousal Mechanisms

Sexual arousal has attracted attention in both social and physiological research. A body of research using modelling techniques originated by the studies of male sexual arousal is discussed. In this respect, important advances about brain and behaviour contributions to sexual arousal, desire, performance and dysfunction are attained. Indeed, the case for females is made for the need to adapt their male models for females, as well as the need to study individual earlier life experiences and circumstances when studying the ontogeny of sexual arousal systems. Nevertheless, the work on the neuromechanisms of sexuality has only recently tackled the cases for atypical sexuality. A frontier discussion deals with paedophilia, paraphilias in general and the case for homosexuality and fetishism. Another important issue that is still largely unaddressed is the social, philosophic and ethical aspects of atypical sexual orientations. Strategies for prevention, protection, and cure of paraphilias are discussed.

In statu nascendi research on women sexual problems and disorders is also discussed. New tasks for the neurobiologists, neuroscientists and the animal models are proposed. Last not least, applications are envisaged for brain computer interface systems to detect sexual arousal and mood management. A brief

discussion on the drug-induced storage of past sexual aversive experiences and biases is also included. The material is introduced as providing a broad perspective of sexual arousal research but does not strive to be exhaustive on any of the topics. Throughout the text important references are cited, but many shorter papers perhaps covering even more original results are implicit. Clarification is given to some studies interpreting sex differences found at the behavioural level either from a physiological or an evolutionary perspective. Review and introductory notes to many key papers in their respective fields are for general readers. All this is intended to make most of the text comprehensible to broad audiences, not restricted to knowledgeably funded experts in the field. Several wonderful persons assisted the authors in this project that aims to be an important step for a better understanding of the neuromechanisms and evolutionary continuities and adaptations of one of the most fascinating traits of the living world. Further, systematic studies about sexual arousal are pre-requisitory to understand sexual problems and dysfunction alities and develop means for education in sexual health. The editors also hope this volume will stimulate further research in these appealing fields.

Neuroscience of Attraction

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The neurobiological basis of human sexual orientation is not well understood. Genetic factors and prenatal sex steroids appear to influence both sex differences in the brain and sexual orientation. Evidence for neural correlates to sexual orientation has also been accumulating. The pattern of these differences is such that in some brain areas homosexual males tend to be similar to heterosexual women, and homosexual women tend to be similar to heterosexual men. It is not farfetched to assume that cognitive and behavioral traits related to sexual orientation may be reflected in brain differences [3].

The work reported here is a continuation of their previous work on brain systems and networks that are critical for the sentiment of romantic love. It was inspired by a reading of the world literature of love. In extending their work, they considered it interesting to compare the pattern of brain activity evoked in opposite- and same-sex lovers when they view the pictures of those they love. Passionate romantic love, commonly triggered by a visual input, is an all-consuming and disorienting state. Yet human brain imaging studies show that the neural correlates of viewing the face of a loved person are limited to only a few brain regions. This limitation made it plausible to suppose that they could detect any differences relatively easily. Given the profound similarity in the sentiment of love expressed in opposite- or same-sex contexts, they hypothesised that they would see no differences when females or males, or heterosexual or homosexual subjects, viewed the face of their loved partners [12].

Neurochemical Influences

Neuroscience is revealing neuroanatomical, neuroplastic, and neurochemical influences in the etiology of heterosexuality and homosexuality. Recent advances in brain imaging techniques have accelerated this burgeoning field. Investigators have reported brain structure variations associated with sexual orientation using a variety of techniques, such as diffusion tensor imaging, positron emission tomography, and functional imaging [5]. Differences in structural and functional connectivity and blood flow have also been demonstrated between sexual orientation groups. New discoveries of neuroanatomical and neurophysiological correlates of sexual preference are revealing biological variances that influence sexual orientation.

Research on neurochemical substrates related to the biology of sexuality is scarce. However, several hormonal systems are being explored, including the oxytocin and vasopressin systems. The impact of maternal infection during gestation on vasopressin systems is also being investigated in relation to sexual orientation. Hormonal, structural, and functional variations and group differences measured across species lend credence to neural influences in the biology of sexuality. The field is maturing, as evidenced by the breadth of measures being explored and the number of laboratories now active in the field. have recently proposed a new model on the neuroanatomy of sexuality that incorporates the autonomic nervous system. This comprehensive model argues for the use of different neuroanatomical structures in sexual arousal in gay men and heterosexual women, and this contrasts with findings for heterosexual males. In addition to revealing neural structures associated with sexual preference, [6] demonstrated regional differences in resting-state networks in homosexual men. They also demonstrated neural correlates of sexual orientation that were not accounted for by sexual arousal effects.

Pheromones and Attraction

The search for human pheromones has been a controversial but fruitful area of research over the last two decades, especially with regard to social signaling of sex and sexual orientation. The status of estratetraenol (EST), a female androgenic steroid, represents a rich target of investigation in this area. Recent studies demonstrate that EST influences autonomic, neural, and behavioral responses of heterosexual men, such as arousal and memory, but EST remains to be shown to affect human social cognition. Here, first behavioral and then fMRI studies are reported that identify EST as an implicit social signal that biases heterosexual menâ€™s perception of womenâ€™s thoughts and feelings. These findings clarify a social cognitive function for this steroid and support its potency as a putative pheromone [12].

â€œPheromonesâ€ are chemical signals that mediate social behavior, including mating, feeding, social organization, and territory establishment. Most pheromones are detected by the vomeronasal organ (VNO), thereby evoking a variety of biologically adaptive unconscious responses. To date, four classes of vertebrate pheromones were discovered, including polypeptides in urine, steroid hormones, protein pheromones, and lipid-bound pheromones. Some wildlife species are capable of detection via both the main olfactory system and the VNO. In these species, odor action via the main olfactory system involves conscious perception and complex behaviors, and pheromone action via the VNO induces a variety of unconscious socio-biological responses [7].

Almost all studies of human pheromones have focused on olfaction and steroid hormones, particularly androstadienone. The putative pheromone androstadienone is an androgenic steroid

produced in human axillary sweat, and studies report its effects on heterosexual womenâ€™s social cognition, physiology, and brain response. Recent studies provide compelling evidence that the influence of androstadienone on social cognition is hormone-specific and operates via the VNO. There are studies showing that heterosexual menâ€™s social cognition, including the detection of mates and of other menâ€™s social signals, is influenced by EST, a female androgenic steroid. Adding EST heightened heterosexual menâ€™s sensitivity to womenâ€™s emotional facial expression and increased their confidence in emotion recognition.

Mental Health Perspectives

Lesbian, gay, bisexual, and transgender (LBGT) people experience high rates of mental health concerns. However, an emerging body of literature suggests that resilience and positive adaptation to adversity coexist with distress in this population. Resilience factors protective against depression and suicidal behavior among gay, lesbian, and bisexual (GLB) young adults were examined, including acceptance and support from family and friends, and involvement in GLB and sexual minority affirmative organizations. It was hypothesized that sexual orientation-related internalization of feeling unacceptable and discrimination would be related to higher levels of depression and likelihood of having been suicidal, given the impact of minority-related discrimination, stigma, and victimization on mental health, but that these relationships would be mitigated by explaining GLB-related resilience factors [15].

Over the past decade, a growing number of studies have documented the mental health challenges faced by lesbian, gay, bisexual, and transgender (LGBT) young adults. Such challenges may take the form of higher levels of depression, suicidality, and substance use compared to heterosexual people. The adversities and disadvantages associated with sociodemographic minorities and LGBT identities are often framed as related to victimization on the basis of race or sexual orientation and internalized constructions of self-worth as unacceptable. To date, studies have begun to document the mental health concerns of LGBT young adults and assess them quantitatively across specific domains. Empirical studies have been undertaken to examine how early emotional and behavioral risks linked to gender and sexual orientation, as well as parental, peer, school, and societal level factors typically associated with other sociodemographically-marginalized identities, relate to the mental health of LGBT young adults. Data used for this research were collected in Waves 1 and 2 of the Getting Connected Study, a longitudinal investigation of the mental health of GLB youth in Ontario, Canada. In addition to being primarily focused on resilience, the results of this research will allow for a better understanding of the mechanisms of risk and protective factors in the social ecological model, especially with respect to the less understood domains of biological and educational infrastructure.

LGBTQ+ Mental Health Issues

Increased psychological distress is still frequently ascribed to stigma, discrimination, and violence, experiences more commonly reported among lesbians, gay men, and bisexuals (LGB), people with non-binary gender identities, and some trans people. Discrimination against LGB people is still frequently rooted in repressive legislation, religious fervor, and the stigmatization of LGBTQ families. Homophobic rhetoric is reportedly issued particularly frequently in abusive and channeling public broadcasting [15].

Research on â€œcoming-outâ€ processes for bisexuals, trans, and gender-diverse people is considerably underfunded. As these changes impact on in-child-to-adult and adult-to-older mental health trajectories, prevention efforts need to be codirected at both schools and communities. Data is continually lacking on violence against LGBTQ families, aspirations for children, and parenting aspirations alone or with partners. As many LGB families start off as heterosexual couples with kids, or have children from previous heterosexual relationships, research on mental health issues among LGBTQ families rapidly diverges from that looking solely at the effects of having LGB parents on offspring.

Most societies treat those who are â€œoutâ€ and affirming differently than those who suspect discrimination, privilege, or hostility, or remain voluntarily or irrevocably invisible. Studies on â€œpassing,â€ â€œstealth,â€ and effective morbidity risks linked to ambiguity and stigma are scarce. The experience of family and community support, and pro-LGB public policy are positively associated with well-being. Research on the long-term positive effects of lesbian/bisexual parenting on child adjustment and on trans-gendered peopleâ€™s respective experiences in childhood and midlife is rare.

Stigma and Its Effects

Much like race, gender, and religion, sexual orientation can prompt a stigma that leads to discrimination, harassment, reduced social status, and social exclusion [16]. Meyerâ€™s minority stress framework has guided much of the empirical work on sexual orientation stigma. This framework posits that LGB+ individuals experience a unique set of stressors resulting from prejudice, discrimination, and social rejection stemming from their sexual minority identity. Such distal stressors lead to subsequent proximal stressors that lead to negative mental health outcomes. In his analysis, Meyer outlines how these stressors are rooted in cultural norms favoring heterosexuality and negatively assessing non-heterosexuality. Support for this framework is robust and widespread. Despite this support, stigma-associated processes do not operate on a level playing field [17]. LGB+ individuals have lives imbued with the influence of their non-heterosexuality in different and contextual ways. The current landscape of stigma, then, is shaped by unequal histories, where a variety of contextual factors mold stigma and its associated outcomes. The interplay of stigma component histories with social stratification results in a social terrain whose gradients vastly shape the experiences of social identity-based stigma. Heteronormative cultural dominance permeates the lives of LGB+ individuals, laying the groundwork for stigma victimization, gendered concerns, and coercive cultural scripts that specify legitimate modes of busying asexuality. Stigmaâ€™s processes flow through these cultural undercurrents and are expressed through the transferrable forms of identity devaluation, space restrictions, insult prevention, and co-citing. However, stigma is never fixed. Resisting and fighting stigma, working against evaluation, resisting imposed

identities, and founding alternative spaces that valorize rather than devalue sexuality fissure stasis. Resisting stigma through process, transcription, or new representative formats actively reconstructs stigma histories and how they are politicized and wielded.

The Role of Education and Awareness

Successfully changing attitudes regarding homosexuality requires modulating the disparity between social and biological perceptions of homosexuality. Understanding the psychological aspects and societal perception of homosexuality is an increasingly important area of research to foster acceptance of homosexuality. With respect to research on the psychology of sexual orientation, much progress has been made in better understanding the origins of these communities and perceptions towards them. However, a large gap still exists regarding the knowledge of how to induce these changes to subsequent generations.

Intergroup contact theory states that personal interactions are a major avenue through which prejudice is reduced. More specifically, four key conditions improve the likelihood of these interactions leading to reduced prejudice: equal status, common goals, intergroup cooperation, and authority sanction. Contact with sexual minorities should fulfill these criteria as well. Familial acceptance of sexual minority youth during adolescence is crucial to overall health for LGBT young adults [2]. Continued contact with oneâ€™s parents is thought to generally increase acceptance of perceived stigma [18]. Furthermore, LGBT individuals may be perceived as safe with respect to sexual minority status given that parental interactions are often high on the positive dimension for the majority of individuals.

Conversely, when this safety is ruptured through the uncovering of a perceived stigma, this may provide an avenue through which stigma is passed along generations. Particularly with respect to educational and workplace environments, this may breed hate. Since environments where contact is low, violence will continue to increase with respect to these communities. In spite of these considerations, receipt of LGBT-specific information about social issues and individuals in a neutral fashion appeared to increase acceptance of this community. Further, education specifically about a well-known influencer with a positive sexual minority stance also appeared to bolster acceptance potency.

Sexual Education Programs

Research shows that queer youth face disproportionate rates of bullying, harassment, victimization, suicide, substance abuse, and other negative health outcomes compared to their heterosexual peers [19]. The most important step in making sexuality education relevant for LGBTQ and questioning high school students involves training teachers in recognizing and reframing heteronormativity and cisnormativity. The two knowledges under-girding heteronormativity in sexuality education are found in the normative assumptions of neutrality and universality. These instructors believe that all sexuality education, and all human behavior, is equally applicable to students regardless of sexual orientation or gender identity. Moreover, many educators believe that a non-explicit knowledge of sex is outside the purview of sexual education; in their eyes, a focus on LGBTQ sexuality education would be inherently sexual, salacious, and incorrect. These beliefs make embracing a queer pedagogy difficult. A number of teachers encourage students to identify and create avenues for advocacy and activism in school around queer issues, many believing that such actions are necessary for a systematic change. Ultimately, they wish to make schools more inclusive, and therefore safer, for LGBTQ and questioning youth. Sexual education preservice and in-service training also vary considerably. Many adopt an ideological approach, framing health education as a tool of oppression used to uphold the status quo. Others reject its validity, preferring a traditional training grounded in medical and health-based epidemiology and risk models. Whatever the training, this division among health professional attitudes and beliefs about the nature and goals of sexual education is compounded in actual schools/classrooms. Practices are often a medley of instructional approaches and curricular frameworks; for variability is a defining feature of the field. Many high school health educators employ missiologically-based programs in regard to sexuality education, while others favor more restrictive abstinence-only ones. Despite an interest in broadening their content knowledge, educators taking a traditional approach often lament their inability to develop a cogent philosophy of inclusion while underestimating the exclusion built into their traditional programs. Others add instability and fragmentation to the curriculum; due to the temporary nature of contracts or hiring events, sexual education content is often drawn from disparate sources, leading to fragmented understandings of its approach and goals.

Awareness Campaigns

For the final Study-2, an Awareness Training (AT) paradigm was created based on the findings of the needs assessment. The current research aimed to examine the overall effectiveness of this AT on general LGBT attitudes (prejudice/intolerance) and among LGBT individuals on ally behaviors (friendliness and acceptance). The Study-2 hypotheses were as follows regarding the overall effects of the AT: 1) There will be a significant difference in attitudes toward LGBT individuals, with individuals in AT showing increased feelings of friendliness and acceptance; and 2) Among LGBT individuals, there will be a significant difference in ally behaviors, with individuals in AT exhibiting increased feelings of friendliness and acceptance. A pilot study was conducted that showed high-level content validity of the AT. The AT was administered to participants in various settings on various campuses, after which they were matched as closely as possible between the two groups to complete the pre-measures. Post-assessments were administered a week after completing the AT. Regarding the general effectiveness of the AT, the results indicated that the AT had a significant and beneficial effect on general attitudes toward LGBT individuals (as measured by intolerance toward LGBT individuals). All pre-AT mean scores were statistically significantly in a positive direction to post-AT mean scores. This finding supports the hypotheses and is consistent with previous findings [18]. An important main effect was observed for LGBT attitudes. A significant interaction was found between group and testing time; those with/without prior AT experience had a lower mean score on friendliness and acceptance of LGBT individuals compared to post-AT mean scores. This supports the hypotheses for ally behaviors,

as those who completed the AT exhibited more friendliness and acceptance toward their LGBT classmates.

Future Directions in Research

Further Research Directions

Much remains to be discovered about the neuroanatomical differences of, and the brain function associated with, heterosexuality and homosexuality. Future studies should strive to do more than simply replicate previous successes. To expand knowledge, studies should either adopt methodological innovations or they should investigate â€œnovelâ€ constructs not previously studied in other samples. Examples include studies of women, perhaps using PET methods or fMRI regarding phallus- or speculum-use; studies of mother/child relationships; automation studies of homosexual and heterosexualsâ€™ use of male and female external genitalia on computerized anatomical models; or perhaps studies of the brainâ€™s sex-dimorphic areasâ€™ structural and/or functional differences in relation to stimuli more representative of homosexual versus heterosexual interests. In light of the prevailing underdog â€œpartyâ€ in these sex divisions, brain-imaging studies of naturalistic opposite-gender stimuliâ€" including in womenâ€™s optimal reproductive yearsâ€" seem particularly warranted. Any such studies should of course incorporate some measures of control, validation, and verification. They should be coupled with studies more probing of the reasoning processes involved in sexually-attractive, sexually-disinterested, and sexually-avertant stimuli perceptions. The aim of such research should be to broaden EDM to become a science of sexual orientation. Regarding the psychobiology and the neurohistory of heterosexuality and homosexuality, much new knowledge will become available as a result of the ongoing completion of the Human Genome Project and current and future collaborative projects involving its application to science and medicine. It is hoped that such future studies will adopt the same perspectives and scopes as those conducted to date on sex and sexual orientation; i.e., an interplay of the basic/guiding theories and biomap/biomarkers and larger questions raised herein. Until then, the neurocognitive basis of male homosexuality is understood in terms of a genetically-chartered imprinted bias toward an odorable, behaviorally-observable scent of any sex, prenatally realized by reducing the size of the sexually-dimorphic male attentional control center in virtue of females organizing the maleâ€™s brain.

Emerging Technologies

The development of new technologies to combine imaging with machine-learning methods holds promise in uncovering the neurobiology of sexual orientation and its complex interplay with sex differences. The neurobiological basis of human sexual orientation, a paradigmatic dimension of individual difference, is currently not well understood. Novel imaging approaches that enable large-scale sample sizes are now being developed for studying the neurobiology of sexual orientation and its sex-dimorphic aspects. So far, there is evidence suggesting that both genetic factors and prenatal sex steroids influence not only sex differences in the brain, but also sexual orientation. Recently, older post-mortem studies suggested that the third interstitial nucleus of the anterior hypothalamus (INAHâ€3) was smaller in homosexual men than in heterosexual men, and not different from heterosexual women. It has been suggested that the pattern of these differences is such that in some brain areas homosexual males tend to be similar to heterosexual women, and homosexual women tend to be similar to heterosexual men. More recent investigations using imaging modalities, however, did not report any sexual orientationâ€related differences, but rather suggested that homosexuality may be associated with a less pronounced sexual differentiation in the volume of white matter tracts [3]. The few previous imaging studies investigating sexual orientation, however, were limited by small sample sizes, were exploratory, and have not been replicated, but produced conflicting results. Homosexual men have been reported to have a smaller or larger or a similar hippocampus than heterosexual men. The absence of female comparison groups in many studies also means that findings cannot be interpreted as crossâ€sex shifts. These studies, however, also indicate that there may be complex multiâ€modal brain endophenotypes related to sexual orientation. This heterogeneity may reflect differing neurodevelopmental pathways between and within subgroups of heterosexuals and homosexuals. Analyses focusing on individual participants in a dataâ€driven fashion may allow researchers to better quantify variation among many brain phenotypes simultaneously [6]. This would be valuable not only for studies of sexual orientation, but also for assessing how other individual differences and psychopathologies relate to structural or functional aspects of the brain.

Interdisciplinary Approaches

Why have scientific research findings on neurological correlates of sexual orientation been so widely misunderstood? Why are lay responses to scientific evidence on the matter often so conflicted and beyond mere stance polarization? Two fundamental problems interfere with a balanced appraisal of the nature and implications of the findings: a lack of familiarity with one of the relevant disciplinary arenas, for instance, social psychology and interdisciplinary conflation. Neuroscience per se is not without a theoretical and methodological framework. It is an endeavor characterized by a distinct object of study and is organized around mainstream theories and widely used methodologies. An adequate understanding of scientific evidence on a neuroscience topic requires inâ€" depth knowledge of that field. Failing to grasp the intricacies of an individual disciplinary domain may entrench misunderstanding. This is especially the case in research areas where several disciplinary perspectives converge [2]. In the case at hand, for example, neuroscience per se has been confused with behavior genetics or evolutionary computation and, in some wellâ€" known instances, with psychoanalysis. Such blurring of disciplinary boundaries is exacerbated by widespread public misconception and anxiety about science. Scientific discoveries or theories of public import are subject to intense scrutiny and are readily seized upon by individuals and groups anxious to employ science in support of a politically or socially motivated agenda. Science is too often hailed as the ultimate arbiter of truth and objectivity. But scientists are not immune to political or personal bias. This is especially true for research on contentious issues like sexual orientation [1]. Scientists often do not engage sufficiently critiques of basic assumptions and mainstream finding interpretations dominant in a research area and to public understanding of the zeitgeist. Ultimately, corrective measures must originate in the targeted science subfield itself. The necessity for expanded efforts in

science education at all levels is starkly evident and urgently needed to ameliorate misconceptions and misuse, especially of virtually unquestioned basic presuppositions that undermine public discourse on the issue.

Ethical Considerations in Research

Ethical guidelines are an essential component of research with sexual and gender diverse groups. Tied to the issue of conducting ethical research is the need to consider such research from an intersectional lens, as social demographic factors intersect to produce different experiences of societal discrimination, oppression, and health outcomes for sub-populations of the LGBTQiS2S community. These disparate experiences must be acknowledged and brought into the ethical consideration of research with TGD communities.

Most of the initial guidelines for conducting ethical research with LGBTQiS2S communities were based in North America, with little input from communities outside of this region. The relevance of North American centered guidelines to non-Western populations, countries, cultures, and languages must be questioned with regard to cultural safety, given the colonial legacies of the research industry.

Inclusivity and diversity in consultations with LGBTQiS2S constitute the cornerstone of community-based knowledge that can inform ethical guidelines for research with TGD communities. The research industry prides itself on being evidence based yet the process of writing ethics guidance has not been conducted in a rigorous way. This is unethical, particularly given the marginalization, discrimination, and violence faced by LGBTQiS2S communities. Research with LGBTQiS2S people often runs parallel to this oppression, exacerbating the psychological, economic, and social harms communities experience. Therefore, guidelines for conducting ethical research with these communities should reflect standards that the industry operates above and that currently honor aspirations for social justice.

A possible site of innovative, community-based practices is the research ethics office at a university, where indigenous and feminist decolonizing analyses of ethics mechanisms have been operationalized to inform, engender, and reflect upon current and novel ethical practices. While gender issues heavily dominate conversations around ethics, it is crucial to highlight the ongoing and virulent homophobia embedded in the territoriality of research. An antinormative lens that acknowledges the historical and contemporary discrimination faced by communities negotiating academic knowledge is necessary for the progress of social research ethics. A critical intersectionality framework can extend the analysis of ethics to more holistically consider the interplay of power relations and institutions constituting normative scripts that galvanize the injustices of multiple communities.

Informed Consent

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The study of the neural substrates of human sexual preference is of great interest for understanding normal and pathological aspects of sexuality as well as for a better understanding of the typical and atypical socioemotional brain. Recently, a number of studies showed that brain anatomy and neural activity during sexual arousal differ between homosexual and heterosexual men [6]. Such studies provide evidence that neural differences may underlie sexual orientation. These studies look at the relationship of sexual orientation with brain structure and function using various approaches. For example, X-ray morphometry of the brain suggested that the brain morphology of homosexual and heterosexual men is different, especially in hypothalamic structures. Structural differences were also assessed by voxel-based morphometry (VBM) in a study with a larger sample size. In another study, diffusion tensor imaging was based on the estimate of the structural connectivity between regions of the brain and identified interhemispheric connectivity differences in homosexual and heterosexual men. These studies suggest that sexual preference is associated with differences in brain morphology, but do not identify the topological effects of sexual preference on brain anatomy. A few studies directly examined the neural activity during sexual arousal with fMRI. It is a powerful method evaluating differences in the brain function of homosexual and heterosexual men, although somewhat confounded by differential sexual arousal. The resting state functional connectivity of the brain is a new approach that provides a non-invasive means to investigate the functional architecture of the human brain at rest [2].

Confidentiality Issues

Confidentiality issues surrounding HIV/AIDS clung closely to concerns about sexual orientation and HIV status. The most daunting problem was that of confidentiality protections for mandatory reporting of health department contacts. This concern arose primarily from the suspicion that offending behaviorâ€" same-sex contactâ€" might become public knowledge in the community and widely shared, resulting in stigma for both the client and the counselor, as well as compromising the cliniciansâ€™ professional licenses and clinical careers [20]. The same apprehension applied to the idea that a child psychologistâ€™s parenting capabilities might become public knowledge and impact the clinicianâ€™s life in a very negative way.

The implementation of the contact tracing law was embraced visually, verbally, and operationally like those of a straight-leaning, heteronormative culture. It would protect the couple-assigned status of marriage and children. The same-day behavioral disclosure question and the mandatory questioning of contacts in a new me-me session was nestled comfortably within the couple-assigned family protections. Those operational concerns nonetheless were viewed as tracking forward the traditional stigmatization of homosexuality and bisexuality and of eclipsing the psychological insights and rigor of the HIV/

AIDS work. Personal life fears implied in professional career, as well as personal social existence, suggested to a few that public testimony to the court was needed to bring attention to the issues and to alert others to the potential for abuse.

There were vigorous discussions surrounding the consideration of a large-scale HIV/AIDS-related protest march, such as Richmond, where HIV+ people became public figures and campaigned for civil rights protections. There were endless discussions over how much of these concerns could be conveyed within the contact tracing laws. Professionals raised concerns that contact tracing might become a witch hunt [21] that violated the spirit of the law; that intolerance and dead-ended questions might constrict the work. Eventually, the demonstration was changed to a personal level, where a small group of four took the original testimonies of clinicians and staged them for a noon-times theater in one of the city plazas.

Public Policy Implications

Despite an enduring societal assumption that sexuality is a simple dichotomy, the scientific literature establishes that sexuality, especially in humans, spans a continuum from exclusive heterosexuality to exclusive homosexuality [2]. Understanding the factors that influence an individual's placement on the spectrum of sexuality -- specifically, understanding the factors that confer an attraction to individuals of the opposite sex or a same sex -- is a major aim of the biomedical sciences [1,14]. Accordingly, the emergence of a "neurosciences of sexuality" should be a boon to the understanding of a fundamental human characteristic. Unfortunately, this nascent field has been beset by the same difficulties that attenuate many burgeoning fields: overextrapolation of findings and, correspondently, the drawing of conclusions incompatible with the existing body of knowledge.

The neurosciences of heterosexuality and homosexuality are the products of rapidly expanding and, in some cases, rancorous scientific inquiries into the neuroanatomy, and subsequently the neurochemistry and molecular biology, of a complex but fundamental human characteristic. The rapid emergence of this scientific literature necessitates a sober, nuanced appraisal of existent claims, in anticipation of a powerful and potentially dangerous embrace of biological determinism by society's political and moral institutions. The neuroanatomical correlates of heterosexuality and homosexuality have been extensively investigated and are the best understood correlates of the many potential neural bases of sexuality. Though progress has been made, the controversy continues, fueled by a small but vocal and well-organized cadre of poorly informed but widely cited critics who ignore extant findings.

A comprehensive review of the body of knowledge concerning the ontogenesis of sexual orientation in humans is beyond the scope of the present undertaking. Thorough reviews are available and are preferable to one that is, necessarily, much more narrow in scope and renders the existing corpus of knowledge through a different theoretical lens. Herein are identified illustrative claims, drawn from a popular literature that is the product of eclectic origins, attended by a mix of seminal and revelatory findings tempered by preposterous claims inconsistent with existent knowledge. As the field emerges, opportunity exists for robust and beneficent advances in the understanding of a complex but fundamental human characteristic. Such optimism is tempered, however, by fear of unwarranted overinterpretation and overselling of the emergent science, if history is a meaningful guide.

Policy Changes and Advocacy

The goal of this project is to work with scholars to become more informed about the neurosciences of sexuality. How the brain becomes acutely responsive, attracted to (or rejecting of) a mate is a fundamental question in the neurosciences. In recent decades much has been learned about the brain basis of heterosexuality and the desire to mate with females. An understanding of the basic mechanisms and biology of heterosexuality is necessary for understanding sexuality in general, including homosexuality. Investigations of the brain bases of homosexuality have been largely neglected; the results have been limited to studies of the size of a few brain structures, and of hormonal conditions during development, mostly in animals. But advances in knowledge about heterosexuality have cleared the way for research on mechanisms involved in male sexual attraction to other males, and on more general questions about sexual preference reversal. Even without such studies, however, a neuroscience of homosexuality is possible, based on the neuroscience of heterosexuality.

A consideration of why many investigators have avoided research on homosexuality is warranted. There seem to be two components of this unease: One is that homosexuality is viewed as stigmatized or deviant, something to be treated with caution and respect. Even investigators with a strong interest in homosexuality have sometimes hesitated from fear of being misunderstood. The second component stems from this unease, which is the fear that the research will not yield any conclusions or, worse, unconsidered conclusions that are later shown to be completely incorrect or off-base. Complicating these concerns is the knowledge that advances have been made in the study of heterosexuality, and they are necessary to understand homosexuality. This self-referentiality has left the better-studied field of heterosexuality largely insulated from the less-studied field of homosexuality. Research is needed on the mechanisms involved in homosexual attraction, as well as on questions more general to various types of sexual attraction.

Investigators in this area have made two major findings: One is the efferent paleocortex circuit from the MPOA/POA that is responsible for displaying copulatory behavior toward females. Inhibitory modulation of this circuit prevents attractiveness of males, and ESD of this circuit induces attraction to both females and males. The other main finding is that male arrestin-3KO mice fail to exhibit a conditioned place preference for a conditioned odor, and show diminished Fos expression in the LS and the BNST when exposed to that odor. Recording from the BNST revealed that the odor-evoked firing of neurons is increased in the WT but not in the KO mouse. These results suggest that ser-3 may be incorporated into G-protein-coupled receptors, and genetic manipulations that target a heterologous species-targeted receptor may enable research into the mechanisms responsible for the reversal of preferences in homosexual animals.

Impact on Healthcare

The neurobiology of sexuality will have an impact on health care. To officers of the American Psychiatric Association, the 1973 decision to reduce the stigma of homosexuality was a moment of triumph. However, that triumph is not complete, still only partial. The American Medical Association is almost completely unaware of the new neuroscience and biology of sexuality. Most physicians, psychologists, mental health providers, administrators of medical schools and training programs, and medical students are unaware outcomes that will follow from this work on neurobiology and biology. The prior decision of the American Psychological Association led to a 1975 memo. The immediate effects on medical care for LGBT patients were far-reaching [23]. Medical education textbooks, case examples, and post-graduate courses were immediately changed. However, more recent changes in health advice for LGBT patients have fallen short. Unless the effects of the neurobiology and biology of sexual diversity are taken into account, LGBI and T patients will receive the same differential, negative treatment (even neglect) by health care providers that has occurred since the late 1980â€™s. Some aspects of this body of work are unknown.

Most medical schools and training programs still operate using a heteronormative framework. LGBT patients have specific requests and requirements. A recent study shows the harsh neglect and abuse faced by transgender patients. Almost all institutions review fairness and quality of medical care for minorities, but LGBT status has not yet made this list. Only occasionally are training programs offered to help care-learners understand the issues in taking care of LGBT patients. Even touching conscious and subconscious heteronormative assumptions that underlie this neglect is a new frontier in simulation exercises [24]. If the new knowledge surrounding the biology and neurobiology of sexuality is widely disseminated, it has a good chance of becoming a part of medically educated practices. Many of these neurobiological and biological findings fit with prior knowledge. Their power comes from the larger effects the new knowledge will have on all aspects of policy and social systems. Eventually rural folk will ask providers to update their knowledge. If this occurs for physicians, then it is likely to occur in schools, law and accounting firms, and many other institutions that provide education and training.

Case Studies

[9] and tested the hypothesis that male homosexuality could be attributed to elevated stress levels in pregnancy. Results provided indirect support for this model. An unexpected finding that same-sex orientated males on average had older siblings was found spurious. The relationship could be accounted for by birth order differences among participants with different sexual orientations. Specifically, the relationship was greatest in heterosexuals, and not at all present in homosexuals. These results are discussed in terms of feminist critiques of the male maternal stress hypothesis (MSH).

As these and other physical-attraction findings have demonstrated, men and women differ dramatically in the way sexual preferences and attractions were studied [6]. Men possess better visuospatial ability than women, and this ability has been related to both heterosexual masculinity and male homosexual preferences. Nevertheless, one of the best-supported explanations for this is that male homosexuals are more feminist than their heterosexual brothers. One needs to be careful in assuming that visuo-spatial abilities are conditioned in early masculinization and that the dose-response mechanisms shaping human preferences extending from prenatal testosterone levels to adult behaviors are similar across sexes. Moreover, even the studies using measures designed to differ preferences rather than orientations show conflicting results.

The etiology of sexual orientation is still a hot topic in sex research. In this regard, recent imaging studies on brain morphology as well as neural activity elicited by sexual stimuli have revealed sexual differentiation probably resulted from sexual preference. Whereas the aetiologias of heterosexuality and homosexuality exist post -or perinatal factors, recent functional studies on default-mode activity and facial inversion effects suggest intervention might also be implicated. Although there is no direct evidence that brain functional differences extend to other types of behaviors, there are measurements relevant to high-level processing having provided suggestive results.

Notable Research Studies

Sexual orientation is a complex trait with complex behavioral and neurological correlates. It is assumed to arise from the interactive influences of a variety of biological, social, and environmental factors. Humans share the biological properties of sexual reproduction with many other species. Despite sexual reproduction being a common evolutionary solution to the perpetual problem posed by parasites, disease, and other organisms trying to pass on their own genes, it is not without its costs. Two major costs associated with sexual reproduction are the reduced reproductive potential associated with a limit on the production of offspring and the cost associated with attracting mates.

The core of sexual orientation is the decorated sexual partners toward which an individual is sexually attracted or with which an individual wishes to engage in sexual activity. In humans, partners are thought to be characterized in a number of ways that include sexual appearance, sexual behavior, sexual activities, sexual desires, and physiological responses to sexual stimuli. Many of these characteristics are ethologically relevant to sexual orientation. A number of intriguing unanswered questions exist in this field of research.

Attempts to study the neurobiology of sexual orientation date back to the 1990s when Turner and colleagues suggested that the third interstitial nucleus of the anterior hypothalamus (INAH-3) was smaller in homosexual than heterosexual men and that the INAH-3 in homosexual men was not different from that in heterosexual women. The size of the INAH-3 appears not to be determined by differences in sexual preference [3]. Nevertheless, in larger studies using other methods, homosexual men have been found to be somewhat less masculine than heterosexual men on measures of cerebellar morphology and forebrain gray matter. Results are inconsistent in studies with female samples. Homosexual women appear masculinized on a number of measures of brain morphology or activity, in particular on several sex-steroid sensitive measures of the forebrain. Other research suggests that homosexuality in women may be associated with an enhanced femininization of brain morphology [6].

Personal Narratives

Results from Personal Narratives

The investigation started with a preliminary analysis of a set of interviews involving stories of heterosexual experiences collected as life histories narrated by individuals of different generations within the family. This study is inspired by an ethnographic analysis of family narratives of heterosexuality [25], although the analysis and scope are quite different. Families are a rich source of narratives of heterosexual life courses and practices, because so much of what is transmitted between parents and children, and between siblings, is tacit and embedded in everyday interactions. However, they also raise questions of honesty. When interviewed in the contexts of narratives about past generations or life period, they omitted crucial details often avoided in public discussions. Further research is needed to disentangle what is reproduced, re-negotiated, or converted in the transmissions. This study showcases preliminary analysis of the narratives of heterosexual experiences in the study. To illustrate how researchers approach entertainment in parental narratives, one family with a rich set of multi-generational narratives about family experiences is used as an example. Each group contains a younger child (Y, 13), a parent (P, 47), and a grandparent (G, 78). Each member of the group is asked to introduce a story about their first encounter with the opposite sex. How the tellers incorporated entertainment in their tellings, and how the listeners interpreted them, are analyzed. Responses to the tellings and interactions between the tellers and listeners will then be analyzed in detail. A great deal of family talk about heterosexuality involves entertaining narratives that are publicly told and shared across generations. These narratives take a variety of forms, including stories about first crushes, infatuations, oppositely sexed friends, dating experiences, cockups, tragedies, and joyful experiences.

Conclusion

It has been known for a long time that people born with a male body tend to be sexually attracted to women, and people born with a female body tend to be sexually attracted to men. However, a small percentage are exclusively attracted to people with the same biological sex as themselves. About 1â€“3% are attracted to both men and women equally, while those factors have remained unknown until very recently. The gay brain is not defined or organized differently than the straight brain. Instead, the heterosexual brain has a strong focus on mate-finding, while the homosexual brain has the same selection criteria but a weak selection force. Environmental, experiential, and learning factors always have a strong role in shaping sexual orientation [2]. Neuroendocrine and neural correlates of some of the reported differences in sexual orientation are discussed.

Intimate partner violence (IPV) is prevalent in both heterosexual (hetero) and gay relationships (homos), although specific forms vary by sexual orientation. Biases and poor service experiences reduce help-seeking in both populations. Through a sharing circle with hetero and homos, stressors in long-term relationships, including violence exposure, coping, and help-seeking were illuminated. Theoretical models from IPV, LGBT, and social support literature informed the analysis, which produced a codebook for stressors common to all partners, differences by sexual orientation, and recommendations to reduce disparities in IPV experiences. IPV policies that only acknowledge heterosexual relationships can misinterpret homosâ€™ IPV experiences and keep them from seeking help [5]. Mental health needs and help-seeking patterns differed by sexual orientation, with more use of health services by homos. Tailored recommendations to reduce the stress of health services informed by this study will benefit all couples.

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