Issues of Diversity in Clinical Neuropsychology

Charles M. Zaroff
Rik Carl D'Amato *Editors*

The Neuropsychology of Men

A Developmental Perspective from Theory to Evidence-based Practice

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Issues of Diversity in Clinical Neuropsychology

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In loving memory of Rita Zaroff, a mother to three very lucky boys.

Charles Zaroff

To David, Thanks for Beijing.

Rik Carl D'Amato

Preface

Numerous advances have been made in the field of applied neuropsychology, in both research and clinical contexts. Technological advances in neuroimaging and genetics, and refinements in the area of cognitive psychology have contributed to the development of the field of cognitive neuroscience, which has helped us to understand the functioning of the brain, and elucidate the workings of the brain in understanding developmental and neuropsychiatric disorders. All neuropsychologists have begun to benefit from this research work, and on their part have further enhanced their roles as scientist–practitioners in their own right. For instance, it is now considered commonplace to, at the very least, *consider* sociodemographic variables in clinical neuropsychological practice. Exemplifying this broadening of scope is the exciting Issues of Diversity in Clinical Neuropsychology series in which the current text is included—there are texts devoted to the neuropsychological assessment of Hispanics, and Asians and Asian-Americans, and also, women.

The current text is focused on understanding the brain–behavior relationships which drive boys and men. Conceivably, criticism could be levied at a book devoted to the neuropsychological assessment of a group in whom the majority of neuropsychological research, until recently, had taken place. In an unfortunate parallel to the medical field, and more broadly, science as a whole, the role of women as participants in research was generally limited, and thus, what was known about brain–behavior relationships was often based on what was known about men, and little consideration was given to how sex might mediate or moderate these findings.

So, why a book about males? One answer speaks to the heart of neuropsychology. In examining boys and men the way we might examine other groups based on, for instance, ethnicity or age, that is, as a group with its own unique characteristics, we are able to shed light on the specific cognitive, behavioral, and psychological findings unique to this group. This has tremendous implications for both research and clinical aspects of neuropsychology, the latter being of great importance for clinical practices such as assessment and intervention. This is crucial when we ponder even an *incomplete* list of what is known about how males differ from females, a list familiar to neuropsychologists, and perhaps, society as a whole. Consider that boys and men are overrepresented, sometimes *overwhelmingly* so, in groups of individuals with:

- Autistic Spectrum Disorder
- Reading Disorder
- Attention-Deficit/Hyperactivity Disorder
- Successful suicide attempts
- Antisocial Personality Disorder
- Sexual Paraphilias

Why are males as children so much more susceptible to developmental disorders affecting their academic and social skills? And, why are males as adults, more likely to kill themselves and others, and commit rape? The definitive answers to these questions are unknown. However, as we begin to discuss what separates females from males in terms of neuropsychological variables, this text argues that the same is now needed for males. Thus, this book is an attempt to understand why males are so much more likely than females to be diagnosed with some of these disorders, disorders often devastating not only to boys and men themselves, but also to society at large. Public policy initiatives have been undertaken with these very facts in mind, and specialty treatment centers for male-specific issues have been created. This text is part of an attempt to understand, and encourage, research into the nature and treatment of these very real and devastating disorders from a neuropsychological perspective.

To start the text, the first chapter by Zaroff ("Introduction to the Neuropsychology of Men: A Developmental Perspective from Theory to Evidence-Based Practice") extends the argument being made in this Preface for a neuropsychological text devoted to men specifically. A brief summary of sex-related differences in cognition and behavior, and the disorders covered in this book, is presented, along with a mention of what is known about this field from intersex conditions. The second chapter ("Imaging and Development: Relevant Findings in Males"), by Semrud-Clikeman and Robillard, discusses findings in males from the field of neuroimaging. The chapter begins with a review of neuroimaging techniques, including some of the methodological difficulties in such research. A review of sex differences in neuroimaging during development, and then adulthood, is discussed, with each of these sections concluding with a review of the neuroimaging findings present in disorders particular to such age groups (e.g., Attention-Deficit/Hyperactivity Disorder, dementia). Also included in this chapter are findings regarding neuroimaging and cognition.

Next, the portion of the text focusing on specific disorders begins, and, to emphasize the developmental approach taken throughout the text, starts with those disorders first evident in childhood. The third chapter is titled, "Understanding the Neuropsychology of Autism Spectrum Disorders in Men" by Clark, Radley, Huber, and Jenson. The chapter includes a discussion of the differences in males and females with such disorders, and the pathophysiological factors involved. It concludes with a review of outcomes in adults with Autism Spectrum Disorders, and implications and recommendations for intervention. The fourth chapter by D'Amato and Wang continues this developmental theme by focusing on issues concerning academic and attentional disorders ("Using an Ecological Clinical Neuropsychology Approach to Understanding and Intervening with Men with Learning Disorders and Attention Deficit/Hyperactivity Disorders"). A rationale is provided for the utilization of neuropsychology in this context, and the need for a specific examination of males is argued. In the sections following, on learning and attentional disorders, the utility of neuropsychological assessment and intervention is further explicated, again with a focus on males, specifically from an ecological assessment perspective as a means of linking assessment *to* intervention. In the fifth chapter "Understanding Disorders of Defiance, Aggression, and Violence: Oppositional Defiant Disorder, Conduct Disorder, and Antisocial Personality Disorder in Males," by Schug, Geraci, Holdren, Marmolejo, McLernon, and Thompson, the aggressive nature of the male sex is discussed. This chapter reviews the overrepresentation of males in disorders of aggression and violence. Subsequently, an integrative review of the findings from neuropsychological and neurobiological research on behaviors of defiance and aggression, including antisociality, is provided. Findings concerning the sexually dimorphic neurobiological correlates of these disorders, and the manner in which such correlates may uniquely contribute to the etiology in males, are explained.

In the sixth chapter, the text takes a turn towards disorders more commonly observed and studied in adolescence and/or adulthood. In "Understanding the Neuropsychology of Substance Abuse in Men," by Horton Jr., Soper, and McHale, sex differences in the use and abuse of substances are reviewed, and the potential cerebral mechanisms behind such abuse are discussed. The chapter provides a review of the residual neuropsychological deficits resulting from the abuse of specific substances. The seventh chapter, titled, "The Neuropsychology of Men with Epilepsy" is an in-depth look at epilepsy. In this chapter, Lebeau, Mihalia, Trobliger, Bailey, Feoli, and Myers consider some of the complications and consequences of the disorder unique to men (i.e., post-traumatic epilepsy, sexual dysfunction, and changes in hormones and fertility), a topic all too often ignored. The chapter follows with a review of the cognitive sequelae of epilepsy, which are quite common, from a sex-based perspective, and the male sex specifically, along with a discussion of sex-related differences in cognitive and behavioral variables including cerebral dominance, post-epilepsy-surgery cognitive outcomes, and psychological findings. In the eighth chapter, by Piehl and Davis, "Serving Men with Traumatic Brain Injuries," the focus is on explaining traumatic brain injuries, by providing an overview of this disorder including sex differences. Sex differences are specifically discussed in sections on cognitive, emotional, and personality functioning post-traumatic brain injury, and the outcomes that are unique to males versus females are emphasized.

The book then turns to focusing on some of the outcomes boys and men all too commonly face in the ninth chapter, "Men at Risk: Special Education and Incarceration," by Koch, Moore, and McIntosh. Koch and colleagues review rates of traumatic brain injury in those incarcerated and those in the special education system. They focus on the role of neuropsychologists and other professionals in the penal system, and how these professionals and the services they provide can first aid in treatment, and eventually aid in community re-integration. The book concludes in considering the ways in which male-specific normative patterns of emotion and socialization may contribute to psychopathology, in Zaroff and Ku's "The Neuropsychological Basis of Emotion and Social Cognition in Men." The ways in which boys and men, and girls and women, differ behaviorally and emotionally are discussed. From a neuropsychological perspective, an argument is made for how sexually dimorphic ways of emotional and social functioning may, in an exaggerated form, manifest as a psychiatric diagnosis, or, serve as exacerbating or protective factors in those with such diagnoses. Specific assessment tools needed for working with men in this context are provided.

Overall, this text is an attempt to synthesize what is known about male-specific findings in normative cognition, behavior, and emotion, and the brain-related basis of such. Much of the text is devoted to understanding and elucidating what happens in boys and men when things *go wrong*, and psychopathology is manifested, and as may be evident from the chapter summations provided above, the text often proceeds from a developmental perspective, both across, and often, within, chapters. This perspective was utilized in part because, as noted above, the symptoms and disorders in which males outnumber females are often developmental in nature. Thus, prevalence rates of childhood difficulties in behavioral control, socialization, and academic readiness/achievement are generally higher in boys. Additionally, in neuropsychology, and in science as a whole, more and more research is now focused on the early identification of psychopathological processes. Studies of prodromes and diagnostic biomarkers proliferate across discrete diagnostic categories.

Thus, our goal with this text is not only to promote research into the specific mechanisms behind the challenges faced by boys and men. We additionally aim to encourage further work both within the field of neuropsychology and in other scientific disciplines, in a collaborative fashion, in order to better understand what can be done to remedy these male-specific challenges. A remedy in this case implies *intervention*, but also, potentially, as our knowledge base increases, *prevention*, and thus in approaching such a challenge, a developmental perspective is beneficial, and even perhaps required.

Research in this field further strongly implicates the need for social policy change. That so many men are incarcerated in so many areas of the world suggests that social policy too often fails boys and men, and as eloquently discussed in the chapter by Koch, Moore, and McIntosh, may actually *exacerbate* the neuropsychological phenomena contributing to their incarceration in the first place. In light of this, we aim to (gently) remind practitioners that men, while often inarguably the beneficiary of good favor at the expense of women worldwide, are nonetheless not without their difficulties, deficits, and pathologies. These deficits and pathologies incur enormous individual and societal expense, and therefore most certainly warrant attention. Thus, it is further hoped that this volume will help provide insight into the neuropsychology of males, both in the population at large and in groups of boys and men suffering from psychopathology. It is our desire that this book manages to accomplish both of these substantial and innovative aims.

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Introduction to the Neuropsychology of Men: A Developmental Perspective from Theory to Evidence-Based Practice

Charles M. Zaroff

The Need for a Male-Specific Text: Gender Differences in Neuropsychological Functioning

Early studies in neuropsychology utilized samples that were heavily male-dominated if not completely male (e.g., McLean & Anderson, 2009; Seeman, 2009). The consequences of such work were twofold. Not only was little information available concerning neuropsychological functioning in women, but almost no attention was given to the impact that the construct of sex might have upon neuropsychological functioning (Geary, 2002). Currently, the inclusion of sex ratios and the measurement of sex as an independent variable in research samples has essentially become a *standard of practice* in peer-reviewed journals devoted to neuropsychology (O'Bryant, O'Jile, & McCaffrey, 2004), to an extent that is perhaps greater than that observed in journals devoted specifically to behavioral research (Sigmon et al., 2007).

Indeed, the incorporation of sex in research has resulted in a wealth of data regarding sex differences in medicine and behavior, as shown by numerous periodicals (e.g., *Gender Medicine*; *Journal of Gender Specific Medicine; Gender; Gender and Behaviour; Gender Issues*) and texts (Einstein, 2007) devoted to this issue. Neuropsychological data across the lifespan has also revealed sex-linked differences in normative and pathological forms of cognition and behavior and in the etiological factors that may contribute to such differences. However, there are many unresolved issues. For example, in instances where men are at a disadvantage relative to women, are the etiological factors sociocultural? Or, are there genetic,

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biological, or hormonal factors inherent in the state of being male that produce this disadvantage? Conversely, are there sociocultural, genetic, neurobiological, or hormonal factors inherent in the state of being female that produce a neuropsychological advantage in women? In many instances, the definitive answers to such questions are not yet available and what is known suggests a complex interaction between strictly biological and strictly environmental factors in etiology. Cleary, further investigation and discussion is warranted.

A textbook focusing on the neuropsychological functioning of boys and men has clinical utility, as there are clear patterns of normal and pathological behavior that appear uniquely male. Arguing from a developmental perspective, one taken within and across chapters in this text, is the fact that most forms of psychopathology with a childhood onset are overrepresented in boys. Additionally, there is evidence that male infants and young boys are more susceptible to the negative cognitive/developmental consequences of certain perinatal stressors such as prematurity (Romeo et al., 2010), low-level lead exposure (Jedrychowski et al., 2009), and maternal alcohol use during pregnancy (Herman, Acosta, & Chang, 2008) than are female infants and young girls. Perhaps these factors are also related to why, in adulthood, men die earlier and at every age have a higher risk of mortality (Migeon, 2007). While sex-linked differences in specific cognitive skills are modest in size and consistency, relative weaknesses in social cognition and emotional experience/expression in men are more stable. The weight of these findings has essentially led some to suggest that the idea of a *weaker sex* is not a fallacy, but that is the *male* sex that is the weaker of the two (Legato, 2008). On the other hand, men also possess advantages to women in other areas of neuropsychological functioning. In adulthood, men are more resilient than women to many common forms of psychopathology, such as depression and anxiety, while the cognitive sequelae that often accompany such disorders are frequently less severe in men. Men may also be less likely to develop specific dementing disorders like Alzheimer's disease. But men do have other problems, discussed later in this chapter.

The goal of this text, *The Neuropsychology of Men: A Developmental Perspective from Theory to Evidence-Based Practice*, is to provide a review of male-specific patterns of cognition and behavior, and the potential etiological factors which can be found behind these male-specific processes. An emphasis on the susceptibility and resilience to psychopathology in males is included, often from a developmental perspective, along with a discussion of neuroanatomical status across the male lifespan. The utility of the findings discussed herein for clinical practice will be reviewed in parts of the text devoted to treatment.

Sex Differences in Neuroanatomy

The most consistent sex-linked findings in neuroanatomy have concerned brain size. The average weight of the newborn brain is about 370 mg in males and 300 mg in females (Kaufmann, 2009). In children, differences in total cortical and subcortical volumes and in the volumes of specific neuroanatomical regions tend to be in the direction favoring boys for size and weight (Pangelinan et al., 2011). However, boys appear to lag behind girls in brain development. For instance, frontal lobe gray matter volumes peak at age 11 for girls and 12 for boys (Giedd, 2004). In adulthood, the total brain size tends to be larger in men, whereas women show a greater percentage of gray matter (Gur et al., 1999). Sex differences in hemispheric asymmetry are reported (Kulynych, Vladar, Jones, & Weinberger, 1994) and may affect the cognitive aging process in the brain (Gur et al., 1991). Numerous reports on the corpus callosum have produced no overwhelming consensus (Hasan et al., 2008) and results tend to vary with the callosal region under investigation. As is the case in childhood, when there are sex-linked differences in individual brain regions, the pattern usually favors men for size. The most consistent findings are evident in the third interstitial nucleus of the anterior hypothalamus (Byne et al., 2001; LeVay, 1991) and the bed nucleus of the stria terminalis (Allen & Gorski, 1990), rodent analogues of which have been investigated for their roles in sexual behavior (Arendash & Gorski, 1983). Sex-linked differences in age-associated neuroanatomical changes exist but are not always consistently replicated. Several reports have found greater reductions in whole brain volumes and in frontal and temporal volumes in men (Curiati et al., 2009; Sowell et al., 2007) while others show that a loss of hippocampal volumes with age is specific to women (Murphy et al., 1996; Nieuwenhuys, Voogd, & Huijzen, 2008). Results in pathological aging are somewhat inconclusive. Men with Alzheimer's disease show a higher overall ventricle-to-brain ratio (Carmichael et al., 2007). In the amnestic type of mild cognitive impairment and in Alzheimer's disease men have larger hippocampal volumes (Apostolova et al., 2006) but similar degrees of hippocampal atrophy compared to women (Bai et al., 2009).

The cognitive and behavioral implications of these potential sexual dimorphisms in human neuroanatomy are unclear. Sex-linked differences in specific cognitive skills in children and adults are often fluid even when reported, meaning they are quite susceptible to environmental influences and are far from permanent. Perhaps this is because unlike animals, in which regions of the brain may be truly sexually dimorphic, differences in human brains are statistical (Byne, 2009) and vary across the lifespan (Giedd, 2004).

Sex-Linked Differences in Cognition and Behavior

Echoing what is observed neuroanatomically, sex-linked differences in cognition and behavior are evident quite early in development. Chief among these are differences in play preference and social behaviors. In the first few days of life, male infants show less interest in social stimuli relative to female infants (Geary, 2002). During early childhood girls are more socially interactive whereas boys are more socially assertive (Benenson, Morash, & Petrakos, 1998; Kohnstamm, 1989). As children get older, the female preference for social stimuli generalizes to higher ability levels on tests of social cognition (Walker, 2005). At one time, it was assumed that sociocultural influences were mainly responsible for sexual dimorphisms such as play behavior differences. However, primate analogues of sex-specific behaviors in human children have been observed as young male vervet monkeys spend less time looking at dolls and more time looking at cars (Hassett, Siebert, & Wallen, 2008). These findings and others have provided increasing evidence for the role that prenatal androgens like testosterone have in the masculinization of play interests (Berenbaum & Beltz, 2011).

In adolescence, boys may display stronger mathematical achievement abilities than girls (Mullis, Martin, Fierros, Goldberg, & Stemler, 2000). However, many studies argue for similarities rather than differences in this area (Hyde, Lindberg, Linn, Ellis, & Williams, 2008). A recent meta-analysis (Else-Quest, Hyde, & Linn, 2010) of two large-scale international data sets in students 14–16 years of age found very small effect sizes for gender in mathematical achievement. In half of the countries surveyed, the difference in performance between the sexes was nearly zero. Sociocultural factors, such as gender equity in school enrollment and women's share of research jobs, were the most powerful predictors of cross-national variability in gender gaps in math. The discrepancies in mathematics achievement, when evident, were most notable on tasks requiring spatial cognition. Spatial cognition differs across the sexes beginning in school-age children and persists into adulthood (Levine, Huttenlocher, Taylor, & Langrock, 1999). In adolescence and adulthood, the relative strength males possess in spatial cognition is most pronounced on tests of mental rotation (Linn & Petersen, 1985). Men's relative strength in spatial cognition is also evident on tests of visual line orientation perception (Caparelli-Daquer, Oliveira-Souza, & Moreira Filho, 2009). In adulthood, men relative to women also possess an advantage in processing man-made relative to natural objects (Laws, 2000, 2002). On the other hand, men exhibit relative weaknesses in language skills, although these difficulties are less pronounced than are those of their strengths in mental rotation (Berenbaum & Beltz, 2011). Areas of language in which women are thought to possess relative strengths include general verbal ability, vocabulary, and speech production (Hyde & Linn, 1988), findings often discussed in the popular press. Men also have greater difficulty relative to women on tasks of autobiographical emotional memory (Davis, 1999; Seidlitz & Diener, 1998).

An understanding of the ways in which environmental and biological influences compete, interact, and contribute to sexually dimorphic behavior is probably best provided by a study of mental rotation. When faced with such a task, the strategic approach taken differs across the sexes. Women but not men tend to use verbally mediated strategies which are ineffective when details of the stimuli in question are not easily translated into verbal terms (Heil & Jansen-Osmann, 2008). As a result, women, but not men, require extra time for task completion when mental rotation stimuli are increased in complexity, suggesting that men utilize a spatially mediated strategy allowing rotation of the figure as a perceptual whole (Heil & Jansen-Osmann, 2008). This choice of strategy may have a neuroanatomical correlate. The male tendency towards holistic visual perception and spatially oriented cogitation, which occurs prior to a conscious cognitive stage of processing (Roalf, Lowery, & Turetsky, 2006), is perhaps based on the greater lateralization of right hemisphere activity in men relative to women during completion of mental rotation tasks (Gur et al., 2000). Men also utilize brain areas associated with visuospatial functioning (e.g., parietal lobe) during mental rotation tasks, while women display greater frontal lobe activation (Schoning et al., 2007). Thus, these strategic cognitive processes and brain activation patterns in men are associated with greater mental rotation skill. There is some evidence pointing to hormones as an etiological factor in the strength men possess in mental rotation abilities relative to women. While research connecting testosterone levels and spatial cognition in normative samples is inconclusive (Burkitt, Widman, & Saucier, 2007; Hooven, Chabris, Ellison, & Kosslyn, 2004), instances of pathologically low levels of testosterone provide greater proof. For instance, in elderly men with lower levels of testosterone, lower baseline abilities in spatial cognition are remedied with testosterone supplementation (Cherrier et al., 2005; Zitzmann, Weckesser, Schober, & Nieschlag, 2001). According to Zitzmann (2006), testosterone affects spatial cognition via a distributed cortical network, the ventral processing stream.

Although potential etiological factors and neuroanatomical bases for sexually dimorphic mental rotation skills have been identified, sex-linked differences in performance can nevertheless be overcome. Mental rotation skills can be modified with exposure and training to an extent that sex differences in performance disappear (Tzuriel & Egozi, 2010). Additionally, sociocultural influences, such as stereotyped threat, may also contribute to such performance differences (Lippa, Collaer, & Peters, 2010). According to the theory of stereotyped threat (Steele & Aronson, 1995), women's relatively weaker performance on mental rotation tasks results from fear that their poor performance will confirm negative stereotypes associated with being female, and not from an underlying deficiency in this skill. When women were exposed to a positive stereotype about their mental rotation skills, performance not only improved but this improvement was associated with greater efficiency in neural activation (Wraga, Helt, Jacobs, & Sullivan, 2007). In an attempt to tease out these neurobiological and environmental influences, Hausmann, Schoofs, Rosenthal, and Jordan (2009) examined the interaction between sex hormones and gender stereotypes on mental rotation. Gender-specific stereotypes were primed with a questionnaire requiring participants to judge the probability that a hypothetical person was male or female using a list of cognitive ability items. In this condition, men in the study achieved superior mental rotation performance. However, on a control condition, in which participants were presented with the same items and asked whether the person in question was more likely to be North American or European, no differences were observed. Interestingly, testosterone levels were significantly higher in the group of men who were primed with gender stereotypes. Given that the level of sex hormones was the best predictors of cognitive performance in men, the results were interpreted to suggest that sex hormones mediate the effects of gender stereotypes on specific cognitive abilities.

Sexual dimorphisms in cognitive abilities appear to persist with age. In a sample of nearly 200,000 participants, 20–65 years of age, using an online task, Maylor et al. (2007) found that men outperformed women on mental rotation and line angle judgment tasks and women outperformed men on tests of category fluency and object location memory. However, attempts to establish a gender-specific pattern of cognitive aging have generally been inconclusive (Hebert et al., 2000). Numerous reports using non-clinical populations throughout the world have found that men in older age groups, relative to women, have higher levels of cognitive functioning (Taboonpong, Chailungka, & Aassanangkornchai, 2008; Yount, 2008). However, others have found the opposite pattern or no difference at all (Meyer et al., 1999). One particular weakness in many such reports is that the measurement of cognitive functioning is often limited to a mental status examination (e.g., Yao, Zeng, & Sun, 2009; Yount, 2008). Additionally, sex may no longer predict cognitive decline when other variables, particularly those related to educational and occupational exposure, are incorporated (Davey et al., 2010). When specific cognitive abilities are examined, there is some suggestion that men show a greater decline. For instance, in the report by Maylor et al. (2007), men showed a significantly greater extent of age-related decline on all tasks administered compared to women. Obviously, more research is needed in this area.

Sex Differences in Pathological Forms of Cognition and Behavior Commonly Observed in Children and Adolescents

Sex-linked differences in the prevalence and symptom patterns of specific forms of psychopathology have significant implications for the field of clinical neuropsychology. Males appear to be at greater risk for developmental disorders of cognitive and behavioral functioning. Thus, Attention-Deficit/Hyperactivity Disorder (ADHD), Autistic Spectrum Disorders (ASD), Oppositional Defiant Disorder, Conduct Disorder, and Dyslexia are all more common in boys than girls. The over-representation of males in these developmental disorders has implications for adult outcomes, and thus argues from a developmental perspective in the study of sex-linked differences. While the etiological bases of these sex-linked differences are unknown, evidence is gaining for specific candidate factors, a review of which is provided in the following sections.

Boys and Men with ADHD

The incidence of ADHD is twice as great in boys relative to girls (Kaufmann, 2009). There are also various differences in male and female presentations of the disorder. Boys tend to develop the Combined Type of the disorder and tend to show greater disruptive behaviors, while girls are more likely to develop the Inattentive Type (Biederman et al., 2002). Sex-based discrepancies in cognition in ADHD have been somewhat inconclusive, although boys have been found to have greater deficits in inhibition (Gunther, Herpertz-Dahlmann, & Konrad, 2010) and processing speed (Rucklidge & Tannock, 2001). The etiology of the difference in ADHD incidence is unknown as the etiology of the disorder itself is unknown. While ADHD is theoretically associated with neuroanatomical dysfunction, few studies specifically examine sexual dimorphisms in neuroanatomy. One report found smaller prefrontal and premotor brain volumes in boys with ADHD (Mostofsky, Cooper, Kates, Denckla, & Kaufmann, 2002). Regardless of the true underlying etiology, boys are disproportionately referred for clinical services (Willcutt & Pennington, 2000) and are more likely to use stimulants even after symptom characteristics and severity are controlled (Miller, Kohen, & Johnston, 2008). Thus, whether boys are simply overdiagnosed due to greater disruptive behavior or whether there is a true sex-linked difference is still a matter of much debate.

Boys and Men with Dyslexia

Reading disorders (or disabilities), commonly labeled dyslexia, are more prevalent in boys than girls (D'Amato, Dean, & Rhodes, 1998). However, studies that incorporate only school-based referral rates may be biased (American Psychiatric Association, 2000). Neuropsychological data has been informative in this area. Boys may have relatively greater difficulty on language tasks relative to girls, and phonemic awareness, thought to be a core cognitive skill needed for successful reading in alphabetic languages, is one such skill in which boys lag behind girls (Meneses, Lozi, Souza, & Assencio-Ferreira, 2004). This finding has been corroborated using neuroimaging data which has demonstrated greater gyrification and relatively larger left hemisphere volumes in language-related areas (Luders et al., 2004). Interestingly, one of the methodological limitations in the study of dyslexia across the sexes is the frequent lack of case ascertainment in girls (Grabowska & Bednarek, 2004). Overall, the performance of boys in the educational system has been one of recent concerns, spurring initiatives designed to improve their performance (Rich, 2014).

Boys and Men with ASD

The male predominance in epidemiological samples of ASD has held over time, with ratios being three to four times higher in males than in females (Chakrabarti & Fombonne, 2005). There is, however, an interaction between gender and severity as the proportion of females in samples of individuals with more severe forms of the disorder are higher than in samples of individuals with more mild forms (Volkmar, Szatmari, & Sparrow, 1993). Despite these sex-linked differences in prevalence, when level of intellectual functioning is controlled, disorder characteristics are similar across the sexes (Volkmar et al., 1993). The cause of individuals with ASD is unknown. As part of the *extreme male brain theory,* Baron-Cohen, Knickmeyer, and Belmonte (2005) have theorized that exaggerations of male-typical behavior manifest as an individual with ASD. Baron-Cohen, Richler, Bisarya, Gurunathan, and Wheelwright (2003) have suggested that this occurs due to increased levels of prenatal androgens which produce excessive masculinization of the brain. A corollary of the extreme male behavior theory is that the neuroanatomy of individuals with ASD represents extremes of normal male neuroanatomy (Baron-Cohen et al., 2005). While the larger brain size observed in males is perhaps one of the most common neuroanatomical findings in ASD, there is little available data on regional differences and further, direct evidence for the association between testosterone and ASD diagnosis is lacking. Genetics have also been studied in individuals with ASD and may contribute to the differences in incidence rates of individuals with ASD. While apparent male-to-male transmission of individuals with ASDs rules out X chromosome linkage as the dominant mode of transmission, studies in this area continue due to the connections between neurogenetic disorders like Fragile X and ASD.

Boys and Men with Oppositional Defiant Disorder, Conduct Disorder, and/or Antisocial Personality Disorder

Differences across the sexes are consistent both in the prevalence and patterns of aggressive and antisocial behavior. Boys are more likely than girls to be diagnosed with Oppositional Defiant Disorder or Conduct Disorder and men are far more likely to be diagnosed with Antisocial Personality Disorder, and this discrepancy is so great that it has raised concerns about the validity of the diagnostic criteria in girls and women (American Psychiatric Association, 2013). In general, boys tend to externalize their anger as physical aggression and other forms of antisocial behavior (Su, Simons, & Simons, 2011), and male adolescents are significantly more accepting of violence and aggressive methods of conflict resolution than are female adolescents (Garaigordobil, Maganto, Perez, & Sansinenea, 2009). The etiology of the sex-linked differences in aggression and antisocial behavior appears multifactorial. Not only do males and females have different normative levels of sex hormones, but their reactions to increases in such hormones also differ. Testosterone is associated with increased aggression and provocation in boys, particularly at puberty, whereas in girls it better predicts affectivity (Azurmendi et al., 2006). Affective empathy, which in non-pathological samples is often lower in boys, is a risk factor for antisocial behavior in males but not in females when it is deficient (Dadds et al., 2009). Sociocultural influences are also important. Boys are more likely to be competitive in group activities while girls are concerned about maintaining social harmony (Maccoby, 2002). In adulthood, adherence to traditional masculine values is associated with violence-related attitudes and behaviors (Jakupcak, Lisak, & Roemer, 2002). All of these findings have enormous societal impact, as demonstrated by the fact that in the United States, most murders and the overwhelming majority of sexual crimes are committed by men (Spratt, 2000).

Boys and Men in Special Education

In the United States, boys are overrepresented in special education classes. In a national survey, Coutinho and Oswald (2005) found that boys were 1.33 times more likely to be identified as being Mentally Retarded, 2.04 times more likely to be identified as having a Learning Disability, and 3.43 times more likely to be identified as having a Serious Emotional Disturbance. However, at the state level, there were substantial variations in the rates of gender-discrepancies in learning disability and serious emotional disturbance classifications. These variations would appear to suggest that at least some of the higher rates in boys are due to biases in referral and identification rates (MacMillan, Gresham, Lopez, & Bocian, 1996). A rejection of school attachment and a negative attitude toward schooling, whether or not accompanied by a developmental deficit, might conceivably have resulted in many more boys being labeled within the special education system. However, recent data has shown that a rejection of school values is not limited to the stereotype of the trouble-making male, but in fact extends in various forms to other school demographics across genders (Lyng, 2009). At present, the cause of the overrepresentation of boys in the special education system is not fully understood and may only be partially attributable to true underlying differences in psychopathology prevalence.

Psychopathology and Sex Differences in Emotion and Social Cognition

Persuasive normative research has accumulated indicating that men have a less expansive range of emotional experience and expression (Vrana & Rollock, 2002), and do not perceive the intentions and emotions of others as acutely as do women (Hall & Matsumoto, 2004). These findings may have relevance for manifestations of psychopathology. Compared to women, men appear to be less susceptible to disorders associated with the extremes of emotional experience, such as affective disorders and anxiety disorders. In contrast, men are at high risk for substance abuse, which may represent attempted self-medication in order to resolve discomfort and distress associated with emotional inexperience and disclosure. Problems in social attachment are common in schizophrenia in which they are probably more severe in men, which factors into their relatively poorer functional outcome compared to women manifesting this same disorder.

Boys and Men with Affective Disorders, Anxiety Disorders, and Schizophrenia

While cross-national studies *do not* suggest that men are any happier than women (Simon, 2008), they seem less susceptible to depression. Furthermore, in samples of men who report depression, they appear to experience a milder version of the disorder, as reflected by a later age at onset (Marcus et al., 2005), and less symptom persistence (Barry, Allore, Guo, Bruce, & Gill, 2008), cognitive impairment (Sarosi, 2011), negative perceptual bias (Bos et al., 2005), and comorbid anger and anxiety (Scheibe, Preuschhof, Cristi, & Bagby, 2003). The overall incidence of bipolar disorder is similar across the sexes (Lloyd et al., 2005). However, men with bipolar disorder also suffer from less recurrence (Suominen et al., 2009), and are less likely to develop rapid cycling (Berk & Dodd, 2004), and severe psychotic symptoms (Braunig, Sarkar, Effenberger, Schoofs, & Kruger, 2009). Various sociocultural explanations for the differences in unipolar depression have been proposed which tend to focus on the greater societal adversity faced by women and their reaction to such adversity (Nolen-Hoeksema & Hilt, 2008). Recent neuroimaging data have shed light on the neuroanatomical basis of this sex-linked difference in response to adversity (Yuan et al., 2009). The lack of a social bias in men may also serve a protective function. In comparison with women, men are less likely to come into contact with others with personal problems (Schuster, Kessler, & Aseltine, 1990), and perhaps as a result are less likely to internalize the problems of others. Men's gender roles also appear to contribute to differential susceptibility to depression and bipolar disorder and the behaviors associated with such disorders. Thus, men with bipolar disorder exhibit lower levels of self-perceived masculinity, while those with higher masculinity are less likely to start or continue with treatment (Sajatovic, Micula-Gondek, Tatsuoka, & Bialko, 2011). In many societies men are overrepresented in cases of suicide (Moscicki, 1997) despite having lower depression prevalence, suggesting that gender roles may influence how stress is experienced and processed. While the evidence for an association between sex hormones and depression is likely stronger in women than men, reduced testosterone in men has been associated with depressive disorders (Seidman & Walsh, 1999). Moreover, the association between depression and testosterone appears to partly depend on androgen receptor genotype (Seidman, 2001).

Men are also more resilient to anxiety disorders (McLean & Anderson, 2009), although this resilience varies with the anxiety disorder subtype. It appears that obsessive-compulsive and/or social anxiety disorders are those with the least amount of sex-linked discrepancies in prevalence. Sex-linked differences in anxiety disorder symptoms are subtle but consistent as diagnosed men are rated as less anxious and depressed (Oei, Wanstall, & Evans, 1990), and are more concerned about the social (and not physical) consequences of anxiety; in women the opposite pattern is true (Foot & Koszycki, 2004). Protective factors exist in men, as they report lower levels of worry and rumination (Robichaud, Dugas, & Conway, 2003). Sex-linked physiological reactions to stress vary considerably with the stressor. For instance, men respond to adrenergic agents with more intense vasoconstriction than women (Ludwig, Vernikos, Wade, & Convertino, 2001) but may also show less cardiovascular reactivity to stress (Stoney, Davis, & Matthews, 1987). As is the case with individuals with a bipolar disorder, higher levels of masculinity are also associated with lower levels of social anxiety (Moscovitch, Hofmann, & Litz, 2005).

The incidence of schizophrenia is comparable in men and women (Seeman, 2009). Concerning symptom expression, men exhibit more deficits in social withdrawal (Mulligan & Lavender, 2010). Men also have greater deficits in social cognition

(Bozikas, Kosmidis, Kiosseoglou, & Karavatos, 2006; Van't Wout et al., 2007), and a greater degree of premorbid social isolation (Haas & Sweeney, 1992). These gender differences in symptom presentation have particular significance because of their association with functional status. That is, negative symptoms such as social withdrawal and blunted affect, which are more pronounced in men, are the most predictive of poorer outcome, and in fact, men tend to have worse functional statuses. Various theories have been proposed to account for schizophrenia etiology (Taylor & Langdon, 2006), and given the male dominance of specific developmental disorders, theories of schizophrenia that emphasize neurodevelopmental and neuroanatomical anomaly may implicate sex-linked differences.

Boys and Men with Substance Abuse

Sex differences in the prevalence and pattern of substance abuse vary with age and with the specific substance of abuse. In adulthood, men are at their highest risk for alcohol and drug abuse/dependence; over the course of a lifetime, nearly a third of all men will develop an abuse or dependence disorder (Kessler & Walters, 2002), rates which far exceed all other mental disorders in men. Some reports suggest that while women may use more alcohol than men, men are more likely to *abuse* alcohol (Cotto et al., 2010). Definitive data on sex differences in the brain mechanisms behind use, abuse, and dependence are not available. Greater central dopaminergic reward system activity has been implicated in male amphetamine-stimulated dopamine release (Pogun & Yararbas, 2009), although further research is needed with other drugs of potential abuse. Attempts to correlate neuroimaging findings like white matter volume, with risk for substance abuse across the sexes have been unsuccessful (Silveri, Tzilos, & Yurgelun-Todd, 2008). Sexually dimorphic patterns of cognitive deficits in substance abuse and dependence vary by substance and dosage. For instance, men display greater impairment of inhibition when receiving an acute dose of alcohol relative to women (Fillmore & Weafer, 2004), whereas deficits are greater in women with heavy use (Nederkoorn, Baltus, Guerrieri, & Wiers, 2009). The latter findings may be attributed to the fact that equivalent brain atrophy exists across the sexes despite greater usage in men (Mann et al., 2005). Of note, the societal cost of substance use is far higher in men than in women in at least one respect: the majority of episodes of intimate violence committed by men are associated with acute alcohol or drug use (Greenfield, 1998).

Sex Differences in Neurological Disorders

Sex differences in neurological disorders vary with the condition under investigation. There are sex-linked differences in the prevalence, risk factors, symptom profile, and recovery when possible, from specific neurological conditions.

Boys and Men with Epilepsy

Men may be more susceptible to developing epilepsy and unprovoked seizures (Kaufmann, 2009) and males tend to predominate in acute symptomatic seizure cases. While men are generally overrepresented in all epilepsy samples compared to women (Amatniek, Sorra, Frey, & Hauser, 2009), the incidence of specific epilepsy syndromes in individual reports may be higher in both women and men. The exception appears to be the epilepsy risk in the oldest age groups, which may be associated with the increased risk of stroke (Amatniek et al., 2009). There is little information available concerning male-specific patterns of cognition and behavior in epilepsy. Most descriptions of sex in epilepsy focus on the unique ways in which the assessment and treatment of women with epilepsy vary by life stage (Fletcher-Janzen, 2009). Typically, effect sizes for cognitive impairment in epilepsy are much larger for epilepsy etiology than for gender. And because men have more accidents they are more prone to cause their own onset of epilepsy, often as a secondary disorder.

Boys and Men with Traumatic Brain Injuries

In childhood and young adulthood, males are *twice as likely* as females to experience a traumatic brain injury (Kraus & McArthur, 1998). Sexually dimorphic outcomes of traumatic brain injury depend upon the operational definition of outcome. Sex differences in mortality rates after traumatic brain injury are inconsistent (Gujral, Stallones, Gabella, Keefe, & Chen, 2006; Harrison-Felix et al., in press; Klauber et al., 1989), although men are more likely to have difficulty integrating into the community post-injury (Reid-Arndt, Nehl, & Hinkebein, 2007). Sex differences in neuropsychological functioning following traumatic brain injury are somewhat equivocal across several cognitive domains. While some reports find that men possess better memory after injury when injury severity and premorbid level of intellectual functioning are taken into consideration (Liossi & Wood, 2009), more commonly, women do better on memory tasks post-injury (Moore, Ashman, Cantor, Krinick, & Spielman, 2010). Findings in other cognitive domains such as attention are equivocal (Moore et al., 2010; Ratcliff et al., 2007). Neurobiological mechanisms and hormonal factors may account for sex differences or the lack thereof in cognitive functioning after traumatic brain injury. That is, men appear to have more focal organization of brain function (Farace & Turkheimer, 1996) and thus may be less susceptible to the effects of diffuse brain injury. On the other hand, progesterone may aid in recovery from traumatic brain injury (Wright et al., 2007).

Men with Dementia

The age adjusted incidence of Alzheimer's disease is significantly higher in women compared to men (Amatniek et al., 2009; Lekoubou, Echouffo-Tcheugui, & Kengne, 2014). However, these findings are not ubiquitous (Musicco, 2009), and may reflect a significantly higher rate of the disorder in the oldest age groups in women, since more men than women have the early onset form. Using artificial neural networks, female gender has also been found to be a risk factor for the conversion of amnestic Mild Cognitive Impairment to Alzheimer's disease (Tabaton et al., 2010). Proposed etiological factors behind the sex differences in prevalence in Alzheimer's disease include higher mortality rates in men and potential neuroprotective effects of sex hormones (Azad, Al Bugami, & Loy-English, 2007; Pike, Carroll, Rosario, & Barron, 2009). The protective effects of estrogens on the brain might explain why women rarely have the disorder before menopause. It has also been suggested that the link between neuropathology in pre-clinical and clinical stages of Alzheimer's disease and the clinical symptoms of the disorder is stronger in women than men, as women in these categories tend to show greater neuropsychological deficits than men despite comparable neuroanatomical findings (Barnes et al., 2005). This has led to the suggestion that the brain's cognitive reserve is reduced in women. It has also been suggested that women are more susceptible to dementias like Alzheimer's disease because the neurons lost to atrophy and other processes are more densely connected than in men, while men may exhibit greater functional preserve due to a greater number of neurons at baseline (Kaufmann, 2009). In addition to cognitive deficits, problem behaviors are common in Alzheimer's disease, although data on the sex-specific patterns of such behaviors are inconclusive (Bassiony & Lyketsos, 2003).

Sex-linked differences in the rates of dementing disorders other than Alzheimer's disease vary. Prevalence rates for Parkinson's disease are higher in men than women (Wooten, Currie, Bovbjerg, Lee, & Patrie, 2004). Men are less likely to experience complications that lead to disability such as depression and medication-induced dyskinesias (as reviewed by Pavon, Whitson, & Okun, 2010). Cognitive impairment in individuals with Parkinson's has been more commonly reported in men (Uc et al., 2009) but also more studied in men. Recent work has focused on genetic polymorphisms, as the BDNF Val666Met polymorphism was found to have a specific effect on planning that was most apparent in women (Foltynie et al., 2005).

Vascular dementia was once thought to be more common in men (Brown, Whisnant, Sicks, O'Fallon, & Wiebers, 1996) although there is recent evidence for a reversal of this trend, perhaps because of a longer life expectancy in women (Seshadri et al., 2006). This is somewhat unexpected given the male preponderance of cerebrovascular disease. However, it has been found that women experience an increased stroke risk during childbearing years, and in the oldest age groups—in women over 75 years of age, hypertension, hyperlipidemia, and diabetes are more common than in similarly aged men (Azad et al., 2007). Cognitive outcomes following stroke are often more clearly sex specific. Aphasia and apraxia are far more common in men than women following restricted left hemisphere lesions (as reviewed by Swaab 2003) which may reflect the more focal representation of language in men.

Intersex and Homosexuality

The concept of *gender*, used to refer to social roles and identities, can be differentiated from that of biological *sex*, used to refer to the physiological state of being male or female. While the terms are often used interchangeably (Haig, 2004), they have implications for the neuropsychological differences between men and women. That is, unlike the sexual differentiation of the body, including the genitalia, the formation of male- and female-specific brains are a matter of degree and are not, strictly speaking, irreversible. This may have relevance for individuals in whom sexual differentiation is incomplete or subjectively inappropriate, such as in transsexuality. Furthermore, there is no consistent argument that sexuality can be changed, arguing against the role of society in the emergence of homosexuality, and instead arguing for a neurobiological basis. However, the neuroanatomical basis of intersexuality and homosexuality is unknown. The suprachiasmatic nucleus in one report was twice as large in homosexuals relative to heterosexual men (Swaab & Hofman, 1990). This pattern has also been found in sexually dimorphic brain regions, as the volume of the bed nucleus of the stria terminalis (Kruijver et al., 2000) and third interstitial nucleus of the anterior hypothalamus (LeVay, 1991) is typically twice as large in men as in women, whereas in male-to-female transsexuals and homosexuals, female-sized volumes of these regions have been found (Kruijver et al., 2000; LeVay, 1991). Research attempting to compare the relative influences of physiological sex and gender identity of male-to-female transsexuals on neuropsychological functioning have been inconsistent; some reports find patterns of neuropsychological functioning that are consistent with a range between post-operative sexual status and biological sex (Cohen-Kettenis, van Goozen, Doorn, & Gooren, 1998) while others find neuropsychological patterns that better correlate with biological sex, not gender identity or post-sex reassignment hormonal status (Wisniewski, Prendeville, & Dobs, 2005). Results in individuals lacking clear sex differentiation have also contributed to the literature. Girls with Congenital Adrenal Hyperplasia, who have higher levels of androgens relative to typically developing girls, may display more male typical behavior in cognitive abilities such as targeting (but not mental rotation) (Hines et al., 2003) and in social-emotional cognitive skills like empathy (Mathews, Fane, Conway, Brook, & Hines, 2009). Women with Turner syndrome, in which part of or all of one of the normal X chromosomes is missing, tend to show a cognitive pattern that more closely resembles men than women (Waber, 1979). While this is an area where recent progress has been made, neuropsychology is only starting to understand and uncover some of these complex brain-driven areas. Future research, using advanced scanning techniques, will offer a great deal of additional information which, hopefully, will lead to advanced understanding.

Summary

The long overdue study of female aspects of neuropsychological functioning has paved the way for a re-examination of male-specific behavior. Neuropsychological aspects of being male manifest themselves in behaviors that boys and men exhibit and in the brain-related basis for these male-specific behaviors. Sexual dimorphisms in neuroanatomy are frequently modest in size and generally inconsistent when examined in specific brain regions. This may contribute to the fluid and malleable nature of cognitive strengths and weaknesses in males relative to females. Studies in intersex and homosexuality yield promise in pinpointing the etiology of sexually dimorphic behaviors, although more research is needed. In the attempt to provide a clear definition of *male neuropsychology*, sex-specific normative behavior and patterns of psychopathology are informative if inconclusive. Boys appear to be at greater risk for childhood developmental disorders and may also be susceptible to early environmental stressors. The basis of sex-specific behavior in boys, such as male-specific play preferences and social behaviors, may have its origin in hormonal factors. However, sociocultural factors such as clinical referral biases may obscure potentially meaningfully differences in childhood forms of psychopathology. The reversal of the male overrepresentation in many adolescent and adult onset forms of psychopathology is likely the result of a complex interaction between numerous etiological factors. The normative weaknesses in emotion and social cognition in men may also contribute to the adult pattern of psychopathology susceptibility.

This current text aims to explore male specific patterns of neuropsychological functioning and does so in a generally developmental fashion. Clearly, more research is needed to help understand both men and women. However, with an eye towards the societal impact of male behavior, *The Neuropsychology of Men: A Developmental Perspective from Theory to Evidence-Based Practice* aims to update the current knowledge base in this field.

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Imaging and Development: Relevant Findings in Males

Margaret Semrud-Clikeman and Rachel Robillard

Imaging and Development: Gender Differences

The ability for neuroimaging to now explore brain structure and functioning variations has opened new avenues of research in gender differences (Cairns, Malone, Johnston, & Cammock, 1985; Gur et al., 1995; Kulynych, Vladar, Jones, & Weinberger, 1994; Schlaepfer et al., 1995; Witelson & McCulloch, 1991). The first studies emphasized different diseases with less emphasis on gender. Most studies utilized males because females were excluded due to concerns about pregnancy issues (Witelson & McCulloch, 1991). The focus of this chapter is on men and neuroimaging findings in various disorders as well as in general development.

Magnetic resonance imaging (MRI) and fMRI (functional MRI) require no radiation. These noninvasive and safe technologies have increased interest in gender differences in brain structure and function. The aim of this chapter is to discuss the extant literature in imaging in men. Gender differences will be briefly discussed as far as what variations may be seen in normal development, as well as in common developmental disorders such as learning disabilities and attention deficit hyperactivity disorder. Where possible, we will follow those differences into adulthood, both for normal development and for those seen in specific disorders in order to more fully understand how normal as well as disrupted development can influence later functioning.

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As it is not possible within this chapter to discuss the neuroimaging findings in all disorders, we are focusing on findings in men in the disorders of schizophrenia, depression, antisocial personality disorder (ASPD), and stroke/heart attack. This chapter begins with a brief discussion of neuroimaging techniques as well as methodological issues that impact our understanding of the existing research in these areas.

Neuroimaging Techniques

Visualization of the structures in the brain is possible through computed tomography (CT) and MRI. Radiation is present in CT but not in MRI. The lack of radiation in MRI allows it to be used for repeat examinations as well as in pregnant women. The ability to easily see structures due to improved resolution has increased the use of MRI as a favored research technique. Moreover, the ability of fMRI to provide a dynamic picture of brain activity also enhances the use of MRI in research. Both of these techniques will be briefly discussed below.

Computed Tomography

Computed tomography (CT) is most frequently used to determine whether lesions, structural deviations, or tumors are present clinically. A narrow X-ray beam that rotates 360° around the scanning area is used in CT. Major advantages of CT scanning are a relatively short period for scanning (15–20 min) and the ability to repeat single slices if movement occurs. One major drawback for CT particularly for imaging children is poor visualization of the temporal lobes and posterior fossa (Filipek & Blickman, 1992). These regions are most susceptible to tumors in childhood and so cannot be visualized using CT. Figure 1 shows a CT scanner.

Magnetic Resonance Imaging

MRI provides visualization of structures that is very similar to those seen in autopsy studies. Figure 2 shows an example of an MRI. The MRI is a large magnet with varying field strength units depending on the particular magnet. Most clinical and research scans are at the 1.5–3.0 Tesla level. The Tesla level is a measure of field strength and indicates how fast the scanner is able to obtain a picture with good resolution. The process behind MRI consists of very complicated physics. In extremely simplified terms, hydrogen photons are numerous in the brain and these photons will align in the same direction as a magnetic field. MRI emits a radio-frequency pulse to deflect these protons at a predetermined angle to provide the best picture of a structure. When the pulse stops, the photons return to their original position.

Fig. 1 CT scanner (Courtesy of General Electric, Inc.)

Altering the rate, duration, and intensity of these pulses provides a different type of visualization. An MRI is a series of these sequences and averages approximately 7–10 min to complete. Most research requires several sequences and takes around 45 min to 1 h to complete. Figure 3 provides an example of an MRI picture.

Fig. 2 MRI scanner

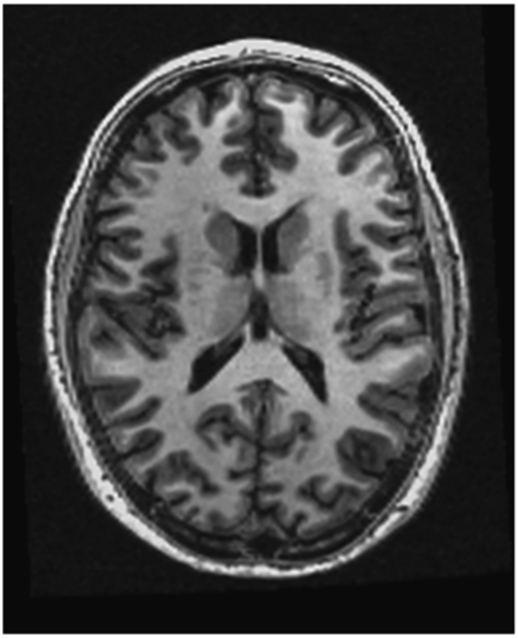

Fig. 3 Example of an anatomical and structural MRI

There are two different types of MRI sequences that are used clinically. Each is used for different purposes. The T_1-weighted scan shows excellent anatomical detail of white and gray matter. Figure 3 illustrates the detail that can be obtained. T_2-weighted sequences are sensitive to water content and are generally used to determine the extent of a lesion or a tumor. When a tumor is suspected, the MRI scan is good at isolating the tumor from surrounding swollen tissue (Filipek, Kennedy, & Caviness, 1992). While an MRI doesn't use radiation, it is fairly expensive and generally used for children or for disorders that do not readily show on CT (i.e., lesions from multiple sclerosis).

Functional MRI. fMRI is a relatively new technique that allows for the visualization of brain activity by tracking cerebral blood flow deoxygenation or the blood oxygen level dependent (BOLD) signal. This signal is assumed to correlate with increased metabolic activity that is present when the brain is actively working on a problem or responding to stimuli. The oxygen level in the blood changes as the brain activity changes with oxygen being expended with use. Differences in oxygen levels in the blood create the BOLD signal and in turn affect the magnetic properties of the oxygenated and deoxygenated blood allowing for imaging (Luna & Sweeney, 2004). Figure 4 shows a map of functionality of a child watching a video.

Diffusion Tensor Imaging. Another more recent neuroimaging technique is diffusion tensor imaging (DTI). DTI allows for visualization of the white matter tracts in the brain and is a static picture. The DTI process is an analysis of the amount of perfused water in the long axons of the brain. As such, DTI can show orientation and density of white matter in the brain as well as provide the ability to analyze the axon fiber tracks. Figure 5 is an example of a DTI scan.

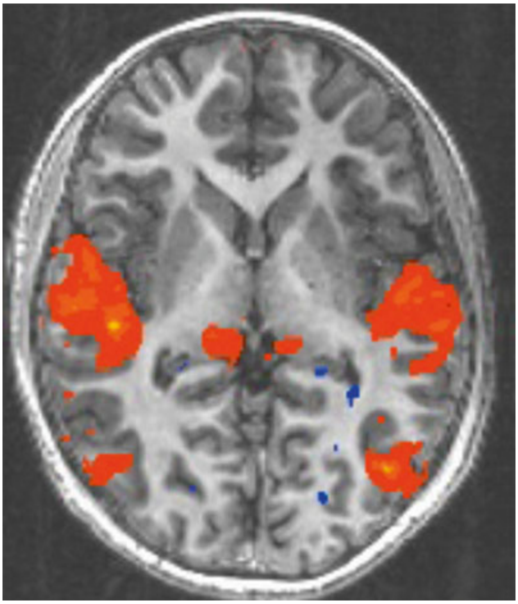

Fig. 4 Example of an fMRI map

Fig. 5 Example of DTI

Methodological Issues in MRI Research

While neuroimaging is an exciting tool, it is also relatively new, and has some methodological issues that can make interpretation of the findings challenging. One issue, which is not unique to neuroimaging, is the issue of how the sample is defined. Age is a variable that can affect the findings, and in many early studies ages can range from 4 to 16, or even to 80 years of age, without attention to the differences that may be present. As seen later in this chapter, there are many structures that change with age, with some growing and others decreasing in volume (Castellanos et al., 1996). In addition, many studies contained mixed samples of gender and ethnicity making it difficult to understand whether there are gender or ethnicity differences among participants (DeCarli et al., 2005). Differences in co-morbidity, age, gender, and medication status have all been found to impact the findings and need to be recognized when interpreting a study. For instance, medication effects have been found to be related to structural differences in children with Attention Deficit/Hyperactivity Disorder (ADHD) (Semrud-Clikeman & Pliszka, 2006).

Other aspects that have not been well controlled in many MRI studies are handedness (people who are left-handed may have speech/language lateralized differently than those who are right-handed), family history of a previous disorder (there may be genetically based differences), and true normalcy (functioning may be normal but the brain may be different).

MRI technology can also differ from study to study. Magnets vary not only in strength but also in acquisition time and in movement artifacts. Children in particular have difficulty remaining still within a closed space and those with developmental disorders experience even more difficulty. In many cases 20–40 % of scans may be discarded due to movement artifacts. It is likely that the most severe cases are either unable to cope with the scanning protocol or move so much that their scans are unusable. If this is the case, then the findings that are published may relate solely to milder cases and may not be informative of more severe types of disorders, especially with children.

Finally, an issue that is not often considered is that of power. Since there can be over 128 slices for each brain, and there are over a hundred brain structures that can be studied, it becomes obvious that statistical power cannot be sufficient for all of these comparisons. Without a data driven hypothesis for a study, the findings may be spurious due to Type II errors. At times neuroimaging research has been faulted for being atheoretical, or a new type of phrenology. Good research approaches the question by asking *what do we believe underlies this difficulty/variable* and *how do our findings relate to theory?* These questions are particularly germane to MRI research because many of the studies use very small samples—sometimes less than ten participants per group.

Brain structural differences between genders are just beginning to be explored. There is more information concerning the male brain than the female brain. Emerging evidence suggests that there are differences in selected structures including the corpus callosum, gray matter, amygdala, parietal lobe, and hippocampus (Semrud-Clikeman & Fine, 2009; Semrud-Clikeman, Fine, Bledsoe, & Zhu, 2012). With the aforementioned cautions in mind, the following section will review differences in brain structure throughout the life span.

Gender Differences in Childhood

The first 3 years of life is a crucial period of time for brain development. Functional and structural development is generally around 90 % complete by age 3, particularly for sulcal and gyral formations and size (Armstrong, Schleicher, Omran, Curtis, & Zilles, 1995; Caviness, Kennedy, Bates, & Makris, 1996; Giedd et al., 2004). There are several million neurons too many during this developmental phase and excess neurons are pruned back to make the brain more efficient. Additional environmental experiences and interactions create an elaboration of neuronal connections and increase the communication within and between neuronal networks (Huttenlocher, 1990). Myelination continues throughout childhood and into young adulthood

(Jernigan, Trauner, Hesselink, & Tallal, 1991; Pfefferbaum et al., 1994; Wang & Young, 2014). Myelination is the formation of a white, fatty sheath that covers the axon and speeds the neuronal impulses. Neither myelination nor synaptic pruning significantly affect overall brain anatomy, thus, brain weight does not change during adolescence and young adulthood (Luna & Sweeney, 2004). In adolescence as well as in young adulthood, myelination increases in the frontal lobes and contributes to the eventual improved insight into behavior and the ability to plan and evaluate behavioral plans, aims, and long-term goals.

Age-related cortical and subcortical development has been found in total brain volume and white matter volume with decreases in gray matter during childhood and adolescence. The white matter increases were due to increases in volume in the frontal lobe and anterior cingulate in adolescents. In contrast the caudate and thalamus decreased in volume within this same time period for males but not females (Giedd et al., 1996). Males showed larger putamen and globus palladi regions compared to females; these areas are responsible for input of motor information. In general, male brains are 7–10 % larger than female brains (Giedd et al., 1996; Giedd, Castellanos, Rajapakse, Vaituzis, & Rapoport, 1997; Reiss, Abrams, Singer, Ross, & Denckla, 1996; Sowell, Trauner, Gamst, & Jernigan, 2002). However, with brain size factored in, females showed larger volumes in the temporal cortex and deep brain structures compared to males, while males had a larger cerebellum (8 % larger in males). The ratio of cerebro-spinal fluid (CSF) to brain volume also changes with age, with young children showing 2 % of total brain volume due to CSF and older children showing 4 % (Sowell et al., 2002).

Increases are also found for the amygdala and hippocampus for both genders during development (Giedd et al., 1997). There were differential changes with the amygdala increasing more significantly in volume for males while the hippocampus increased in volume for females. Some hypothesize that these differences are related to hormonal gender differences. Androgen (a male hormone) is more present in the amygdala (Clark, Maclusky, & Goldman-Rakic, 1988), while the hippocampus has more estrogen receptors (Sholl & Kim, 1989). These differences have been related to a theory that the X chromosome may be connected to volumetric differences in the caudate, thalamus, and gray matter of the cerebral cortex (Murphy et al., 1993), while others speculate that hormonal effects are related not just to specific brain structures, but to overall brain size and asymmetry of the hemispheres (Kelley, 1993). These hypotheses require further study.

To more fully study possible hormonal effects on brain development, Rose et al. (2004) evaluated children with congenital disorders associated with hormonal disturbance. Sixteen boys with congenital adrenal hyperplasia (CAH), which results in fewer androgens, completed an MRI. These boys were compared to 20 children with Klinefelter's syndrome (XXY). Each clinical group was matched to controls by age. Findings were of smaller amygdalar volumes in the boys with either CAH or XXY. The boys in the XXY group showed smaller hippocampi volumes. A major limitation of these findings was that there were no behavioral or neuropsychological findings with which to compare the neuroanomalous results. Such data would have provided an opportunity to determine whether these structural differences related at all to the child's ability to manage stressful situations. At this point it is only clear that there are differences in structures in these children with anomalous hormonal distribution.

Another structure which has shown to differ between the genders is the corpus callosum (CC) (Giedd et al., 1999). A longitudinal study found that the genu of the CC was larger in males compared to females with age-related changes found in the splenium between the ages of 5 and 18. Hemispheric differences were also found. The right hemisphere and right caudate volumes were larger than the left for both genders (Giedd et al., 1999). In contrast, the left lateral ventricles and putamen were larger than the right for both genders, showing consistent asymmetries for males and females.

Many of the neuroimaging differences seen may differentiate children with various psychiatric disorders from typically developing children. The regions involved in attention, inhibition, reading, and language are all areas that have been found to differ in males with ADHD and/or reading disabilities. The following section briefly discusses the work that has been completed with males with these disorders. The interested reader is also referred to the chapters within this volume on learning disabilities and ADHD for further information.

Gender Differences in Disorders Diagnosed in Childhood

Differences in genetics, hormones, and environmental effects contribute to developmental differences in brain function and size that may differentiate children with various psychiatric and learning disorders. Specifically, the regions involved in attention, inhibition, reading, and language are specific areas found to differ in children and adolescents with ADHD and/or learning disabilities. Additionally, recent studies indicate there may be specific differences in the brains of males and females diagnosed with autism spectrum disorders (ASDs) (Doyle-Thomas et al., 2014; Groen et al., 2008).

Neuroimaging in Males with ADHD

Many gender-specific research findings are of interest in children with ADHD. However, this disorder has been found to have a higher incidence for males, and the majority of theories and published research has been based on samples consisting primarily of boys. Psychosocial impairment in girls with ADHD is also well established. On the other hand, the neuropsychological and neurobiological basis of these deficits is less frequently examined (Mahone & Wodka, 2008). Many studies that include small samples of girls preclude the ability to examine the findings in a sex-specific manner. Some preliminary data is available. In a longitudinal study Shaw et al. (2009) found that children with ADHD show relative cortical thinning in regions important for attentional control, with those with a predicted worse outcome having a *fixed* thinning of the left medial prefrontal cortex, which may compromise the anterior attentional network and hamper clinical improvement. Right parietal cortex thickness normalization in patients with a better predicted outcome was hypothesized to represent compensatory cortical change, although growth curves for both males and females were similar in developmental trajectories of regional brain volumes. For most regions of interest examined (including total cranial volume and cerebellum, but not caudate), the growth curves of children with ADHD (relative to controls) were parallel, but on a lower track. Additionally, there was no interaction between diagnosis and sex, implying that both males and females with ADHD show stable reductions in brain volume as compared to controls (Castellanos & Tannock, 2002). While this study included children as young as 4 years, most participants were of school age. Therefore, it is difficult to draw conclusions about the early trajectory of anomalies that may be associated with ADHD.

Child and adolescent males with ADHD have been found to show smaller caudate volumes (Filipek et al., 1997; Semrud-Clikeman & Pliszka, 2006). Studies in ADHD have found smaller volumes specific to the right caudate, in addition to smaller volumes of the right frontal lobe, right globus pallidus, and left cerebellum in males but not females (Castellanos et al., 1996). These consistent gender-based differences have been found in the cerebellum and in total brain volume for both genders with ADHD. Additionally, it has been suggested that females and males use different behaviorally relevant neurocognitive strategies. Several studies have found greater right prefrontal cortex activation in females. However, the spatiotemporal dynamics of neural events associated with these sex differences remains unclear. One event-related potential (ERP) study examined the neural substrates of human cognitive sex differences elicited by a visual attention challenge (an area of deficit often associated with ADHD) (Neuhaus et al., 2009). Equal numbers of male and female participants (22) matched for age, education, and nicotine use were studied with 29-channel-electroencephalography recorded under a visual selective attention paradigm, the Attention Network Test. Visual ERPs were topographically analyzed and neuroelectric sources were estimated. This analysis revealed a novel frontal-occipital second peak of the visual N100 that was significantly increased in females relative to males, as well as a corresponding central ERP component, that was recorded in females exclusively, at around 220 ms. Thus, this study found a strong sex-based difference in the relationship between stimulus salience and central ERP component amplitudes. Subsequent source analysis revealed increased cortical current densities in right rostral prefrontal (BA 10) and occipital cortex (BA 19) in female subjects that was not found in males. This study was the first to report a three-part association between sex differences in ERPs, visual stimulus salience, and right prefrontal cortex activation during attentional processing and suggests that anatomical differences exist between males and females with ADHD.

Cerebral glucose metabolism studies (using positron emission tomography (PET) scans) have also been used to investigate differences in males and females with ADHD. However, studies have taken place with small sample sizes, so caution should be exercised when interpreting the results. These studies have indicated that girls with ADHD may show decreased cerebral glucose metabolism compared to girls without ADHD, with decreased metabolism in the left anterior frontal lobe significantly correlated with ADHD symptom severity ($p < 0.001$). While sample sizes have been small, the findings and hypotheses have been replicated, indicating adolescent girls with ADHD show less activation compared to healthy control girls, and less global cerebral glucose metabolism than boys with ADHD (Mahone & Wodka, 2008).

One complication in understanding ADHD is that it is considered a developmental disorder that, by current definition, has onset prior to 7 years of age. Imaging studies have provided some insight into brain differences, but thus far have almost exclusively focused on children 7 years of age and older. Recently, Mahone et al. (2011) completed a study using high-resolution anatomical (MPRAGE) images to better understand the neurobiological development of ADHD in younger children presenting with symptoms of the disorder, while controlling for language disorders. Cortical regions were delineated and measured in the study using automated methods in Freesurfer, while basal ganglia structures were manually delineated. Results indicate that even younger children with ADHD show significantly reduced caudate volumes bilaterally. However, there were no significant group differences in cortical volume or thickness in this age range. Furthermore, results indicated that, after controlling for age and total cerebral volume, left caudate volume was a significant predictor of hyperactive/impulsive behavior, but not inattentive symptom severity. Although results are not gender-specific, they suggest that irregularities in basal ganglia, particularly caudate development, appear to play an important role in children presenting with early onset symptoms of ADHD (Mahone et al., 2011).

There is a substantial literature demonstrating that the neuropsychological and neurobiological basis of ADHD in children is associated with globally decreased total brain and cerebellar volumes and striatal volumetric abnormalities that are age-dependent. However, these studies typically do not contain a large enough sample to determine if findings are sex-dependent. A previous prospective study of lobar volumes in children with ADHD was reexamined using a measure of cortical thickness (Shaw et al., 2009). Findings indicated children with ADHD had global thinning of the cortex that was most prominent in the medial and superior prefrontal and precentral regions important for attentional control. Although not sex specific, the children with worse clinical outcomes had a *fixed* thinning of the left medial prefrontal cortex, which may compromise the anterior attentional network and deter clinical improvement. Cortical thickness developmental trajectories did not differ significantly between the ADHD and control groups except in the right parietal cortex, where trajectories converged, which occurred only in the better outcome group. This right parietal cortex thickness normalization may represent compensatory cortical change. However, further study is needed to determine whether these effects are sex specific.

The mechanisms underlying the increasingly recognized motivation deficits that contribute to ADHD are being examined through neuroimaging. Tomasi and Volkow (2011) compared the functional connectivity density between 247 ADHD and 304 typically developing control children from a public MRI database. Results of their analysis indicated enhanced connectivity within reward-motivation regions and decreased connectivity with regions from the default-mode and dorsal attention networks. Again, while not sex specific, this study suggests impaired interactions between control and reward pathways in ADHD that may contribute to both attention and motivation deficits.

Increasingly sophisticated methods examining cortical topography, cortical thickness, or voxel-based morphometry, as well as neuroimaging techniques that provide a means to uncover the neurobiological mechanisms by which gene variants impact the brain, are beginning to better demonstrate more clearly delimited anatomic abnormalities. The overall pattern of results from the more sophisticated imaging techniques is not clearly convergent, potentially suggesting heterogeneity in ADHD (Castellanos et al., 2009). Models focusing on intra-subject variability, intrinsic brain activity, and reward-related processing are progressing rapidly and should provide clearer understanding of the multiple types of ADHD, as well as a better understanding of variations of connectivity contributing to differences between ADHD processing anomalies in males and females. Additional studies focusing on how genetic changes can affect brain structure, chemistry, and function are also promising (Durston, 2010).

In conclusion, findings suggest that lower glucose metabolism is more characteristic of girls with ADHD. However this has not been tested with samples that control for sexual maturation, cognitive ability, and genetic relatives with ADHD. Additionally, studies have shown that both males and females with ADHD show stable reductions in brain volume as compared to controls, with males with ADHD found to show smaller caudate volumes. Emerging imaging techniques, particularly those based on the approach of resting-state functional connectivity, and genetic neuroimaging, appear to be promising in better understanding gender differences for the disorder, as well as offering a possible means of addressing the complex heterogeneity of ADHD as testable models of pathophysiology are developed.

Neuroimaging in Males with Learning Disabilities

While there is now an informative body of research on the use of neuroimaging techniques in revealing brain morphometric differences in people with learning disabilities (Altarelli et al., in press; Hynd & Semrud-Clikeman, 1989), most differences have generally been studied with either a mixed gender sample or with males only. These studies have typically been focused on the language regions of the brain, and language laterality and degree of difference has varied among the studies due to methodological issues. Most studies have not controlled for sex and have thus provided little information about possible sex-specific variations in brain structure and function in children with learning disabilities. However, with less invasive techniques becoming available, younger children are now beginning to be included in study samples.

Language acquisition, strongly tied to learning ability, is inherent in changes that occur in the rapidly developing young brain. During the years of language acquisition, the brain not only stores linguistic information but also adapts to the grammatical regularities of language. Advances in functional neuroimaging have substantially contributed to systems-level analyses of brain development, including overall language acquisition, including reading language, and understanding of the contributions of cortical plasticity for second language acquisition (Sakai, 2005). There is about a 2.5 to 3:1 gender difference in dyslexia (a very broad term defining a learning disability that impairs a person's fluency or comprehension accuracy for reading) for boys to girls, with studies showing females have more cell density in the planum temporale than males (Witelson, Glezer, & Kigar, 1995; Witelson & Kigar, 1988a, 1988b, 2004; Witelson & McCulloch, 1991). Given the lower incidence of dyslexia in girls, it may be that this cell density is protective for reading and written language problems in females.

More recent neuroimaging studies investigating the neural correlates of verbal fluency (VF) focused on sex differences. It has been hypothesized that reading disabled children have a domain-general deficit in processing rapidly occurring auditory stimuli that degrades speech perception, thereby limiting phonologic awareness and so, reading acquisition. This was not proved to be the case in a study with 100 7–11-year-old children with learning disability and 243 non-learning disabled children who were evaluated on a two-tone auditory discrimination paradigm (Waber et al., 2001). Those with a learning disability committed more errors, but effects of timing were comparable to their non-disabled peers. The same result was obtained for a subsample of good and poor readers. The authors concluded that task performance did predict reading, spelling, and calculation ability. However, while neural processes underlying perception of speech and other auditory stimuli may be less effective in poor readers, rate appears to not be specifically affected regardless of sex.

Another study focusing on fluency rate found activation in the inferior frontal gyrus (IFG), insula, anterior cingulate cortex (ACC), medial frontal gyrus (mFG), superior (SPL) and inferior parietal lobules (IPL), inferior visual areas, cerebellum, thalamus, and basal ganglia (Gauthier et. al., 2009). This study was completed with right-handed, French-speaking, male (172) and female (159), college-age subjects performing a phonological verbal fluency task. Results indicated males, more than females, activate several regions involved in mental imagery strategies linked to word generation, including the lingual gyrus, inferior temporal gyrus (ITG) and posterior cingulate, in addition to one region linked to performance monitoring (the ACC), and other areas associated with the implementation of top-down control processes (right superior frontal gyrus (SFG) and right, dorsolateral prefrontal cortex (DLPFC)), as well as the cerebellum. Thus, findings indicated activity in three discrete subregions of the ACC related to sex, performance and their interaction, respectively. In addition to these differences, results show males seem to require greater use of visual mental strategies, subserved specifically by the precuneus, to reach a verbal fluency level equivalent with that of high-scoring females. High-scoring men also were found to solicit more areas in the left hemisphere implementing top-down control processes (DLPFC). Regardless of sex, a low level in verbal fluency scores related to greater activity in the dorsocaudal ACC. In females only, the low performance level is associated with a stronger activation in a more rostral part of the dorsocaudal ACC, which reinforces the role of the ACC in general performance monitoring. Findings also indicated that the cerebellum seems to contribute to the high verbal fluency performance level independently from sex.

Another investigation examined the impact of subject age, language task, and cortical region on the occurrence of sex differences in functional MRI with 205 (104 male, 101 female) right-handed, monolingual, English-speaking children between the ages of 5 and 18 (Plante et al., 2006). The study used fMRI at 3T to evaluate BOLD signal variation associated with sex, age, and their interaction. Brain activation in classical, left hemisphere language areas of the brain and their right homologues were assessed for sex differences. For this study, children completed up to four language tasks, which involved listening to stories, prosody processing, single word vocabulary identification, and verb generation. Sex difference for behavioral performance was found for the prosodic processing task only. Left lateralization was present for both frontal and temporal regions for all but the prosody task, although no significant sex differences were found for the degree of lateralization.

Although sex differences in visuospatial processing, also thought to contribute to learning difficulties, are a consistently robust finding in adults, few neuroimaging studies have examined this issue in younger populations. Clements-Stephens, Rimrodt, and Cutting (2009) used functional neuroimaging (MRI) to examine whether sex-based differences in visuospatial processing exist in children, and/or if they develop during childhood. Thirty-two participants, between 7 and 15 years of age (16 males, 16 females) matched on performance, participated in this study. Overall, both groups showed overlapping activation in the superior parietal lobes bilaterally, extrastriate cortex, and cerebellum. Males had significantly greater activation in the cerebellum and right lingual gyrus. Formal comparisons between age groups indicated older males show engagement of left hemisphere regions, while females show greater engagement of right hemisphere regions traditionally associated with visuospatial processing. Results also suggest older males, as compared to younger males, may engage regions that are associated with a visuomotor network, whereas females may tend to use areas indicated in spatial attention and working memory to complete visuospatial tasks. Furthermore, results suggest that differential engagement of networks associated with visuospatial processing may be due to differences in strategy use that are evident early on and continue to develop over time.

Connectivity neuroimaging studies are also beginning to be conducted with younger children, and appear to support the view that a left-lateralized brain network is crucial for language development in children. Kikuchi et al. (2011) used a custom-sized magnetoencephalography (MEG) system, a noninvasive brain imaging technique that is a practical neuroimaging method for use in young children, to investigate brain networks of 78 right-handed preschool children (32–64 months) while they listened to stories with moving images. MEG produces a reference-free signal, and is therefore a useful tool to compute coherence between two distant cortical rhythms. Results indicated that left dominance of parietotemporal coherence in theta band activity (6–8 Hz) was specifically correlated with higher performance of language related tasks. This laterality was not correlated with nonverbal cognitive performance, chronological age, or head circumference. These results suggest that it is not the left dominance in theta oscillation per se, but the left-dominant phase-locked connectivity via theta oscillation that contributes to the development of language ability in young children.

The growing body of evidence that male and female brains develop and mature at different rates (Holland et al., in press) suggests that early differences in brain development likely contribute to learning differences that may also be sex-specific. Much larger numbers of subjects would be needed to confirm findings from neuroimaging studies involving learning disabilities. However, it does appear that over time, males develop a more integrated visuomotor/visuospatial network while females appear to develop a more spatial attention/working memory system for learning. The differences in activation patterns in females may be mediated by a strong verbal strategy used early in development. Additionally, differences seen in males are consistent with visually based strategy use in which it appears that males may rely on imagery and are *more hands-on* when completing tasks. Males' reliance on a visuomotor network may also account for the traditional advantage reported on visuospatial tasks. The differential engagement of different networks associated with visuospatial processing between males and females seen with more complex tasks (such as mental rotation) seems to be supported, which could reflect a true sex-based difference in visuospatial processing that may affect learning in general. Also, emerging research suggests that the in utero experience of testosterone may affect functional asymmetries and could be linked to some differences in learning. These areas of research, as well as the relationship of handedness and/or age effects in differences of area and volume for key structures, are variables that require additional study across sexes. Additionally, there are very few studies that include sufficient numbers of minorities, and the possible effects of ethnicity on brain development have not been explored sufficiently. As these students are often *over-identified* for special education remediation, there may be even more reason to develop gender-specific research in this area.

Neuroimaging in Males with Autism

Characteristics that are attributed to autistic children, including impairments in social interaction, deviations in language usage, and restricted and stereotyped patterns of behavior have been found regardless of age, IQ, and gender. However, brain changes due to age, IQ, and gender may pose potential confounds in autism neuroimaging analyses (Kurth et al., 2011). Causes and contributing factors for autism continue to be poorly understood. The prevalence of children identified with autism is rising with the most recent data from the Center for Disease Control (2006) indicating an average of 1 in 110 children in the United States being diagnosed with autism. The most current information suggests that genetic and environmental factors contribute etiologically to this disorder. Data gained from twin, family, and genetic studies support a role for an inherited predisposition; with, clinical, neuroanatomic, neurophysiologic, and epidemiologic studies suggesting that gene penetrance and expression is likely influenced by the prenatal and early postnatal environment (Hertz-Picciotto et al., 2006). Some studies link autism to xenobiotic chemicals and/or viruses, including the CHARGE (Childhood Autism Risks from Genetics and Environment) project, begun in 2003 to investigate underlying environmental and genetic causes for autism and triggers of regression and to systematically study a wide spectrum of chemical and biologic exposures, susceptibility factors, and their interactions (Hertz-Picciotto et al., 2006). To date, CHARGE is the largest and most comprehensive assessment of children with autism ever undertaken. It aims to distinguish subgroups, or phenotypes, of autism based on thorough biomedical and behavioral analyses of affected children. A wide variety of studies have resulted from the ongoing CHARGE project, including the launch of another comprehensive autism-focused venture, the Autism Phenome Project (APP). However, little of the derived information is sex-specific.

Others have begun to research the relatives of people with autism who show milder expression of traits for the disorder, referred to as the Broader Autism Phenotype (BAP). Several neurofunctional and neuroanatomical studies of autistic individuals and their relatives using neuroimaging techniques such as fMRI, MRI, EEG, MEG, and DTI were compiled to examine important differences in brain structure, activity and connectivity in and between regions of the brain (Sucksmith, Roth, & Hoekstra, 2011). This extensive examination of the neural substrates of the BAP contributes to our overall understanding of the disorder, and helps to delineate better the possible heritable endophenotypes so that autism susceptibility can be more reliably indexed. The compiled research, although again not sex-specific, also adds to our understanding of the neural correlates of the cognitive aspects of autism (e.g., sensory perception, social cognition, and visual attention), and contributes toward a solution that will bridge the gap between genes and clinical autism diagnosis.

One hallmark symptom for children with autism includes deficits in the perception of social stimuli that may contribute to the characteristic impairments in social interaction. The cortical processing of voice is abnormal in even high-functioning autistic children (Groen et al., 2008). Significant differences in response time to the perception of a voice are noted with children with autism responding much more slowly compared to control children. No gender differences were found for either the autistic or control samples.

Another area of perception of social stimuli that may contribute to the characteristic impairments in social interaction for autistic children is the ability to understand and respond to emotions. Most neuroimaging studies that have reported gender differences in response to human emotions have used face photographs. One exception is a study completed by Fine, Semrud-Clikeman, and Zhu (2009) that used human face photographs of positive and negative emotions, along with video vignettes of positive and negative social human interactions, in an attempt to provide a more ecologically appropriate stimuli paradigm. Although this study involved healthy, non-autistic male and female young adults (ten each), findings contribute to the overall understanding of sex-specific differences in processing emotion. Using conservative ROI (region of interest) analysis, the authors found greater male than female activation to positive affective photographs in the anterior cingulate, mFG, SFG and superior temporal gyrus, all in the right hemisphere, with no significant ROI gender differences observed for the negative affective photos. More activation was noted in ROIs of the left posterior cingulate and the right ITG to positive social videos, and in the left middle temporal ROI for negative social videos for males as compared to females. Additionally, males were more lateralized than females. Furthermore, although more activation was observed overall to video compared to photograph conditions, males and females appear to process social video stimuli more similarly to one another than they do for still photos. As males are four times more likely to be diagnosed with autism, it may be that further research can expand on this information concerning differences in processing human emotion that may be useful in understanding sex-specific differences in emotional processing between autistic males and females.

Connective imaging has also been employed with autistic subjects. As autism has been hypothesized to reflect neuronal disconnection, several recent studies have examined key thalamic relay nuclei and cortico-thalamic connectivity in the pathophysiology of the disorder. One study, using DTI with 17 boys with ASD and 17 typically developing controls, produced results (using whole-brain voxel-wise analyses) that evidenced disturbances in the thalamo-frontal connections. These findings, although found in a sample that includes only males, so cannot be noted as sex-specific, emphasize the role of hypoconnectivity between the frontal cortex and thalamus in autistic children (Hong et al., 2011).

Imaging studies have also examined genetic variation in ASDs, particularly the oxytocinergic system that may modulate sociality and indicate risk for social dysfunction (Tost et al., 2010). Oxytocin, centrally released, facilitates offspring survival by initiating mother–infant bonding and the onset of maternal behavior. The neural architecture of the oxytocinergic system targets a variety of brain areas, but for children with autism, the most salient are those critical for emotion regulation (e.g., amygdala, lateral septum, and brainstem) (Lee et al., 2009). Given the known heritability of social behavior in humans, it is possible that the genetic variation in the oxytocinergic system may modulate sociality and contribute to risk for social dysfunction. Consequently, common variants in the oxytocin receptor gene (OXTR) have been examined in the context of risk for ASD. Toth et al. (2007) used a multimodal imaging intermediate phenotype approach to show that a common genetic variant in OXTR linked to social function predicts individual differences in brain structure, brain function, and personality in healthy humans. The same study provided evidence for a sex-dependent impact of OXTR genotype on limbic structures related to prosocial temperament. Together, these findings indicate a neural mechanism for genetically increased risk of social impairment, predominantly in males, that seems to be of potential relevance for autistic (and possibly other psychiatric) disorders. Other connectivity imaging studies using DTI and diffusion tensor tractography have been conducted with findings implicating the corpus callosum (Hong et al., 2011) and the cerebellar peduncles (Brito et al., 2009). Additionally, morphometric measures of the basal ganglia and thalami in 3–4-year-old children have been studied which indicate that rigid social behavior (repetitive behavior), common early in the clinical course of ASD, may be associated with decreased volumes of the basal ganglia and thalamus. Although these studies indicate reduced connectivity in corpus callosum, internal capsule, and superior and middle cerebellar peduncles and reduced volumes in the basal ganglia and thalamus as compared to the findings in age-matched healthy children, they still do not control for sex, and so it is unknown whether these findings manifest differently in males and females with autism.

Neuroimaging studies have found that children with ASDs also exhibit abnormalities in semantic processing, with particular difficulties in verbal comprehension. Differences in connectivity, genetics, and structural anomalies have also been studied in autistic individuals and their relatives using neuroimaging techniques such as fMRI, sMRI, EEG, MEG, and DTI. However, information concerning conclusive evidence as to sex-specific differences has not yet been examined. As less invasive imaging techniques are available, it may be possible to increase the number of autistic children and adolescents studied, making it more feasible to examine data concerning important differences in brain structure, activity and connectivity in and between regions of the brain in terms of specific male and female presentation.

Gender Differences in Adulthood

Metabolic Differences

Men's brains tend to be 10 % larger than women's (Dekaban & Sadowsky, 1978) possibly due to fewer cortical neurons being pruned back during early development. Thus, the disparity may be due to differences in the number of cortical neurons that survive initial pruning during gestation and early development (McEwen, 1983; Witelson & Pallie, 1973). Some have suggested that the higher neuronal density present in women's brains due to a smaller cranial vault offsets the 10 % larger brain volume of men (Witelson et al., 1995). Supporting this hypothesis is a finding of higher metabolic rates found in the cortex of women (Hatazawa, Brooks, Di Chiro, & Campbell, 1987).

Studies using PET have found metabolic differences between men and women. Women were found to show increased left hemispheric activity particularly in the cingulate region (Gur et al., 1995). In contrast, men were shown to have higher metabolism in the temporal-limbic system. These differences are hypothesized to be related to cognitive and emotional behavioral differences between the genders. The authors suggested that women may inhibit responding to direct their behavior through cognitive means (anterior cingulate) while men may use more emotionally based reactions to stimuli with less inhibition. Further study is needed to understand how functional, structural, and behavioral aspects of cognitive processing are interwoven.

Structural Differences

One structure that appears to differ between the genders is the corpus callosum. Left-handed males were found to have the largest posterior corpus callosal area while females did not show this difference for handedness (Witelson, 1989). Females were found to have a larger proportional isthmus (middle of the CC) compared to right-handed males with the genu, and the corpus callosal segment adjacent to the genu was largest in men. Age was an important variable for men but not for women. Older men had smaller CC while a similar age change did not occur for women (Witelson & Kigar, 2004). One hypothesis was that women's motor and perceptual functioning skills are less connected then men and thus are less lateralized. Men's stronger connections between these skills may be related to their improved ability in visual-spatial functioning (Voyer et al., 2006).

The Sylvian fissure may also vary depending on gender. This region is strongly associated with language abilities particularly in the left hemisphere. Autopsy results have found that strongly right-handed men have longer horizontal segments bilaterally compared to men who are not as consistently right-handed (Witelson & Kigar, 2004). This association was not present for women. These findings are intriguing. The interconnectedness of the corpus callosum for men is likely related to stronger visual-spatial skills while the lack of lateralization in the Sylvia fissure for women is consistent with superior verbal abilities. Processing skills likely differ between the genders and result in variations in skills that now appear to be structurally based rather than solely the result of environmental experience.

Thus, it has been concluded that the basic neuroanatomical differences between genders in adulthood are present in the temporo-parietal region of the brain (Witelson & McCulloch, 1991). The stronger skills in language processing present in women coupled with the stronger skills in visual-motor-spatial functioning in men has led some to speculate that these differences are due to sex hormones. The larger volume present in male brains has been related to lower levels of androgens and androgenic receptors during gestation and early development resulting in less cell pruning and cell death during this time, which in turn results in a larger corpus callosum, a larger brain volume, less cell density, and specialization for visual-spatial and motor skills (Moffat, Szekely, Zonderman, Kabani, & Resnick, 2000). Prenatal exposure to testosterone may influence cerebral lateralization in girls (Cohen-Bendahan, Buitelaar, van Goozen, & Cohen-Kettenis, 2004). In this study, twins with the same gender were compared to twins of opposite sex. The female of the opposite sex twin was found to show more lateralization of function compared to the same sex female twins. These authors speculated that prenatal testosterone exposure in the opposite twin pair altered brain organization of the opposite female twin in utero. Similarly, at the time of the study there was no difference in testosterone level for any of the female twins lending support to the hypothesis that the brain differences were a result of prenatal testosterone exposure. Supporting these hypotheses is research on gender differences that may be related to sex hormones.

Sex Hormones

As found in the animal literature, there are specific structures that appear to be particularly sensitive to sex hormones (Goldstein et al., 2001; Remage-Healey, in press). Structures that appear to be selectively responsive to sexual steroid hormones include the cerebrum particularly in the white matter volume and volume of the lateral ventricles. Men were found to have larger brains generally due to larger white matter volumes while women were found to have more gray matter compared to men relative to their brain size. Particular differences were found in more gray matter in the frontal regions for women with larger volumes in the medial section of the frontal cortex, the hypothalamus, the amygdala, and the angular gyrus. These areas have been found to have more sex hormone receptors.

Sex hormones have been hypothesized to play a part in development prenatally in terms of adult structures, particularly in the volume of the hippocampus (Kallai et al., 2005). Sexual steroid hormones have been found highly present in the hippocampus for both estrogen and testosterone and thus, this structure is thought to be particularly sensitive to sex hormones during gestation as well as development (O'Keefe, Pedersen, Castro, & Handa, 1993). Some have hypothesized that the ratio of the second finger to the fourth finger on the right hand of right-handed participants is related to testosterone or estrogen exposure during gestation. Lower ratios are associated with higher rates of testosterone exposure and higher ratios with greater estrogen exposure (Manning, 2002). There is one study that did this comparison but unfortunately only with women. A significant relation was found between volume of the hippocampus (particularly the right hippocampus) and finger length. Without a comparison of males for this study, these findings are not readily interpreted and should be viewed with caution. It is also not clear from the study whether these differences translated into more masculine or feminine behaviors.

MRI Findings

Corpus Callosum. The splenial area of the corpus callosum (CC) has been found to be smaller in women aged 56–85 compared to men independent of brain size (Davatzikos & Resnick, 1998). Women with larger areas of the posterior CC were also found to perform better on measures of spatial rotation, naming of pictures, verbal fluency, and memory tasks while no relation was found between the CC measure and these skills for men (Salat, Ward, Kaye, & Janowsky, 1997). Differences were not found in the anterior regions of the CC, frontal brain regions, cerebellum, or the pons.

Brain Volume. Using MRI and consistent with autopsy findings, males were found to have larger cerebrums compared to women with no difference found in the cerebellum (Nopoulos, Flaum, O'Leary, & Andreasen, 2000). All of the lobes were larger in males while the proportion of gray to white matter was similar for the genders. No gender differences were present in cortical surface anatomy. This study utilized large areas for comparison rather than studying smaller regions. For this reason the findings are not directly comparable to those of Witelson et al. (2004) who utilized smaller regions of interest. Differences that are due to gender may not be widespread throughout the brain and may be region specific.

Parietal Lobes. The parietal cortex has been found to be important for visual-spatial processing; a skill in which most men have been found to perform better than most women (Frederikse, Lu, Aylward, Barta, & Pearlson, 1999). The right posterior parietal cortex has been implicated in spatial working memory and recognition of affect (Borod, Koff, Lorch, & Nicholas, 1986; Jonides, Smith, Koeppe, & Awh, 1993; Jonides et al., 1993). The left posterior parietal cortex has been implicated in mental rotation, complex motor planning, and time estimation (Alivisatos & Petrides, 1997; Maquet et al., 1996; Winstein, Grafton, & Pohl, 1997). This region has also been hypothesized to be interconnected to the planum temporale (an area utilized for phonological decoding), the DLPFC (an area involved in planning, organization, and attention), and Broca's area (an area specialized for verbal output) (Mesulam, 1998).

Gender differences have been evaluated in the parietal region of the brain (Frederikse et al., 1999). Males were found to have larger left posterior parietal gray matter volumes compared to females with no difference present for the right posterior parietal gray matter volume. No measure of white matter volume was obtained. The authors suggest that these findings are consistent with previous findings of male dominance on tasks of mental rotation as well as indicating more lateralization in male brains than in females. Further discussion of the relation between cognitive and brain functioning for the sexes is described later in this section.

Frontal and Temporal Lobes. The temporal lobes contain many of the limbic structures in the limbic system. A study of hippocampal and amygdala volume did not find gender differences (Gur, Gunning-Dixon, Bilker, & Gur, 2002). Women were found to have larger orbital-frontal volumes compared to men. This region has been strongly implicated in inhibition of impulses. It may be instructive to state that this region has been found to be compromised in men with higher levels of psychopathy (Raine, Lencz, Bihrle, LaCasse, & Colletti, 2000). It may well be that a larger proportion of orbital-frontal volume to amygdala volume may assist in modulating emotions, particularly aggressive impulses (Gur et al., 2002). These findings are intriguing and further study is needed to determine whether true gender differences are present, and more importantly, how these findings relate to behavioral measures.

Another aspect that is important to study is the effect of aging on the brain. While there are differences in brain structure and possibly activation based on gender, further studies of the effect of aging and gender may provide us with important information about gender differences. Linking these findings to behavioral and neuropsychological functioning is a necessary next step that is currently being undertaken.

Aging

Early studies of structures that change with age found that elderly men (men above the age of 70) have lateralized atrophy in the left hemisphere while women show a more symmetrical form of atrophy (Gur et al., 1991). In addition, the frontal lobe appears to be most vulnerable to aging for both genders with males showing more atrophy in this region (Cowell et al., 1994). After the age of 50, the frontal lobes show marked decline while a smaller decline is found in the temporal lobe and very little difference in the occipital or parietal lobes. Men were found to show significantly smaller frontal lobe volume for every age range after the age of 50 (DeCarli et al., 2005). Estrogen has been suggested as a protection for atrophy in other brain areas beyond the frontal lobes (Eberling et al., 2003). In one study women on estrogen replacement therapy (ERT) were found to have larger right hippocampal volumes compared to those not on ERT or males (de la Torre, 1997; Jack Jr et al., 2002). The decrement of hippocampal volume was also found in a study evaluating age differences over a 5-year period using serial MRIs (Raz et al., 2005). In addition to the hippocampal volume being related to estrogen, it was also found that those subjects with hypertension (uncontrolled) also show smaller hippocampal volumes as well as cerebellar volume independent of gender. It would be very interesting to note whether people with well-controlled hypertension (120/80 or lower) would show similar decrements. It was also suggested that the regions that mature at the oldest ages (frontal lobe, anterior cingulate) are most vulnerable to decline.

In summary, the frontal and temporal lobes appear to be most vulnerable to change during aging for both genders with males showing the most decrement. In most cases, the parietal, occipital, and limbic systems appear to be similar by gender during the aging process. Further study is needed to evaluate possible complications from hypertension, particularly if uncontrolled. There was only one study that included minorities, which studied the effects of ERT on hippocampal functioning. Further investigation is needed to determine what other aspects may differ across gender, ethnicity, and age. The following section reviews the emerging literature on the relation of these differences to neuropsychological functioning. There are three main areas that have been most clearly studied; language processing, visual-spatial processing, and emotional processing.

Gender Differences in Activation During Cognitive Tasks

As discussed earlier, there is evidence that language areas of the brain are less lateralized in women compared to men with more cell density present in women than in men in the Sylvian Fissure region (Shaywitz et al., 1995). In contrast, activation of the occipital region involved in visual discrimination was activated similarly between the genders. Gur et al. (2000a) further studied language and spatial tasks in adult females and males. Males have been found to show a greater association between right hemispheric activation and performance on a spatial reasoning task relative to women (Gur, Skolnick, & Gur, 1994; Wendt & Risberg, 1994). Both genders showed similar left lateralization for a verbal analogies task. These findings suggest that complex verbal tasks are processed similarly for the genders while those requiring sound-symbol processing (phonological coding) differ, showing a wider distribution of activation for females compared to males. It may also be that the superiority of males on visual-spatial reasoning tasks is related to more lateralization and possibly more specialization in the male brain for this type of task compared to females.

There have been very few studies conducted that evaluate how the processing of emotional stimuli differs across gender. One study that evaluated emotional recognition found more activation in the left IFG in males compared to more bilateral activation in females (Baron-Cohen et al., 2006). In a study that solely evaluated females DeCarli (2003) found that positive pictures of emotional stimuli evoked more activity in the left hemisphere while negative pictures show increased activation in the right hemisphere. More recently a study evaluating hemispheric differences in the interpretation of positive and negative interactions using fMRI found more activation in the right hemisphere compared to the left for both types of interaction (Semrud-Clikeman, Fine, & Zhu, 2011). While there were no significant gender differences, the sample for this study was too small to say anything definitive about this topic. Additional study in this area is needed in order to more fully understand whether males and females differ in emotional processing activation.

At this point in time we have little information as to how gender differences in structure and possibly in activation map onto behavioral and neuropsychological functioning. The comparison of genders is just beginning and is an important step for our understanding of the brain. In addition, there are even fewer studies that have compared ethnicity and gender to determine whether important differences also exist. A brief review of the aging literature suggests not only that male brains show more decrement over time but they are also highly susceptible to difficulty when hypertension is present. Studies have found possible hormonal influences for gender-specific structural variations, but these studies do not also include behavioral and neuropsychological findings. Such behavioral data will assist in understanding how these differences play out.

The following section expands the above discussion to four types of disorders: schizophrenia, depression, stroke/heart attack, and ASPD. The existing literature in these areas is fairly sparse and will be briefly reviewed below. This chapter will synthesize these findings, tie them to normal development, and point out areas that require further study.

Schizophrenia

As neuroimaging has become more accessible, additional studies have provided valuable information regarding sex-specific anomalies in patients with schizophrenia. Differences have been found in cortical and grey matter volume, cerebral spinal fluid and cerebral blood volume, as well as specific structures including, but not limited to, the hypothalamus, corpus callosum and hippocampus. MRI studies examining patients in which there is more than one family member with the disorder have indicated significantly increased hypothalamic volume, particularly in regions of paraventricular and mammillary body nuclei, both in the patient and their nonpsychotic relatives (Goldstein et al., 2007). It was also found that women with schizophrenia had a greater propensity for increased hypothalamic volume than men. In addition, a higher level of anxiety was present in both genders when there were more members of the family with a similar diagnosis.

White Matter Differences

Post-mortem studies have long suggested sex differences in the brains of schizophrenic patients, particularly in the size and fiber composition of the corpus callosum. Alterations in the density of axons in all regions of the corpus callosum except the posterior midbody and splenium have been observed in males with schizophrenia who exhibit greater density than females; the exact opposite of what is found in healthy controls.

Several studies have examined cortical and grey matter volumes in patients with schizophrenia. An MRI study of whole brain grey matter volume grouped the patients with schizophrenia by five symptoms (negative, relational, inattention, disorganization, and reality distortion). Findings indicated that the negative symptoms (of schizophrenia) were generally associated with larger cortical volumes in all regions of the brain, and relational and inattention factors were associated with larger frontal grey matter volumes. Similar findings were reported for both males and females (Nesvåg et al., 2009).

Differences in white matter volume of the cerebellum have also been found in patients with schizophrenia (Lee et al., 2007). These differences were also found to correlate with verbal fluency. Results indicated patients with schizophrenia exhibited significantly increased cerebellar vermis white-matter volume compared with controls. Total cerebellar volumes, and grey- and white-matter volumes of cerebellar hemispheres, were not significantly different between groups. However, increased vermis white-matter volume in schizophrenic patients (although not sex-specific) was associated with poor verbal fluency performance on neuropsychological tests. This finding suggests that increased white-matter connectivity in the cerebellar vermis may be associated with verbal executive dysfunction in men with chronic schizophrenia.

DTI has been used to examine white matter pathology in schizophrenia. Areas that have been studied include the fiber tracts in the uncinate and arcuate fasciculus, anterior and dorsal cingulum, and subdivisions of the corpus callosum. At this point in time the findings have been equivocal. Some studies have indicated no white matter pathology (Kanaan et al., 2005; Okugawa et al., 2006) while others have indicated increased white matter pathology (Hubl et al., 2004). These contradictory findings may be related to differences in subject characteristics, DTI methodology, or possible effects of age, gender, level of education and illicit substance use on DTI findings (Peters et. al., 2009). To date, there do not appear to be sex-specific differences in the fiber tracts of schizophrenic brains.

Language-Based Structures

Structural MRI has been used to examine brain dimorphisms in language-associated regions in schizophrenic male and female patients. Findings specific to males indicated abnormalities in the left hippocampal and planum temporale regions

(Walder et al., 2007). These anomalies were associated with phonological, semantic, and grammar deficits. For females, the right Heschl's Gyrus and left planum temporale regions were significantly associated with phonology, right Heschl's Gyrus with semantics and grammar and the right hippocampus with semantics. Women with schizophrenia tend to have better verbal fluency and memory compared to men. Moreover, an additional laterality effect was noted in this study where females may recruit more right hemispheric function during language processing than males. This recruitment is accompanied by poorer semantic processing in women with schizophrenia compared to men. It may well be that these differences in language skills in men and women with schizophrenia are related to the neuroanatomical differences, particularly in findings of larger right hippocampal volume (Walder et al., 2007).

Cranial-Facial Structures

A pilot study of facial, cranial and brain MRI morphometry in men with schizophrenia (Henriksson et al., 2006) applied a 3D morphometric MR method to test the hypothesis that males with this diagnosis have deviant facial shapes and landmark relations in cranio/facial/brain (CFB) regions. Findings indicated men with schizophrenia had significantly longer mid- and lower-facial heights, and greater lower, left facial depth, with a tendency toward rotation along the facial midline. While these findings are interesting, it is unfortunate they were not linked to behavioral and/or neuropsychological functioning. They do suggest that there are neurodevelopmental differences that are present in-utero and further suggest that other neuroanatomical deviations may have a common pathway that is genetically based.

CSF and rCBF

Cerebral blood flow (rCBF) and CSF abnormalities have also been noted through imaging studies with the schizophrenic population. Although not sex-specific, these studies tend to incorporate a significantly greater number of male subjects. Findings have shown abnormally reduced and inverse hemisphere rCBF in a large (mostly male) population of patients with schizophrenia. Chronic low CBV has been hypothesized to sustain neural hypoactivation and concomitant increase of free radicals, ultimately resulting in neuronal loss and cognitive impairments (Brambilla et al., 2007). Significant extra-cortical CSF enlargements have been observed in first episode patients, with regional differences in the temporal, anterior frontal and parietal cortices. Subsequent volume and ventricular surface analyses failed to show significant effects of diagnosis. However, interactions indicated dorsal superior horn expansions in female (but not male) patients compared with same-sex controls. As ventricular enlargements are widely reported in chronic patients, this study suggests ventricular enlargement may progress after disease onset with early changes occurring around the dorsal superior horn. However, it is unclear whether there are sex-differences in this progress, as males do not exhibit the same first episode expansion that has been observed in females (Narr et al., 2006).

Medication Effects

A recent area of neuroimaging study for this population is examining interaction effects of drugs commonly used to manage symptoms for schizophrenics. There is some indication that rate-corrected electrocardiographic QT (QTc) intervals may significantly increase in patients with schizophrenia taking antipsychotic drugs. Longer QTc intervals are associated with sudden heart attacks and death. A 2011 study completed by Yang et al. (2011) suggests there are sex differences in the prevalence of QTc prolongation and QTc lengthening in schizophrenia. Their studies' findings indicate that schizophrenic females taking antipsychotic drugs are at higher risk for QTc prolongation, and risks are substantially higher for those on clozapine (Sekimoto et al., 2011).

Depression

Depression has a significant impact on development, can adversely affect school and work performance, impair peer and family relationships, and appears to exacerbate the severity of other health conditions such as asthma and obesity. Children and adolescents who have had a major depressive episode (MDE) in the past year are at greater risk for suicide, are more likely than peers to initiate alcohol and other drug use, are most likely to have a comorbid substance use disorder, and to smoke tobacco daily (Cohen, & Reporting, 2015). Depressive episodes often persist, recur, or continue into adulthood. There has been a slight trend in the statistics. In the United States, 8 % of the population ages 12–17 had an MDE, a lower rate than that reported in 2004 (9 %). However, the prevalence of MDE among youth was more than twice as high among females (12–13 %) compared to males (4–5 %) between 2004 and 2009 (Cohen, & Reporting, 2015). Further, suicide is listed as the seventh most common cause of death for males in the United States (Cohen, & Reporting, 2015).

Neuroimaging studies are contributing to research concerning depression, specifically gender differences in depression, so that better treatment can be developed to improve these sobering statistics. In 1994, Nolen-Hoeksema and Girgus reported that there were no gender differences in depression rates in prepubescent children, but, after the age of 15, girls and women are about twice as likely to be depressed as boys and men. The authors theorized that girls are more likely than boys to carry risk factors for depression even before early adolescence, but that those risk factors lead to depression only in the face of challenges that increase in prevalence in early adolescence (e.g., peer pressure).

More recent research (Essau et al., 2010) continues to confirm the 1994 findings. Gender differences in the onset, duration, number of depressive episodes, and rate of recovery from major depressive disorder (MDD) were examined in a population based sample of 773 individuals during adolescence (age 14–17), and then again, at age 30. This study examined gender differences in the developmental course (i.e., incidence, duration, number of depressive episodes, and recovery rates) of MDD in adolescents and young adults. Findings indicated that females continue to have higher incidence rates of MDD than males, and a more chronic course. Differences in episode duration were found to be marginally but significantly larger in females. However, an earlier onset age correlated significantly with more number of episodes for both genders. One difference in the earlier onset rate was that it predicted a worse course of depression in females, indicating childhood depression seems to be a more serious risk factor for girls than for boys.

Structural MRI Findings

A meta-analysis of primary studies that investigated structural brain changes in MDD was completed in 2011 (Kempton et al., 2011). The actual aim of this compilation was to assess the effects of medication, demographic, and clinical variables, and compare the findings with those of a meta-analysis of studies on bipolar disorder (BD). MEDLINE, EMBASE, and PsycINFO databases were searched (January 1, 1980, to February 2, 2010), producing 225 studies that used MRI or X-ray computed tomography (CT) to compare brain structure in patients with MDD with that of controls, and 143 that measured common brain structures. Compared with the structure of a healthy brain, MDD was associated with lateral ventricle enlargement, larger cerebrospinal fluid volume, and smaller volumes of the basal ganglia, thalamus, hippocampus, frontal lobe, orbitofrontal cortex, and gyrus rectus. Additionally, patients imaged during depressive episodes had significantly smaller hippocampal volume than patients during remission. Compared with healthy controls, both MDD and bipolar disorder were associated with increased lateral ventricle volume and increased rates of subcortical gray matter hyperintensities.

There also appears to be a relationship demonstrated between pro-inflammatory cytokine activity and depressive symptoms. This relationship was examined using lab-induced pro-inflammatory cytokine (intravenous injection of a low-dose endotoxin) over a 2-h period (through repeated blood draws), and comparing IL-6 (pro-inflammatory cytokine) levels to imaging findings using *f*MRI, during a socially painful experience (Eisenberger et al., 2009). Replicating previous research, this study found that individuals exposed to endotoxin, compared to placebo, showed increases in IL-6 levels, as well as depressed mood. However, no meaningful neuroimaging differences were found between the endotoxin and control groups. What was found were sex specific differences in the relationships between IL-6 increases and neural responses to the painful social experience among subjects exposed to endotoxins. Females exposed to endotoxin exhibited increases in social pain-related neural activity (dorsal ACC and anterior insula) and reported depressed mood, as compared to males who exhibited no significant relationship. This data supports the theory that pro-inflammatory cytokine (IL-6) increases and depressed mood increases are mediated by painful social experience exposure in females, but not males (Eisenberger et al., 2009).

Functional neuroimaging offers a window into the structural functions of the human brain as it deals with depression. Imaging studies repeatedly report certain structures to be implicated in particular disorders, and the insular cortex is one of those often implicated in emotional processing. The insula is a structure employed in the evaluation of one's own emotion, as well as in the general neurobiology of MDD (Essau et al., 2010; Hulvershorn, Cullen, & Anand, 2011). Imaging studies indicate both current and remitted MDD patients exhibit significant volume reduction of the left anterior insular cortex as compared with healthy controls. No difference in the posterior insular cortex volume was found between these groups, even when there were additional symptoms of melancholia and co-morbidity with anxiety disorders (Takahashi et al., 2010). Other differences involving specific structures, noted through MRI, PET, and proton spectroscopy study include, but are not limited to, the superior and inferior frontal gyri, anterior cingulate, subgenual prefrontal cortex, left DLPFC, parahippocampal gyrus, and inferior temporal gyri. A preliminary within-subjects MRI study of seven patients revealed that, compared to remission, depression was associated with gray matter density increases in subgenual prefrontal cortex, parahippocampal gyrus, and inferior temporal gyri, with decreases observed in superior and inferior frontal gyri and anterior cingulate (Brooks, Foland-Ross, Thompson, & Altshuler, 2011).

PET studies have contributed information concerning the role of serotonin, a neurotransmitter frequently linked to depression, by imaging proportionally normalized α-[11C]methyl-Ltryptophan brain trapping constant (α-[11C]MTrp K*N), an index of serotonin synthesis (Benicio et al., 2010). In this study, women with MDD displayed higher serotonin synthesis than men in the IFG, ACC, parahippocampal gyrus, precuneus, superior parietal lobule, and occipital lingual gyrus, and significant hemispheric differences in fronto-limbic structures between men and women with MDD were also observed. Results indicate depressed women have higher serotonin synthesis in multiple regions of the prefrontal cortex and limbic system involved with mood regulation, as compared to depressed men, which may be related to higher risk for MDD in women.

There is less known about depression from a developmental perspective. However, a few studies have begun to target the child and adolescent population as imaging techniques have become available that are less invasive. Ten depressed males (ages 13.3 ± 2.3) were imaged using proton spectroscopy of the left DLPFC, with findings indicating significantly lower levels of choline-containing compounds and higher myoinositol (a 6-carbon, cyclic polyalcohol present in measurable concentrations in all living cells) levels in the left DLPFC compared to healthy controls (Caetano et al., 2005). Significant inverse correlations between glutamate levels and both duration of illness and number of episodes were found for the depressed subjects, with healthy controls exhibiting a significant direct correlation between age and glutamine levels. Lower choline compound levels in pediatric MDD may reflect lower cell membrane content per volume in the DLPFC, and increased myoinositol levels may represent a disturbed secondary messenger system, although replicating studies were not found for either child or adult populations, and none were reported as sex specific.

Overall, males appear to have less risk factors for developing an MDD, with females exhibiting higher incidence rates of MDD and a more chronic course. An earlier onset age predicts a worse course of depression only in females. The difference in duration of depressive episodes is marginally significant between males and females, with females having longer episodes. However, an earlier onset age correlates significantly with more episodes in both genders. Findings suggest that the morphologic abnormality of the anterior insular cortex, which plays a major role in introspection and emotional control, may be a trait-related marker of vulnerability to major depression, supporting the notion that MDD involves pathological alterations of limbic and related cortical structures. Results indicate depressed women have higher serotonin synthesis in multiple regions of the prefrontal cortex and limbic system involved with mood regulation, as compared to depressed men, which may also be related to higher risk for MDD in women. Recently, studies involving combat exposure (CE) with men and women have indicated there are gender-based differences in depression and comorbid post traumatic stress disorder (PTSD) risk (Luxton, Skopp, & Maguen, 2010).

As with most areas neuroimaging psychiatric disorders, more research is needed with minority populations. However, given the current body of knowledge, it appears childhood depression may be a more serious risk factor for girls than for boys, as the relationship between most neural activations and depressed mood appears to be specific to females. It is also strongly suggested from the research that women have differences in amount of neurotransmitters that may also be related to the more severe presentation of this disorder than that found in men.

Antisocial Personality Disorder

Over the past 30 years there has been a great deal of work trying to reconcile and integrate the often overlapping work of mental health professionals on personality traits and disorders (Costa & Widiger, 2005). DSM-IV-TR (American Psychiatric Association, 2000) suggests that there are likely to be sex differences in many disorders, (DSM-IV-TR; American Psychiatric Association, 2000) noting that personality disorders all have a long history of gender differences, and have an onset no later than early adulthood. Nevertheless, diagnosis of the personality disorders across genders has been the focus of considerable controversy in the literature, most of which has centered around the possibility of a sex bias. However viewed, the complicated nature of interpreting sex prevalence rates across different samples exists, and the DSM-IV-TR offers a consistent conceptual model for understanding sex differences among the personality disorders. While sex specific differences in personality are established, particularly for ASPD, there remains little research using imaging studies to better understand gender differences with this population.

In 2007, Coccaro, McCloskey, Fitzgerald, & Phan, in reviewing available neuroimaging research, conceptualized personality disorders as, *Trait-like dysfunctional patterns in cognitive, affective, impulse control, and interpersonal domains that have been linked to specific neural circuits*. (p. 65). Neuroimaging allows the researcher to examine the neural integrity of these circuits in personality-disordered individuals. Their review indicated findings across personality disorders for both functional and structural dysfunction in fronto-limbic circuits in borderline and ASPD, as opposed to temporal lobe and basal striatal-thalamic compromise that was evident in schizotypal personality disorder (Coccaro, McCloskey, Fitzgerald, & Phan, 2007).

More recently, Furnham and Trickey (2010) took another approach to understanding sex differences within the personality disorders by asking approximately 18,366 British adults to complete the Hogan Development Survey, a measure derived from the personality disorders framework and designed to identify personality-based performance risks and derailers of interpersonal behavior. Results of the study suggested sex differences in personality disorders although the effect sizes were small. The authors remind the reader that, to date, all estimates indicate only between 1 and 3 % of the population actually has these disorders, and when examining only those with ASPD, the number is even smaller. In a 2003 review of the neuroimaging literature on personality disorders, McCloskey et al. merged older, psychopathy data with antisocial personality data, as there was such a paucity of imaging studies using either.

The frontal cortex and limbic areas have been the primary focus of imaging research involving antisocial behavior, although other brain regions have also been implicated. MRI studies show that men with ASPD have increased white matter in the corpus callosum (CC) both in volume and length (Raine, Lencz, Bihrle, LaCasse, & Colletti, 2000). Functional MRI studies have shown decreased right superior temporal gyrus activation to abstract words, but increased temporal gyrus and insula activation in response to negatively valenced words and pictures with this population (McCloskey, Phan, & Coccaro, 2006). Sex-specific research is minimal to date.

Stroke and Heart Attack

Imaging studies with stroke and myocardial infarction (heart attack) patients are becoming more common. The reasons for gender disparities in stroke outcome remain unclear, and little is known about the value of using acute neuroimaging data to better understand differential stroke outcomes between the sexes. A recent study involving 676 patients (322 women) used CT angiography (CTA) performed in all patients within 24 hours of symptom onset (Silva et al., 2010). CTA source images were used to evaluate lesion volume. More women in the study had intracranial artery occlusions than men, but there was no significant difference between ischemic lesion volumes. CTA scores were correlated with modified Rankin scale (mRS) scores. The mRS is a commonly used scale for measuring the degree of disability or dependence in the daily activities of people who have suffered a stroke. Being female was significantly related to poorer outcome on the mRS at 6 months even after adjustment for clinical and imaging covariates.

Transcranial magnetic stimulation, magnetoencephalography, single photon emission computed tomography (SPECT), MRI, and *f*MRI have all been used to study stroke and heart attack patients post insult (Chatterjee, Fall, & Barer, 2010; Grefkes & Fink, 2011; Meehan, Randhawa, Wessel, & Boyd, 2011; Roiha et al., 2011). Unfortunately few of these examine differences between the sexes, and rarely are participant numbers great enough to guarantee robust findings when divided by gender for comparison.

Balance within the motor network is often critically disturbed after stroke. Lesions may either directly affect motor areas or damage-related, white matter tracts. Recent research suggests cortical regions remote from the ischemic lesion may also contribute to motor impairment after stroke (Grefkes & Fink, 2011). Models of functional and effective connectivity are using neuroimaging data to investigate how stroke influences the interaction between motor areas, as well as how changes in connectivity contribute to impaired motor behavior and overall functional recovery. While available information thus far suggests that pathological intra- and inter-hemispheric interactions among important motor regions constitute a significant pathophysiological feature of motor impairment after subcortical stroke (Wang et al., 2010), gender-specific data is not yet available.

Other imaging studies have focused on language recovery in patients with aphasia due to left hemisphere damage, as well as the role the right hemisphere plays in supporting recovered language functions in the chronic phase for patients with different site and size of stroke lesion. Rajani and Swathi (2011) explored the role of perilesional, ipsilesional, and contralesional activation in participants with aphasia using *f*MRI to characterize brain activations in healthy and age/gender matched stroke patients during tasks involving semantic judgment and oral picture naming. During the semantic judgment task patients without lesions involving the left frontal region activated the left IFG in a similar manner to what is observed in normal controls. Participants with left frontal lesions activated both contralesional regions in addition to perilesional left frontal regions. There were no differences in bilateral brain recruitment during the picture-naming task between healthy controls and stroke patients. However, subsequent regions of interest analysis and laterality index analysis indicated patients with large lesions produced greater right hemisphere activation than patients with small lesions. Again, no gender differences were reported.

In contrast to explicit motor functioning, implicit motor learning is preserved after a stroke. Our understanding of how the brain compensates for damage following a stroke is unclear. It is also unclear whether men and women recruit different regions to compensate for post-stroke or myocardial infarction. Emerging evidence from neuroimaging studies is contributing to a better understanding of how the brain compensates following damage.

In one *f*MRI study patients were compared on a tracking task following a stroke to study the way sequence-specific implicit motor learning differentiated from general improvements in motor control. In addition, these same patients were later tested to determine retention of information (Meehan, Randhawa, Wessel, & Boyd, 2011). Both healthy and post-stroke participants demonstrated implicit sequence-specific motor learning at the retention test. Substantial differences were apparent in the left dorsal premotor cortex during repeated sequence tracking. In addition, implicit sequence-specific motor learning and general improvements in motor control were associated with an increased blood oxygenation level dependent (BOLD) response in the left middle frontal gyrus after stroke. While these data emphasize the potential importance of a prefrontal-based attentional network for implicit motor learning after stroke, they did not address differences between men and women, and did not take into account the literature concerning how motor learning differs between genders.

Some effects of stroke and heart attack on emotional, motor and cognitive functioning have begun to be examined in a gender-specific manner (Chatterjee, Fall, & Barer, 2010; Kapral et al., 2011; Rajani & Swathi, 2011). Findings indicate that, compared with men, women are less likely to achieve independence after acute ischemic stroke (Silva et al., 2010). Other studies, some using large samples, have concluded there are no significant gender differences in stroke care or outcomes (i.e., readmission or mortality rates), although they cite evidence of improvement for men compared to women when techniques such as lipid-lowering therapy, carotid imaging, and endarterectomy are utilized (Kapral et al., 2011).

As the disparity in stroke outcome does not seem to be explained by differences in ischemic lesion volume or the presence of intracranial artery occlusions, it is likely that gender differences may account for some portion of this difference. Emerging research has begun to evaluate gender differences in emotional processing following a stroke or heart attack but findings are equivocal at this time (Kornerup, Zwisler, & Prescott, 2011). Further study is needed to assess the burden of myocardial infarction and stroke in men, and for men of African-American and Hispanic descent in particular, as their rate of death from these disorders now exceeds that of Caucasian males. Morbidity and mortality from these vascular disorders can be reduced by early treatment, which requires correct pre-hospital identification of symptoms that may be better understood at the gender level, rather than expecting similar responses and results from treatments applied uniformly across sexes.

Contributions from neuroimaging allow us to begin to understand sex differences, not only in general, but also for more specific disorders such as those presented here (schizophrenia, stroke/myocardial infarction, depression and ASPD). To date, neuroimaging has contributed to our understanding that childhood depression may be a more serious risk factor for girls than for boys, as the relationship between most neural activations and depressed mood appears to be specific to females. Alterations in the density of axons in all regions of the corpus callosum except the posterior midbody and splenium have been observed in males with schizophrenia who exhibit greater density than females, and schizophrenic women have been reported to have a greater propensity for increased hypothalamic volume than men. In the area of stroke and myocardial infarction there is less definitive understanding of how these diseases may manifest in differences in brain structure and function, but there is considerably more study occurring in this area than there is for ASPD. Neuroimaging studies for the ASPD population continue to be sparse, with the few that exist focusing almost exclusively on a male population. Both the lack of neuroimaging in this area and the lack of study focused on both sexes leave one with little current information about the neural circuitry involved in observed differences in behavior between males and females with the disorder.

As with many areas of research, there is a significant lack of information concerning the way in which psychiatric disorders manifest in minority populations, particularly in a gender-specific manner. Neuroimaging studies have contributed to the overall understanding of the developmental differences involved in depression and schizophrenia. However, gender-specific research is sparse for these as well, and almost nonexistent in the stroke, myocardial infarction, and ASPD literature.

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Understanding the Neuropsychology of Autism Spectrum Disorders in Men

Elaine Clark, Keith C. Radley, Rebekah S. Huber, and William R. Jenson

Introduction

Men in the general population exhibit more autistic traits than women. In a study of autistic traits in adults with normal intelligence, Baron-Cohen and colleagues found that, among control subjects without autism spectrum disorder (ASD), twice as many men as women had elevated scores on an autism screener, the Autism Spectrum Quotient (AQ) (Baron-Cohen, Wheelwright, Skinner, Martin, & Clubley, 2001). While only 4 % of male controls in their study scored at the highest level on the screening measure, none of the women scored as high, even women who were later diagnosed with ASD (i.e., Autistic Disorder, Asperger's Disorder, or Pervasive Developmental Disorder-Not Otherwise Specified (PDD-NOS).

A preponderance of males with ASD have been observed since Leo Kanner wrote his seminal article about autism in 1943, and a year later Hans Asperger published an article describing the *autistic personality* as an extreme variant of male intelligence or character (Asperger, 1944; Kanner, 1943). More than five decades later, Baron-Cohen and Hammer (1997) posited the *Extreme Male Brain* (EMB) theory of autism. The EMB theory states that the male proclivity for precision,

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logical thinking, and analysis is consistent with the preference for predictable rule-governed systems such as mathematics and fact memorization. Similarly, individuals with ASD have little interest in unpredictable or ambiguous situations such as social systems. Clearly, males and individuals with ASD have shown a preference for science, engineering, and technology. A survey of Cambridge University undergraduate students majoring in the sciences (e.g., science, engineering, and mathematics) revealed six times as many family relatives with ASD when compared to humanity majors (e.g., English, French literature) (Baron-Cohen et al., 1998).

Gender differences in social cognition, emotional expression, and perception continue to support the EMB theory of autism. Recent research has shown that males and females with ASD differ both neuropsychologically and behaviorally. Symptoms of ASD and the degree of symptom severity may be manifested differently in males and females. Furthermore, males and females with ASD vary in areas of social cognition and executive functioning. Therefore, gender considerations may have important implications for assessment and treatment of individuals with ASD.

In this chapter, issues related to ASD in males will be presented, including symptom manifestation, prevalence and comorbidity, neuropsychological underpinnings, long-term outcomes, and implications for assessment, treatment, education, and vocation.

Explanations for Male Bias and Male ASD Symptoms

Females have been shown to have an advantage in language acquisition over males (Huttenlocher, Haight, Bryk, Seltzer, & Lyons, 1991). Though the early language development advantage in females is not maintained over time, it is thought to be partly responsible for the failure to identify females with ASD at younger ages. By the age of 4 or 5 years, boys with ASD have been found to display significant deficits in social and pretend play, show more unusual interest in visual aspects of objects, and interact more with objects than with people (Nicholas et al., 2008). In contrast, young females with ASD have been shown to be better at imitation, participate more in social play, and rely on communication skills to interact with others (Koenig & Tsatsanis, 2005; Lugnegard, Hallerback, & Gillberg, 2011; Nicholas et al., 2008). Studies have also shown that females are more capable of decoding nonverbal cues (facial and gesture) and identifying another person's thoughts and feelings. According to Baron-Cohen et al. (2011), males with ASD are not as proficient with *Theory of Mind* (ToM) tasks and tend to focus their attention on local details instead of global concepts that are important for social situations. This has otherwise been referred to as *Weak Central Coherence* (WCC) (e.g., Baron-Cohen et al., 2011). WCC and ToM are two cognitive models that have been used to explain some of the core deficits, specifically in males with ASD.

Successful social interactions typically require recognition and understanding of another's thoughts and feelings (i.e., empathy). According to EMB theory, females have a propensity toward empathizing and males have a tendency toward systemizing. In a study of empathy in adults with and without ASD, Baron-Cohen et al. (2011) found that women in the control group scored significantly higher on the Empathizing Quotient (EQ) than control males, who scored significantly higher than female controls on the Systematizing Quotient (SQ). Both men and women with ASD, however, had significantly lower scores on the EQ scale compared to SQ, indicating a stronger drive towards systemizing over empathizing in adults with ASD. According to the authors, findings such as these support the EMB theory and are best explained by fetal testosterone exposure.

Males and females are both exposed in utero to testosterone; however, males are born with higher levels of testosterone. At around 3 or 4 months of age, males experience a surge that allows them to maintain higher testosterone levels throughout the first 12 months of life (Knickmeyer & Baron-Cohen, 2006). Researchers have shown that *Amniotic Fluid Testosterone* (AFT) levels are negatively correlated with frequency of eye contact at 12 months (Lutchmaya, Baron-Cohen, & Raggatt, 2002a), size of vocabulary words at 18–24 months (Lutchmaya, Baron-Cohen, & Raggatt, 2002b), and quality of social interactions at 48 months (Knickmeyer, Baron-Cohen, Raggatt, & Taylor, 2005). Additionally, AFT levels are positively correlated with a narrow range of interests at 48 months (Knickmeyer et al., 2005) and systematizing and attention to task detail at 96 months (Auyeung et al., 2006). Berjerot et al. (2012) also found that women with ASD had higher testosterone levels than female controls, and women with ASD were more physically androgynous than same sex controls. On the other hand, researchers failed to show that men with ASD had higher testosterone levels than male controls. Given these findings, Berjerot and her colleagues concluded that autism could not be explained simply by brain masculinization. Rather, they concluded that autism was a *gender defiant disorder* that was caused by disruption of the reproductive endocrine system due to environmental impact (internal and/or external).

According to Corrales and Herbert (2011), gene studies have underestimated the impact of the environment on the development of ASD, and environmental studies have failed to show that environment alone adequately explains the development of ASD. The more plausible explanation, according to Rutter (2008) and others (e.g., Corrales & Herbert, 2011), is a gene–environment interaction. A good example of this is the impact from viral infection and maternal prescription drug use during pregnancy. The occurrence of rubella before 8 weeks gestation is associated with ASD. Likewise, ASD is associated with maternal use of valproic acid around 4 or 5 weeks gestation (Rodier, 2000). However, as Rodier points out, these associations fail to account for the complex role of multiple impacts, including the initial exposure and secondary effects caused by gene alterations that increase the fetus' vulnerability to further toxicological and immunological assaults. With greater attention being paid to multiple impacts from environmental and genetic sources with multiple interactions, it is hoped that the factors contributing to autism will be understood to further improve diagnosis and treatment.

Sex Differences in Reported Male ASD Prevalence Rates

Current estimates from the Centers for Disease Control and Prevention (CDC) (2012) show that 1 in 88 individuals in the United States has ASD (i.e., Autistic Disorder, Asperger's Disorder, or PDD-NOS). In the case of males, the rate is even higher, at 1 in 54. The rate for females is much lower (i.e., 1 in 252), and the ratio of males to females with ASD is 4.6 to 1. The largest sex difference has been found in cases of high functioning autism (HFA) or Asperger's Disorder, for which the ratio is 11 males to 1 female (Baron-Cohen et al., 2011).

According to the 2012 CDC report, 37 % of males with ASD have comorbid intellectual disability (ID) compared to 46 % of females. It should also be noted that data collected from the CDC is based on 8-year-old children. Given this, it is unclear how many individuals with average or higher cognitive abilities are being missed in the surveillance counts, especially females, who have been found to mask autistic symptoms better than males at early ages (e.g., see Lugnegard et al., 2011; Nicholas et al., 2008). Additionally, recent data show that the proportion of individuals with ASD and comorbid ID in the total population of people with ASD is much lower now than it was a decade ago, that is, 38 % compared to 67 % (Yeargin-Allsop et al., 2003).

Impairments Associated with Biologic and Neurologic Disruption

Failure to orient to and process facial features is thought to be due to faulty biology from the disruption of the dopamine reward circuit. This results in reduced time spent processing facial features, which limits the amount of information that can be extracted from interactions with others. Additionally, it is thought to affect cortical specialization and limit future opportunities for social learning and further neurologic development (Dawson, Webb, & McParkland, 2005). By 3 years of age, children with ASD demonstrate impaired differential responding to familiar and unfamiliar faces during Evoked Response Potential testing (Rozga, Anderson, & Robins, 2011).

Functional magnetic resonance imaging (fMRI) studies have shown both abnormal recruitment of brain regions, and neural under-connectivity in individuals with ASD. For example, when processing social stimuli, older children and adults with ASD recruit the inferior temporal gyrus, an area typically associated with object processing, instead of the fusiform gyrus, an area associated with social processing (Rozga et al., 2011). A number of studies have shown that individuals with ASD have greater recruitment of brain regions associated with lower level, or visual processing, as compared to higher level verbal processing. Using fMRI, Ring et al. (1999) found that adults with ASD more often employ the right occipital cortex than the bilateral parietal cortex or right dorsolateral prefrontal cortex (the former having to do with visual processing and the latter verbal). Recent fMRI studies suggest complex gender differences in verbal and visual spatial domains due to differences in activation across occipital, temporal, parietal, and medial frontal regions for males and females with ASD (Beacher et al., 2012).

Task complexity may limit performance in individuals with ASD. According to Kana and Just (2011), individuals with ASD are impaired on tasks requiring integration. For example, while they understand the meaning of individual words, they have difficulty integrating these single-word meanings into sentences and paragraphs, thus affecting communication. This difficulty has been associated with disrupted neural circuitry. Results from fMRI studies have demonstrated under-connectivity of the frontal-posterior regions, and abnormalities in the amygdala, hippocampus, and prefrontal and medial temporal cortices. Frontal-posterior under-connectivity has been associated with a number of deficits, including poor sentence comprehension, processing of discourse, verbal communication, working memory (verbal and facial), facial recognition, and visual-motor coordination (Boucher, 2011; Kana & Just, 2011). Boucher also describes other abnormalities in neural circuitry associated with sensory-perceptual deficits, emotional processing, and declarative and emotionally based memory impairments. Other problems, according to Kana and Just, include executive dysfunction.

Executive Functioning in Individuals with ASD and Brain Activation

Attempts to attribute the deficits in ASD to deficient executive functioning (EF) have been criticized. These criticisms focus on the overlapping EF deficits found among individuals with ASD, and those with other neurodevelopmental disorders, such as ADHD and learning disability (Barnard, Muldoon, Hasan, O'Brien, & Stewart, 2008). Studies that have been cited as lacking specificity are those that include only singular measures of EF, or measures lacking complexity. According to some researchers (e.g., Ozonoff, South, & Provencal, 2005), studies using multiple measures are more likely to demonstrate deficits in areas thought to be impaired, as well as average or better functioning in areas expected to be unaffected in individuals with ASD.

Understanding the strengths and weaknesses that are associated with ASD is important, especially in areas that have been shown to impact aspects of everyday life. For example, planning, inhibition and set-shifting, selective and sustained attention, working memory, and fluency are critical aspects of EF that are affected in ASD (Barnard et al., 2008; Ozonoff et al., 2005). Due to EF abnormalities, individuals with ASD may face challenges that impact their ability to interact socially, perform up to their potential in school and work, and function independently in everyday life.

Planning deficits for individuals with ASD may affect task organization, allocation of resources, and time management. Planning is the ability to identify and organize complex sequences of elements necessary to achieve a goal. It requires multifaceted cognitive demands, strategic behavior, reasoning ability, organization, and efficient goal-directed behavior. Individuals with ASD have demonstrated impaired planning on tasks such as the Tower of London and Tower of Hanoi, which are used to measure an individual's ability to plan. The Tower tasks require the rearrangement of disks or colored balls in the least number of moves possible to match a target configuration (Just, Cherkassky, Keller, Kana, & Minshew, 2007; Rumsey & Hamburger, 2008). Planning ability improves with age in individuals in the general population, but not in individuals with ASD. In fact, studies have shown that as individuals with ASD get older, they make more errors on Tower test tasks (Ozonoff et al., 2004). This could subsequently impair their performance at school and work, and in other aspects of living, especially as they age. Consequently, this is a noteworthy finding, especially when considering rehabilitation.

Inhibition and set shifting are important elements of EF that are also affected in individuals with ASD (Linnankoski et al., 2015). Inhibition refers to selective attending, whereas set shifting refers to switching attention to different stimuli. Individuals with ASD perseverate, have a narrow focus on details, and are unable to inhibit behaviors and responses. Furthermore, individuals with ASD are often rigid and lack the ability to demonstrate cognitive flexibility. Cognitive flexibility facilitates novel behavior and allows an individual to navigate from one topic to the next, which requires inhibition and set shifting, and is an important life-skill (Berger, Aerts, van Spaendonck, Cools, & Teunisse, 2003; Williams, Goldstein, & Minshew, 2005). Adults with ASD have difficulty inhibiting response patterns and shifting sets to solve problems, especially on complex tasks (Rinehart, 2001). Studies examining the performance of adults with ASD on simple inhibition and set shifting tasks have not consistently distinguished groups with ASD from those with executive dysfunction. When evaluated using the Stroop Color and Word Task (SCWT), individuals with ASD have not differed in performance to those of controls. The SCWT is an inhibition task that requires individuals to say the color of the ink of printed words and involves interference of incongruently written words. On the other hand, when inhibition tasks are verbally mediated and involve arbitrary rules, adults with ASD demonstrate impairment (Rumsey & Hamburger, 2008). An example of this is the Hayling task, which involves complex verbal stimuli, such as the completion of incomplete sentences containing both congruent and incongruent words (Boucher et al., 2005). Males perform differently than females on response inhibition. In a simple stop task measuring response inhibition, females with ASD showed significantly increased stopping time and poorer inhibition, whereas no response inhibition impairment was noted for males with ASD or controls (Lemon, Gargaro, Enticott, & Rinehart, 2011).

Results of studies examining selective attention have shown that adults with ASD tend to be overly selective and focus intensely on details, while at the same time struggle to interpret multiple stimuli from the environment (Pierce, Glad, & Schriebman, 1997). Filtering problems are thought to explain some of the attention problems observed in ASD (Wiggins, Robins, Bakeman, & Adamson, 2009). Burack (1994) demonstrated enhanced selective attention in individuals with

ASD. Results showed that individuals with ASD had greater problems with visual search tasks when the field was broader and distractors were present.

In contrast, results of studies comparing individuals with ASD to controls on selective attention tasks have been inconsistent (e.g., Goldstein, Johnson, & Minshew, 2001; Siegel et al., 1992). In fact, Raymaekers, van der Meere, and Roeyers (2004) suggested that impairments found on tasks thought to measure selective attending may be better explained by poor sustained attention (e.g., poor performance on the Go/No-Go task requiring inhibition and sustained focus). Belmont and Yurgelun-Todd (2003) found that adults with ASD had increased activation in the ventral occipital and striate regions of the brain, whereas controls had increased activation in the superior parietal, medial, temporal, dorsolateral, prefrontal, premotor, and medial frontal cortices. Other studies have shown that compared to controls, individuals with ASD take longer to voluntarily orient to (Wainwright-Sharp & Bryson, 1993) and disengage from, target stimuli (Plaisted, 2001). While the results are equivocal, it is evident that *inhibition* and *selective attention* may affect important aspects of EF and brain functioning in individuals with ASD.

Another critical component of EF is working memory, which involves the simultaneous processing and storage of information, skills that are impaired in adults with ASD, including those with ASD and HFA (de Vries & Geurts, in press; Joseph, McGrath, & Tager-Flusberg, 2005). Furthermore, these deficits worsen when memory load increases or tasks become more complex. For example, individuals with ASD demonstrate difficulty on tasks requiring evaluating and updating stored information (Steele, Minshew, Luna, & Sweeny, 2007). Adults with ASD also perform poorly on simple tasks such as the Spatial Span subtest of the Wechsler Memory Scale-Third Edition (Barnard et al., 2008; Minshew, Luna, & Sweeney, 1999). According to Koshino et al. (2005), left frontal lobe activation on fMRI during experiments using the n-back test, a sequential letter memory task, is reduced for adults with ASD. Researchers have also found abnormal right hemisphere activity (i.e., reduced activation in the dorsolateral prefrontal cortex, inferior frontal gyrus, and pre-central sulcus). Some researchers have associated working memory difficulties in ASD with WCC, and a favoring of lower level processing (Mottron, Morasse, & Belleville, 2001).

The final aspect of EF that has been associated with problems in ASD is fluency, the ability to generate multiple specific responses. Studies of men with HFA or Asperger's have shown greater fluency deficits than adult controls, in particular, on design and word fluency tasks (Turner, 1999). Adults with ASD who have lower cognitive abilities have been shown to have a higher rate of repetitions on these types of tasks (e.g., random number tasks) (Williams, Moss, Bradshaw, & Rinehart, 2002). Fluency deficits may cause individuals with ASD to respond to situations more slowly, in a disorganized fashion, or with restricted responses. Speed and accuracy of responding can affect the performance of individuals with ASD at school and work, and during social situations. On the other hand, studies examining the relationship between fluency and restricted behaviors have shown mixed results, and some have demonstrated negative findings (e.g., Lopez, Lincoln, Ozonoff, & Lai, 2005). Therefore, the question remains as to what extent fluency problems may impact a person's ability to tolerate uncertainty and consider alternative situations (see Bailey, Phillips, & Rutter, 1996; Jarrold, Boucher, & Smith, 1996).

Other Associated Cognitive Impairments

Adults with ASD also experience impairments in language, sensory-perceptual functions, and learning. Early language skills have been found to predict long-term outcomes among individuals with ASD (Paul & Cohen, 1984). Children with ASD who have functional language by age 5 are shown to have better long-term outcomes, particularly in the areas of academic, occupational, and social functioning. Indeed, Howlin, Goode, Hutton, and Rutter (2004) found that language outcomes were significantly correlated with IQ for individuals with ASD.

Studies have found considerable variability in language skills among individuals with ASD, including those with Asperger's Disorder. By definition, an individual with Asperger's does not experience early language delays (APA, 2000). However, these individuals have been found to experience difficulties with the social aspects of language and to struggle to derive meaning from context (Tager-Flusberg, 2001). In addition, individuals with Asperger's have problems interpreting non-literal language and irony (Martin & McDonald, 2004). Other language-related problems in individuals with ASD include the organization of speech (Ozonoff & Miller, 1996) and expressive skills (Happe & Frith, 1996). Additionally, individuals with ASD experience problems with prosody of language (e.g., unusual rhythm and intonation, with stresses on unusual aspects of language) (Shriberg et al., 2001) and the matching of affect implied by speech prosody (Rutherford, Baron-Cohen, & Wheelwright, 2002). It should be noted that Miles (2012) found different language profiles for individuals with ASD. Some have relatively few problems with the quality of speech production (fluency and articulation) and grammatical structure, while others struggle with sound production.

Neuroimaging studies have demonstrated reduced or reversed hemispheric dominance of language perception among adults with ASD (Cardinale, Shih, Fishman, Ford, & Müller, 2013; Muller et al., 1999). Scott-Van Zeeland, Dapretto, Ghahremani, Poldrack, and Brookheimer (2010) demonstrated atypical frontal-temporal-parietal network activations during tapes of artificial languages in adults with ASD. Although controls in their study showed decreases in frontal-temporal-parietal activity when cues to word boundaries increased, there were no brain activation changes in the adults with ASD. Recruitment of the intra-parietal sulcus, an area previously associated with visual imagery in sentence comprehension (Just et al., 2004), has been observed during reading of low-imagery stimuli. This suggests a tendency for individuals with ASD to recruit areas involved in visual-spatial processing when attempting to comprehend sentences unrelated to spatial objects or relations (Kana, Keller, Cherkassky, Minshew, & Just, 2006). Moreover, Fishman, Yam, Bellugi, Lincoln, and Mills (2010) showed that when exposed to sentences with incongruent endings, adults with ASD had smaller N400 effects. These effects measure the cognitive demand required for integration of a meaningful stimulus into a general context. Therefore, a smaller effect suggests less elaborate semantic network connections, which take part in the integration of bringing words together. Just as WCC is characterized by failure to integrate information into a whole, less elaborate semantic networks among those with ASD suggest poorer integration of language inputs.

In terms of sensory functioning, researchers have found that at least 90 % of individuals with ASD have one or more sensory processing abnormalities (Crane, Goddard, & Pring, 2009). Sensory processing deficits can be experienced in several domains and include auditory and visual processing, tactile sensitivity, and feeding behaviors. Crane et al. (2009) found that sensory deficits in ASD were the same in children as in adults. Other researchers have shown that younger individuals with ASD who have lower ability levels have greater sensory impairments owing to an inability to inhibit responding as well as adults (Leekam, Nieto, Libby, Wing, & Gould, 2007). Adults with ASD have been found to have structural abnormalities in the brain that might explain some of these sensory problems. For example, Tsatsanis et al. (2003) found reductions in the size of the thalamus in adults with ASD. The thalamus is a critical structure for sensory processing since it relays sensory and motor signals throughout the cortex.

When considering sound signal detection, a study by Kasai et al. (2005) failed to show a difference between adults with ASD and control groups. However, these researchers observed delayed automatic processing of speech sounds specifically in the left hemisphere in those with ASD. Findings such as this suggest that language-related dysfunction may be present at lower levels of auditory processing among individuals with ASD, thus impacting language functioning in a bottom-up fashion. Hypo-activation of left temporal networks during exposure to speech-like sounds has been found, which further suggests that abnormal auditory processing is contributing to the language deficits observed among individuals with ASD (Boddaert et al., 2003).

Sensory processing abnormalities have the potential to explain a wide variety of impairments associated with ASD, as nearly all functions rely on sensory input. Individuals with ASD have hyper-arousal of various sensory domains, a finding that is hypothesized to have the same neural underpinnings as WCC, because these individuals are overly sensitive to sensory information due to abnormal attention to detail (Baron-Cohen & Belmonte, 2005). South, Ozonoff, and McMahon (2007) have hypothesized that oversensitivity to sensory input contributes to the manifestation of self-stimulatory behaviors because these behaviors can serve to reduce environmental stimuli variance.

The basal ganglia and striatal structures, which support learning, appear to be normal in the cases of ASD studied (Bauman & Kemper, 2005). When abnormalities have been found, they tend to be in orbitofrontal cortex (Dawson, 2008). Given the fact that the orbitofrontal cortex relays signals of reward value from the basal ganglia and stores these in short-term working memory (Rolls, 2004), impairments in this area are likely to impact the ability to benefit from activities that are typically rewarding. Just et al. (2007) found decreased neural network integration between the prefrontal cortex and other brain regions. They thus hypothesized that this might contribute to problems *updating* reinforcement history in individuals with ASD. When Solomon and colleagues demonstrated delayed learning response to positive feedback in individuals with ASD, they were of the opinion that enhanced basal ganglia functions may help individuals with ASD compensate for problems associated with structural abnormalities in the prefrontal and orbitofrontal cortices (Solomon, Smith, Frank, Ly, & Carter, 2011).

Abnormalities in the amygdala have also been implicated in learning problems given the functional connectivity between the amygdala, the fusiform facial area, and the frontal lobes. Due to the role this structure plays in the associations made between sensory perceptions and emotional reinforcers, it is thought to be associated with learning problems (Aggleton, 2003). Amygdala dysfunction and disconnectivity has been associated with reduced social motivation (Shultz, 2005), which in turn reduces interactions and opportunities for learning. Implicit learning, which occurs without awareness of what has been learned, is impaired in individuals with ASD. Based on WCC theory, focusing on the parts and not the whole prohibits an individual with ASD from integrating information. Thereby, they fail to automatically recognize and learn from similarities and relationships between stimuli (Plaisted, 2001). Although the majority of individuals with ASD are male, it is difficult to hypothesize substantial gender differences because gender is rarely studied as a variable in most research focusing on individuals with ASD.

Adult Outcomes in Individuals with ASD

Independent Functioning

Overall, studies have shown that the majority of individuals who are identified with ASD as children have poor outcomes as adults. This includes those who have average or higher scores on intelligence tests administered when ASD was first diagnosed during childhood, and those with less severe autistic symptoms (e.g., Farley et al., 2009; Howlin et al., 2004). According to some researchers, even adults who no longer meet ASD criteria often demonstrate some degree of impairment in terms of their ability to function independently (e.g., Cederlund, Hagberg, Billstedt, Gillberg, & Gillbergm, 2008). Data from a longitudinal study by Howlin et al. (2004) with 68 adults diagnosed as ASD, and IQ scores of 50 or better when tested during childhood, showed that 66 % of the participants had never been employed, and only 8 out of the 23 adults who had ever held a job were engaged in independent work. Vocational outcome and independent living was associated with the acquisition of age-appropriate language by the age of 5, and an IQ score at the initial time of diagnosis of 70 or higher. Surprisingly, adults with IQ scores at the 50th percentile or higher (i.e., score of 100 and above) did not have better outcomes than those with scores in the 70s, or what is referred to in the DSM-IV (APA, 2000) as *borderline* intelligence.

In a 20-year follow-up study of 41 adults with IQs in the 70s or higher, only 19 % were living independently, while 56 % were living with family members and 25 % were residing in state-supported facilities (Farley et al., 2009). However, 39 % had obtained some form of post-high school education, and more than 50 % had been employed in some capacity, whether part-time or full-time. Outcome ratings by family members and other informants indicated that, for the most part, these adults with ASD were doing much better than would be predicted from other similar studies. This includes the subgroup of adults in the Howlin et al. (2004) study who had similar IQ scores. Howlin et al. found that 45 % of the adults in their study, with IQ scores 70 or higher (44 adults in total), were described as having poor or very poor outcomes, compared to 17 % of the adults in the Farley et al. (2009) study. In fact, 48 % of the adults Farley and her colleagues studied were reported to have had a *good or very good* outcome as adults, and 34 % were reported to have *fair* outcomes. It is unclear why the participants in this study seemed to be performing better than others with near-average IQ scores; however, environmental supports may have played an essential role. Participants in the Farley et al. study grew up in relatively large families and were living in communities with a strong church affiliation, both of which would be expected to provide support, and greater opportunities, including employment opportunities, for individuals with ASD. This type of information is not clear in some of the other studies, which makes clear comparisons difficult.

Vocational Needs

Studies have found very low rates of post-high school education and employment for adults with ASD compared to other disabilities, including those with ID. In a sample of young adults with ASD (Shattuck et al., 2012), 34.7 % attended college and 55 % were able to secure paid employment within 6 years of high school graduation. The situation was more dire in those who failed to finish high school, as more than 50 % did not find employment over the span of 2 years and did not participate in any other formal educational activity after leaving school. Risks were exacerbated for individuals with greater functional impairments, and from lower income families. Results from a study by Lawer, Brusilovskiy, Salzer, and Mandell (2009) showed that vocational rehabilitation counselors were twice as likely to classify adults with ASD as being too severely compromised to benefit from services, and as a result offered them suboptimal vocational programs. According to this report, only 44 % of adults with ASD who participated in vocational programs obtained employment, compared to 57 % of adults with ID who received jobs after participation in rehabilitation services.

Even adults with ASD who find employment are often under-employed. For example, Taylor and Seltzer (2011, 2012) found that 37 % of adults (mostly men) with ASD who were employed were working in some type of supported setting. These included sheltered types of workshops typically reserved for lower functioning individuals, such as those with ID. One difficulty faced by adults with ASD, and normal or near normal intelligence, is being perceived as having lower functional status and as lacking in independence.

The vocational rehabilitation system is designed to improve employability by providing services such as counseling, job search assistance, and on-the-job training. Vocational services offered to adults with ASD are suboptimal, and oftentimes do not provide the help needed for an individual with ASD to gain employment. Not surprising, the jobs that adults with ASD often obtain are not competitive. In comparison with most disabled individuals, including those with ID, speech and language impairment, and learning disability, individuals with ASD have the lowest rates of post-vocational rehabilitation employment (Lawer et al., 2009; Shattuck et al., 2012). Employers who have contact with adults with ASD often lack knowledge about comorbid psychiatric conditions and the possibility that such conditions might interfere with work activities.

Mental Health Concerns

Studies addressing mental health problems of adults with ASD are scarce. A recent study by Lugnegard et al. (2011) examined the psychiatric histories of men and women with Asperger's Disorder. Results showed that 70 % had suffered from at least one episode of major depression and 50 % had recurrent depressive episodes and anxiety disorders. Even though more men than women had been diagnosed with a social anxiety disorder or obsessive-compulsive disorder (or OCD traits), men were less likely to have a generalized anxiety disorder. Thirty percent of the men and women had a diagnosis of ADHD. Although no participant in the study had been diagnosed with a psychotic disorder, 11 % of the men and 14 % of the women reported having experienced recurrent auditory hallucinations. Substance use and related concerns are often not reported for individuals with ASD; however, Lugengard et al. found that 19 % of the men and 4 % of the women in the study had substance dependence disorders. No woman in the study was found to have Tourette's Disorder, however, 4 % of the men did. Results from another study of psychiatric comorbidities in adolescent and young males with Asperger's or HFA found that 70 % of the young men admitted to a psychiatric hospital for treatment were admitted due to being physically or verbally assaultive (mostly toward parents or teachers), and about 50 % had made a suicide attempt or threat (Backner, 2012). Similar to other studies, about half of the young men had been diagnosed with major depression, anxiety disorder, or ADHD, and the majority had experienced some type of encounter with law enforcement for violations of the law.

Legal Problems

Reports of legal problems are fairly common among adolescents and adults with ASD, especially for males. Results of studies, including one by Backner et al. (2012) and another by Allen et al. (2008) show that violent or threatening behaviors often occur because of an inability to handle stressful social situations, including bullying from peers. For example, Allen and his colleagues showed that very few offenses committed by the individuals they studied with ASD were related to drugs, theft, fraud, sexual assault, or motor-vehicle violations. Instead, the offenses, including physical assaults, occurred after repeated taunts, social rejection, thwarted sexual advances, and conflicts with family members. Farley et al. (2009) also found that the offenses committed by the adults in their study were often related to suspicious behaviors stemming from special interests, being coerced by peers to engage in antisocial behavior, or misinterpreting situations (e.g., situations where there are multiple complex inputs that must be understood and an appropriate action taken). Findings such as these reinforce the notion that a wide range of impairments associated with males who have ASD complicate many functions of their daily living and not just social interactions.

Implications for Assessment, Treatment, Education, and Vocation

Tools for the assessment of individuals with ASD consist of the ADOS-2 and the Autism Diagnostic Interview-Revised (ADI-R). Other checklist screeners such as the Autism Spectrum Rating Scales (ASRS), the Gilliam Autism Rating Scales-Second Edition (GARS-2), the Social Communication Questionnaire (SCQ), and the Social Responsiveness Scale-Second Edition (SRS-2) are often used in conjunction with the ADOS-2 and the ADI-R. Standardization for these screening and assessment measures has primarily utilized males for the samples. This is helpful for the purpose of this chapter on males with ASD. However, this should be taken into consideration when using these screening and assessment measures in females. Due to gender differences in symptoms and manifestations of ASD, the concern has been raised regarding whether the same diagnostic criteria and assessment cut-offs should be used for both males and females. Identification of individuals with ASD is critical for the provision of appropriate services, and professionals need to be aware of changes to diagnostic criteria in the DSM-V. Furthermore, it is necessary for mental health professionals to consider gender differences in the assessment and diagnosis of ASD.

Whether it is schools, vocational training facilities, employment sites, or mental health agencies, most are ill-prepared to deal with the unique challenges that individuals with ASD bring and must face. It is important that teachers, employers, and community leaders be provided with information that will help them provide the assistance and supports that are required for individuals with ASD. As previously mentioned, Farley et al. (2009) found that those individuals with high levels of community support had improved outcomes compared to the outcomes of individuals from other studies where no such support was provided (e.g., Howlin et al., 2004). In order to produce the best possible outcomes for individuals with ASD, professionals should focus their efforts on improving support systems available. Autism Speaks (www.autismspeaks.com) is one resource that can be helpful for individuals working with those with ASD, since it provides a guide to community support, such as securing housing and other support for independent living.

Many individuals with ASD are likely to benefit from counseling and other support services that aim to improve decision making, reduce inappropriate behaviors, and improve social skills. Professionals working with individuals with ASD may also have an important impact on outcomes through creation and implementation of a vocational and educational plan that provides for a good match between the individual with ASD and the environment. Although the students at Cambridge are not typical in terms of academic outcomes, they provide an excellent example of the importance of finding a good fit between the individual and the environment (Baron-Cohen, Wheelwright, Scahill, Lawson, & Spong, 2001). Similar to the science majors in that study, professionals working with individuals with ASD should help them find an educational or vocational environment where their interests and talents are accepted *and* respected. Additionally, it is necessary that comorbid learning difficulties and health problems (mental or physical) are identified and supported, given that these difficulties further compromise an individual's functioning in educational and vocational settings (Farley et al., 2009). Examples of supports and strategies that may be provided are found in Table 1. Research with young adults with ASD indicates that these and other behavioral interventions are critical to increasing the chances of an adult with ASD of having the best possible outcomes in terms of employability and social functioning (e.g., Hillier, Fish, Siegel, & Beversdorf, 2011).

Table 1 Examples of vocational, educational, and social strategies and supports for individuals with ASD

Domain	Vocational	Educational	Social
Planning	• Utilize time management strategies • Model and practice strategies for task planning • Develop templates for tasks to be repeated • Assign a workplace mentor • Clear workplace expectations	• Utilize organizational strategies, such as colored folders • Provide steps for completion of assignments • Write assignment due dates on calendar • Utilize highlighters for important information	• Develop social scripts for a variety of situations
Cognitive flexibility/ set-shifting	• Increase structure in environment to allow for predictable shifts in tasks • External cues for set-shifts, such as notes or oral directions	• Break assignments into multiple steps to make shifts clear • Practice solving problems in several different ways	• Plan in advance for change in routine • Structured social activities
Inhibition	• Increase structure • Create scripts for workplace interactions	• Reinforce academic routines, such as homework completion	• Inform individual of explicit guidelines for behavior • Create social scripts
Fluency	• Video-modeling to increase task fluency	• Work with other students on homework and projects	
Attention	• Use headphones to block out distracting noises	• Utilize tape recorder during class lectures	• Social skills training for attention
Attention memory	• Provide breaks • Repeat instructions for assignments • Shorter assignments • Visual schedules for due dates	• Provide students with notes prior to class • Sit near front of class • Utilize visual organization strategies • Link new information to existing information	• Self-management programs

(continued)

Table 1 (continued)

Domain	Vocational	Educational	Social
Language	• Prompt employers and coworkers to communicate in a clear and direct manner • Utilize scripts that can be used in various settings	• Develop strategies to obtain additional instruction if material is unclear • Encourage use of campus-based tutoring and writing centers	• Use video modeling for social language behaviors • Practice with non-literal language
Sensory functioning	• Move work to a quiet location • Reduce clutter • Allow for breaks	• Use headphones • Utilization of computerized instruction	• Reinforce tolerance of sensory stimulation in social settings
General functioning	• Assign a coworker to serve as a "translator" • Assessment of adaptability of individual and fit of workplace environment • Instruction in job interviewing techniques	• Frequent monitoring of student work • Immediate feedback on performance	• Teach use of anxiety reduction techniques • Teach independent and community life skills

Conclusions

Although much research remains to be done on the neuropsychological underpinnings of individuals with ASD, it is clear that professionals may have a positive impact on the outcomes of men with ASD. Professionals working with individuals with ASD should actively work to reproduce the positive effects associated with a supportive environment, and help individuals with ASD to overcome the social isolation, bullying, and victimization that many individuals experience throughout their lifespan (e.g., Baron-Cohen et al., 2001). While men with ASD have substantial obstacles to overcome, many such obstacles related to men in general, the advocacy and support provided by professionals and others in the community are essential in improving the chances of adults with ASD at achieving their social, educational, and vocational potential.

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Using an Ecological Clinical Neuropsychology Approach to Understanding and Intervening with Men with Learning Disorders and Attention Deficit/Hyperactivity Disorders

Rik Carl D'Amato and Yuan Yuan Wang

Why We Need to Study Males

It is difficult to be of the male gender, a boy or a man (Pollack, 1999). Men suffer from numerous mental, emotional, physical, neurological, and neuropsychological disorders, and many go undiagnosed *and* untreated (Berninger & May, 2011; Wasserman, McReynolds, Lucas, Fisher, & Santos, 2002). Young boys tend to lie more than young girls and are more aggressive and oppositional (Toch, 1992). Even at a very young age, in research studies, boys display behavior which is more aggressive whereas girls display behavior which is more nurturing (DiCicco-Bloom & Romer, 2012; Pollack, 1999, 2006; Toch, 1992). While the focus of this chapter is not on the physiological differences between genders, numerous chapters in the current volume focus in detail on which specific areas of the brain are different in males and females. This is initially introduced in chapter "Introduction to the Neuropsychology of Men: A Developmental Perspective from Theory to Evidence-Based Practice" by Zaroff and discussed in more detail in chapter "Imaging and Development: Relevant Findings in Males" by Semrud-Clikeman and Robillard. This theme continues in most other chapters which document a variety of brain structure differences (and related problems) between men and women. It is clear that boys and young males have more trouble in school classrooms than their female counterparts, and young men display more school problems as they mature—they

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are more truant and more violent in school, and also less engaged in their education (Kaplan & Cornell, 2004; Pollack, 1999). The male gender drops out of school more, and displays more conduct complications, more attention difficulties, as well as significantly more learning problems (Davis, 2011; Rosler et al., 2004). The purpose of this chapter is to understand some of the history of men with Learning Disabilities (LD) and Attention Deficient/Hyperactivity Disorders (ADHD), as well as to begin offering some possible solutions for the future. In an ideal educational enterprise, with a very low teacher to student ratio—perhaps 1:15—instructional individualization and teacher professional development, coupled with comprehensive school neuropsychological services, should help many of the difficulties discussed in this chapter disappear. But we do not live in an ideal world and most boys and young adults do not receive the services they so critically need (D'Amato, Fletcher-Janzen et al., 2005; Pollack, 1999, 2006).

Introduction to Learning Disorders in Men

The area of learning disorders and LD are fraught with a number of difficulties, beginning with the relative terminology. The medical perspective follows the *Diagnostic and Statistical Manual of Mental Disorders, fifth edition* (DSM-V, 2013), as well as previous editions (American Psychiatric Association, 2000), and uses the diagnostic term Learning Disorder. According to the DSM-V, updated in 2013, a Specific Learning Disorder is:

> a neurodevelopmental disorder with a biological origin that is the basis for abnormalities at a cognitive level that are associated with the behavioral signs of the disorder. The biological origin includes an interaction of genetic, epigenetic, and environmental factors, with affect the brain's ability to perceive or process verbal or nonverbal information efficiently and accurately (American Psychiatric Association, 2013, p. 68).

Usually, the educational perspective as practiced in public and private schools uses the words LD. A specific LD was originally defined by Public Law 94-142 in 1975 (see D'Amato, Crepeau-Hobson, Huang, & Geil, 2005). It is defined as:

> a disorder in one or more of the basic psychological processes involved in understanding or in using language, spoken or written, which may manifest in an imperfect ability to listen, think, speak, read, write, spell, or to do mathematical calculations …(p. 97).

Considered together, it is clear that these terms identify the same problem. The difference seems to be that one is focused more on a biological-behavioral base while the other may be seen as more educationally focused.

Characteristics of Individuals with LD

A single LD category is often insufficient to describe the wide-ranging nature of *males* with LD (D'Amato, Dean, & Rhodes, 1998; Kavale & Forness, 2000; Lagae, 2008). This imprecision may be due to the slow development of theory-based intelligence and achievement measures and ineffective curriculum modifications. In schools, children and youth are usually diagnosed as LD, and are placed into one of four major categories, after significant curricular modifications have failed (i.e., reading disabilities, mathematical disabilities, written expression disabilities, and language disabilities). Individuals with LD often have life-long difficulties, which initially present as preschool or school problems, at various ages, and then, if not diagnosed and treated, they can create immeasurable barriers to the full development of an individual male's life (D'Amato, Fletcher-Janzen et al., 2005; Gaddes, 1980). There is some consistency in countries around the world, in that children, youth, and adults showing difficulties in distinctive learning skills are generally identified as individuals with LD (Büttner & Shamir, 2011; Lagae, 2008; Semrud-Clikeman & Teeter Ellison, 2009).

Factors such as age, medical history, family history, level of educational achievement, and intelligence quotient are often seen as contributing factors to related learning problems. Earlier on, during the development of special education services for children who could not learn, some authors envisioned an educational science, which would integrate teaching, learning, and the brain, to offer an appropriate curriculum and a qualitative and quantitative neuropsychological intervention service model (e.g., D'Amato, 1990; Gaddes, 1980). At present, it is clear that what these early authors envisioned, which was that learning could change the brain, *is now true* and has been proven in dozens and dozens of studies (e.g., D'Amato, Fletcher-Janzen et al., 2005; D'Amato, Wang, & Davis, 2014; Shaywitz, 2003). Indeed, numerous studies have shown that an appropriate neuropsychological intervention *can* change the brain—in addition, many individuals with disorders have brain scans which have revealed differences in brain structures when compared to normal individuals (Semrud-Clikeman, 2005; Semrud-Clikeman & Bledsoe, 2014). This has been found to be true in most neuropsychological disorders which, to date, have been studied (D'Amato, Fletcher-Janzen et al., 2005). However, a neuropsychologically based intervention component which many of these authors have argued for has not been applied to male clinical outcomes (D'Amato et al., 1998; Witsken, Stoeckel, & D'Amato, 2008). In fact, these authors have argued for *individualized intervention* which rarely has taken place within a school population or other setting (Davis, 2011; Gaddes & Edgell, 1993). This idea is discussed further in this chapter.

The prevalence rate for LD is substantial. Numerous authors advocated that, depending on the definition which is used, some 5–25 % of school-age children could be viewed as having an LD (D'Amato, Fletcher-Janzen et al., 2005; Fletcher, Lyon, Fuchs, & Barnes, 2007; Semrud-Clikeman, 2005; Shaywitz, 2003). D'Amato, Dean, Rattan, and Nickell (1988) studied the referral rate of children with LD before and after the passage of United States (US) Public Law #94-142. D'Amato and colleagues found a significant difference in referral rate both before and after the implementation of this public law. Moreover, over a 20-year period, they found that for every female referred, 3.5 males were referred for LD. In addition, 80 % of the referrals occurred at an elementary school level. This clearly suggests a problem which is *primarily male* related and is clustered around grades 3 and 4. In 2006, there were nearly 3 million school-age students in the US identified as being LD, which comprises virtually half of all students with disabilities (US Department of Education, 2006). The cause(s) of individuals with LD are still not plainly recognized (Hallahan, Kauffman, & Pullen, 2008). Clearly, there is a complicated interaction between genetic and environmental factors, which makes it difficult to define or understand the diverse individuals within this disability area (D'Amato, Fletcher-Janzen et al., 2005; D'Amato & Hartlage, 2008; Titley, D'Amato, & Koehler-Hak, 2014).

According to recent developments, Neurofibromatosis Type I (NF1), which is a single-gene disorder characterized by a high incidence of complex cognitive symptoms, can potentially explain the molecular and cellular mechanism of learning disabilities (Shilyansky, Lee, & Silva, 2010). Other authors have advocated for similar causes (see Biederman et al., 2008). But individuals with LD represent a multidimensional systematic problem within the educational enterprise and no single explanation has been found to be able to clearly define this group or the type of interventions which are needed (D'Amato et al., 1998; D'Amato, Crepeau-Hobson et al., 2005; Sousa, 2005, 2006). Liederman, Kantrowitz, and Flannery (2005) believe that male vulnerability to having a potential reading disability (RD) is not likely to be a myth. They argue for future research to evaluate numerous causes:

> Thus, RD seems to resemble other neurodevelopmental disorders in terms of its male bias. Therefore, it is necessary to seek explanations for the neural basis of this gender dimorphism. Possibilities would include gender differences in terms of neuroanatomy, perinatal hormones, immunological factors, heritability, sexual imprinting, incidence of perinatal complications, and differential resilience in the face of neural insult (p. 127).

Services to Students with LD

The services provided to individual males receiving special help for students with LD have been evaluated by numerous researchers (D'Amato, Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005; Fuchs & Fuchs, 2006; Gaddes, 1980; Gaddes & Edgell, 1993; Peterson et al., 2014; Reynolds & Shaywitz, 2009). This is because there has been a great deal of concern about *if* the current educational and psychological needs of the students with LD have been provided for in a proper manner. Stated another way, unique student needs, which might require the administration of a specific educational approach, may not be offered by teachers, who tend to focus on a single instructional approach (e.g., teaching reading phonetically), in which they have been trained (Shaywitz, 2003; Sousa, 2005, 2006). In fact, D'Amato and Dean (1987) argued that what was written in psychological reports detailing specific student needs often was *not* put in the students' individual education programs (IEP) or often carried into a teacher's daily lesson plans (DLP).

To evaluate this hypothesis, they randomly selected 45 students who were diagnosed as LD and evaluated their psychological reports in light of each student's IEP and DLP provided by related public school teachers. In this study, they excluded all school students who had been diagnosed with other exceptionalities (e.g., visually impaired; see Hallahan et al., 2008). These researchers found that *only 17 %* of the psychological and educational recommendations offered in the reports were carried through to the IEP and DLP. This portrays a very serious difficulty in the provision of special education services to students with LD attending public schools. In other words, this means that the needs of the students were not properly met. It seems that while student needs may have been identified by a psychologist or special education teacher, if they were not indicated in the IEP or DLP then it would seem that these needs would not be met by special education or regular education teachers or related service personnel. It would appear that the special education system itself may *not* be at fault in serving students—it may be that a shortage of person power could be responsible in tandem with the application of single educational approaches for students who do not have their addressed needs met (D'Amato, Rothlisberg, & Leu Work, 1999). Stated another way, special education may not be *special* at all! Moreover, the difficulty may lie in the fact that while we say we provide individualized, focused services, data show that many students may not receive the services which they need or these students receive services which they do not need. To be sure, the area of serving students with LD is fraught with numerous difficulties and research needs to guide us in answering these many additional questions (D'Amato, Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005). This includes diagnosis as well as the provision of individualized special education services.

Serving Males with Learning Disorders

A number of authors have attempted to solve some of the difficulties within the area of diagnosing and serving individuals with LD (D'Amato, Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005; Semrud-Clikeman, 2005; Witsken et al., 2008). Fletcher, Coulter, Reschly, and Vaughn (2004) summarized four components used to identify individuals with LD, including (1) a severe aptitude achievement discrepancy, (2) heterogeneity of multiple learning domains, (3) exclusion of other disorders or economic disadvantage, linguistic diversity, or inadequate instruction, and (4) the understanding that LD is related to variables intrinsic to the individual (Fletcher et al., 2004). Many of these authors have argued convincingly that curriculum modification should be provided before a student begins to fail significantly in an academic area. They emphasized that assessment can be directly related to instruction to establish a better assessment-instructional link to properly serve the individual who is beginning to show prominent learning problems (Fletcher et al., 2004). These authors proposed that using a *Response to Intervention* (RTI) model will promote a shift to increase achievement for individuals with LD since it can be provided at the *start of learning difficulties*, before a diagnosis of LD is offered. These authors also pointed out that there is little evidence that intelligence tests determine an individual's style of learning—although it is clear that these cognitive ability tests can diagnose a student's lower learning limitations (e.g., mental disabilities). This has reduced the number of initial psychological evaluations in the area of LD and has increased services to students who have yet to be diagnosed as LD. Some of these authors (e.g., Fletcher et al., 2004) have argued for levels of services to be provided directly to students, where diagnostic testing takes place only after *significant* curriculum modifications, entitled Level I and Level II services have been implemented. Some have argued that this should now be normal practice in the majority of public schools and it seems like such a system could work well in the public schools if integrated with neuropsychological services (e.g., see Witsken et al., 2008). It is important to note that the reduced use of intelligence testing for the initial diagnosis of LD has been questioned by many researchers and is currently an area of great controversy (e.g., Reynolds & Shaywitz, 2009). One reason for this is that the tests typically administered provide a great deal of new information which is not covered in the normal school curriculum (Chittooran, D'Amato, Lassiter, & Dean, 1993). However, the RTI approach does allow early intervention with undiagnosed individuals and that has been shown to improve reading scores (Sousa, 2005). In the US, recent efforts have specifically targeted how to improve reading instruction, reflecting the accumulation of research on how children learn to read and how to assist struggling readers (Fletcher et al., 2004; Titley et al., 2014).

D'Amato and colleagues have focused on a variety of different neuropsychologically related approaches to understand which evidence-based interventions work well with students diagnosed as LD (Traughber & D'Amato, 2005). Hoerig, Davis, and D'Amato (2002) found that many of the students routinely diagnosed as LD had memory difficulties. In view of this, D'Amato and colleagues found that the Computerized Continuous Performance test (CPT) was a valuable instrument in discovering how to diagnose many unique memory and attention problems related to LD (Whitten Campbell, D'Amato, Raggio, & Stephens, 1991). The CPT measure has also been useful in the diagnosis of individuals with ADHD. The main thrust of our research has been in the area of subtyping children's learning disabilities, and then matching the children's subtypes with different evidence-based interventions. While this research is only in its infancy, and additional study is needed, we have found a number of extremely promising approaches which could be imported from clinical neuropsychology into school classrooms where they should be tested as evidence-based interventions (D'Amato et al., 1998, 1999; D'Amato, Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005; Work & Choi, 2005).

The field in general has tried to reconcile male individual's need for a comprehensive neuropsychological evaluation, which could lead to appropriate diagnosis and intervention, with school-age students who are failing in their daily curriculum, and who thus require an *immediate* curriculum intervention (Witsken et al., 2008). It is clear that a comprehensive neuropsychological evaluation can be coupled with the RTI model—which are two widely used school methods when identifying individuals with LD (D'Amato, 1990; Huang, Bardos, & D'Amato, 2010). A combination of the two models melded together may serve as a future direction for supporting students who are failing as well as to assist with the later diagnosis of students with LD (Semrud-Clikeman, 2005; Witsken et al., 2008). Such integration must incorporate the best aspects of both models and offer a balanced view. It would seem essential to offer modified brain-based classroom instructional activities to individuals who are showing difficulties in reading in regular education classrooms as a first step (D'Amato, Crepeau-Hobson et al., 2005). These modified curricular services could be called Level I RTI activities. If significant curriculum modifications cannot help a student with learning problems move to a higher reading level, advanced services may be needed which could be called Level II services (see Witsken et al., 2008). While a large number of males are diagnosed as LD, another disorder which is prominent for men is Attention Deficit/Hyperactivity Disorder (Samuelsson, Lundberg, & Herkner, 2004).

Introduction to Attention-Deficit/Hyperactivity Disorders and Men

Attention-Deficit/Hyperactivity Disorder (ADHD) is a disorder characterized by a pattern of extreme pervasive, persistent, and debilitating inattention, overactivity, and impulsivity, which affects children, adolescents, and adults (Rhee & Waldman, 2004; Tetter Ellison, 2005). From the DSM-IV-TR, there were three types of ADHD: the predominantly inattentive type, the predominantly hyperactive-impulsive type, and the combined type (Tannock, 2013). The recently released *Diagnostic and Statistical Manual of Mental Disorders-Fifth Edition* (DSM-5) was published in 2013 and these categories remained (American Psychiatric Association (APA), 2013).

The vast majority of the initial research about individuals with ADHD has highlighted that males are the predominant clients in these nosological categories. As previously discussed, males are more likely to be diagnosed with ADHD (Rhee & Waldman, 2004). So too, it appears appropriate to subtype individuals from this nosological diagnostic category because a variety of subtypes have been found not only in the area of LD but also in the area of ADHD (Crews & D'Amato, 2010; D'Amato et al., 1998; Rucklidge & Tannock, 2002). Some researchers attribute gender differences to a bias in the clinical population studied (Biederman et al., 2008). For example, Biederman and colleagues found that gender effects on individuals' with ADHD were absent when conducting research in a nonreferred group of individuals. These researchers argued that the prevalence problem of individuals with ADHD is influenced by referral bias rather than gender differences, and they believe that gender did not influence ADHD-associated morbidity and dysfunction in a nonreferred group. This research group maintained that boys with ADHD are referred more often than girls due to the fact that boys with ADHD engaged in more rule-breaking and externalizing behaviors. Other researchers examined gender differences in individuals with ADHD via a meta-analysis (Gershon, 2002), and found that more boys were referred than girls, although again this is an area filled with controversy. However, Gershon (2002) discovered that boys with ADHD had higher ratings on hyperactivity, inattention, impulsivity, and externalizing problems, while girls with ADHD were impaired more in intellectual and internalizing problems. Thus, researchers have indicated that gender may interact with the behaviors that make up the individual subtypes within ADHD, rather than individuals with ADHD overall (e.g., Bauermeister et al., 2007).

Moreover, Ghanizadeh (2009) found psychiatric comorbidity differences in children and adolescents with ADHD although there were no specific gender subtype affects.

They mentioned that it is unclear if Asian subtypes are comparable to subtypes from more Western cultures. However, Reid et al. (2000) found differences when comparing subtypes by ethnicity. (This issue is more fully discussed in the book in this series by Davis and D'Amato (2014) focusing on serving an Asian and an Asian American population.) Considering this great variety of findings, it may be necessary to reduce the risk of misdiagnosis in girls who display inattentive ADHD type because girls could be overlooked and diagnosed as having an anxiety disorder (American Psychiatric Association (APA), 2013). So too, males from an Asian culture could be misdiagnosed when placed into a Western-based school system (Davis & D'Amato, 2014). A review of the research suggests that it is not clear whether boys with ADHD are over-diagnosed or if girls with ADHD are under-diagnosed, or if either or both are misdiagnosed (e.g., see Bauermeister et al., 2007; Jackson & King, 2004; Rhee & Waldman, 2004; Semrud-Clikeman & Teeter Ellison, 2009). Such findings leave clinical practitioners in quite a quandary, waiting for a client multidisciplinary team kerfuffle. Whatever the reason, in general it seems like more boys and men suffer from ADHD or related diagnostic disorders and almost *no* practitioners or researchers have focused on how we should provide unique intervention services for *males* (Pollack, 2006). The provision of *male service intervention models* must be an area of additional research in the future if we are to provide evidence-based services.

Do Gender Differences Exist?

Researchers have offered many interpretations on why gender differences may exist in individuals with ADHD. By using simultaneously recorded electroencephalography and electrodermal activity, Hermens, Kohn, Clarke, Gordon, and Williams (2005) found that gender difference in individuals with ADHD may be associated with psychophysiological differences. The profile of theta enhancement in males with ADHD is consistent with an ADHD developmental deviation model, whereas females with ADHD are more distinct in central and autonomic function within an arousal model. According to Andersen and Teicher (2000), gender differences in dopamine receptor density may be one potential cause of gender differences in individuals with ADHD. More research clearly needs to be conducted to understand causal models, gender differences, and brain functioning.

Serving Males with ADHD

Diagnosing and serving students and adults with ADHD is common and this diagnosis can severely influence the intellectual, emotional, educational, and social development of an individual (Bell, 2011). The diagnosis of males and females with ADHD is different than the diagnosis of those with LD because often this diagnosis is not completed in the public schools. Family practice or pediatric physicians (sometimes working with psychiatrists) make this diagnosis and concomitantly start the child or adolescent on a psychotropic medication. Some clinical neuropsychologists work in practices with physicians and they complete such a diagnosis in concert. Whenever possible, school psychologists or clinical neuropsychologists should work with the physician to help provide behavior rating scales and a comprehensive psychological evaluation in an effort to appropriately diagnose a student in a public or private school. School personnel must monitor changes in the student before and after the medication regiment is implemented if quality services are to be provided.

Many psychotropic medications are well advertised, widely available, and popular with parents. When children come to school with a physician's diagnosis, and are currently on medication, depending on the unique characteristics of the child, they may be served using Public Law 94-142 (currently called the Individuals with Disabilities Education Improvement Act, IDEIA) diagnostic category of *Other Health Impairment* (OHI), or if there are academic problems, the child may already receive services as a student with LD (Hallahan et al., 2008). If the student has been diagnosed by a physician as ADHD, they should qualify as OHI, LD, under Section 504 Rehabilitation Act, or under the Americans with Disabilities Act, and accordingly should be provided with special education services (see McIntosh & Decker, 2005). It is vital to have a comprehensive evaluation completed and not just to receive a *prescription* from the family physician. All medication has significant side-effects and each child or adolescent's behavior should be monitored at school and at home. If the dose of the medication is high students often operate in a state of bewilderment and miss out on learning both academically and socially. Teachers commonly report this concern to school psychologists, principals, and sometimes even to parents.

Although the diagnostic criteria for ADHD were developed for children, there are increasing studies in the area of adults as well (i.e., see Kessler et al., 2010; Matte, Rohde, & Grevet, 2012). Studies with college students are also common because of college student availability to researchers. In a study by DuPaul et al. (2001), college students with ADHD symptoms were described from universities in a variety of cultures and countries. Students from Italy, New Zealand, and the US were compared and all had different diagnostic rates based on their student self-reports. Furthermore, to understand what happens when children and college students grow up, Simonm, Czobor, Balint, Meszaros, and Bitter (2009) completed a meta-analysis focusing on the prevalence rates and correlates of adults with ADHD. These researchers found that the population of individuals with ADHD changes as individuals age. Interestingly, it seems like individuals with ADHD come from all cultures as well as all parts of the world.

Ecological Assessment *for* Clinical Neuropsychological Intervention

Serving Men with LD and ADHD

D'Amato and his colleagues have advocated that the traditional medical-deficit model, which is often used in clinical neuropsychology, needs to be significantly modified for use when diagnosing individuals with LD and/or ADHD (D'Amato,

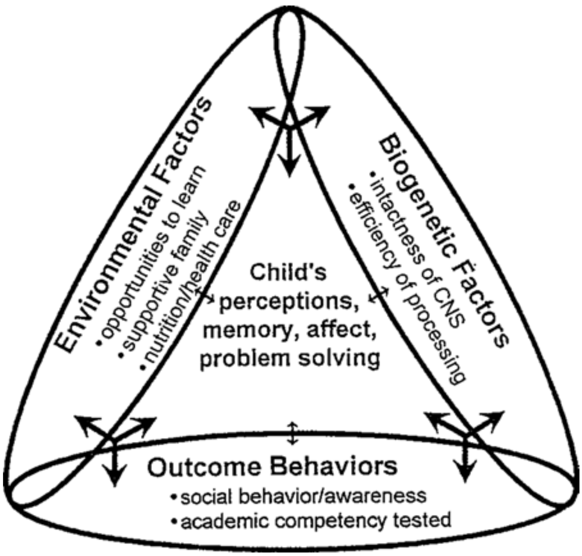

Fig. 1 Graphic display of the interactional framework of ecological neuropsychology applied to clinical practice. Adapted with permission from D'Amato et al. (1999)

Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005; Davis, 2011; Witsken et al., 2008). The ecological neuropsychology model can serve these individuals better, since it is a strength-based model rather than a deficit-based model. The first step in this model is to evaluate the underlying variables or data points which make up the individual, and understanding this information should then lead to appropriate intervention. Research has shown that 40–60 % of our behavior is biologically based and some 40–60 % of our behavior is environmentally based (Davis, 2011). Moreover, D'Amato and Hartlage (2008) discuss this conundrum in more detail.

Environmental Factors versus Biogenetic Factors. Figure 1 demonstrates how the *two* components contribute to the outcome for a single individual. Environmental factors make up about half of the individual's foundation. These variables include items such as family members reading to a young child, instructional opportunities provided in preschool, and appropriate nutrition and health care across the lifespan. This is in contrast to the organic/biological factors which compose the central nervous system as well as the brain. When environmental factors are considered with biogenetic factors, this leads to how the child can understand input, process information, and begin to interact with the world. This then provides the clinical neuropsychologist or psychologist with outcome behaviors relating to what the individual has learned and how the individual may function effectively in the world including the educational enterprise.

How to Understand the Individual under Study*?* Figure 2 shows how intra-individual characteristics interact with the educational and home enterprises

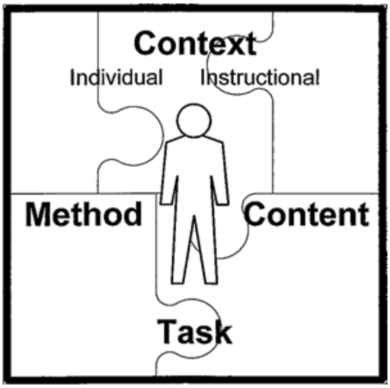

Fig. 2 Graphic presentation of variables that interact with the learner and his or her environment. Adapted with permission from Hess & D'Amato (1998)

including the ecology of the classroom (e.g., the instructional context, content, task, and method) to create a more comprehensive view of the individual and his or her learning or attention difficulties. All of this relates to context. Another critical component of our model is the differentiation between remedial instruction and compensatory activities (D'Amato et al., 1999). This can be seen in the difference between content, method, and task discussed later in this chapter. All of this information must be considered before deciding on instructional activities (e.g., teaching reading using a phonetic *or* whole word approach). Such teaching should relate to *strengths* in the right hemisphere of the brain (e.g., use simultaneous or whole word approaches) or *strengths* in the left hemisphere of the brain (e.g., use sequential or phonetic instructional approaches). Frequently, clinical neuropsychologists focus on and list the disabilities where *interventions need* to be offered but do not list *how* instruction should be offered. Thus, they often neglect *methods* and *tasks*, which are perhaps two of the most important components for client learning. An individual disability could also be related to the learner's prior knowledge, specific components of the task under study, or even teacher related variables. The importance of each data point or variable is critical and intervention must consider all of these areas if it is to be effective. Accordingly, the ecological neuropsychological model views individual men as *dynamic* with great opportunities for change rather than the medical model view, which sees the individual as having chronic, within person, fixed or unchangeable disabilities (D'Amato, Crepeau-Hobson et al., 2005; Sousa, 2006; Work & Choi, 2005). Obviously, since previous research has shown significant differences between boys and girls or men and women, these unique characteristics specific to each gender must be considered as part of the assessment process. Psychologists in general have done a poor job in intervention development or rehabilitation although they have worked at it for more than a decade (D'Amato, Zafiris, McConnell, & Dean, 2011; Davis, 2011). They also seem to have forgotten the numerous and undeniable facts provided by Pollack (1999, 2006) regarding the uniqueness of each man (regardless of age).

What Areas Should Be Evaluated Using an Ecological Clinical Neuropsychological Model?

Five Systemic Sources of Information

Figure 3 is a graphic display of the brain-based *systems* which should be evaluated. This represents the main foundation of our model. It is appropriate for the differential diagnosis of men who may be at risk for LD or ADHD. Initially, all brain-based systems should be evaluated. This includes **Systems**, focusing on language, personality/behavior, sensory/perception, environmental fit, academic ability, motor functions, and cognitive ability. Be aware that motor functions, which are often not evaluated in traditional school psychology examinations, may play an

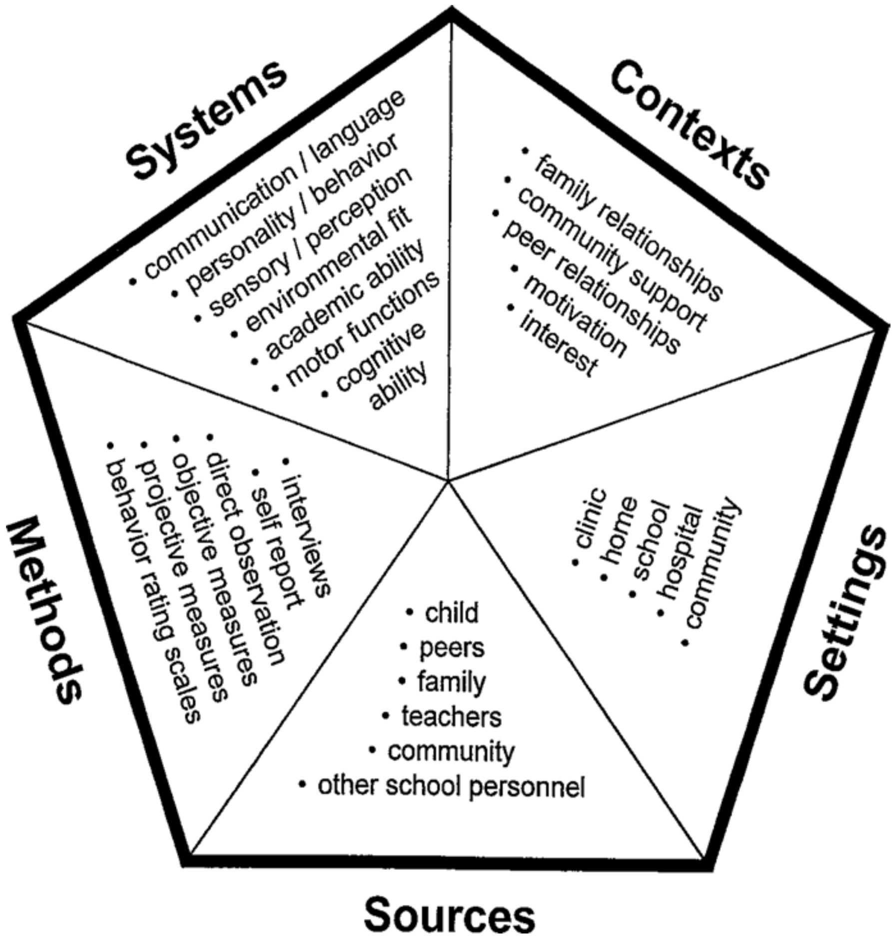

Fig. 3 Components of a comprehensive ecological neuropsychological evaluation. Adapted with permission from D'Amato, Crepeau-Hobson et al., 2005

important role for offering appropriate interventions for boys and men who may have LD and/or ADHD. **Contexts** must also be evaluated and this area, which similarly is often neglected, offers a wealth of information including family relationships, community support, peer relationships, and then with a focus on the individual, considers information such as the individual's motivation and interests. All evaluations must also consider the variety of **Settings** in which individuals interact. This includes the community, hospital, school, home, clinic, and any work settings where the individual may be employed. Men may have significant relationships in unique settings like in health clubs, work, churches, lodges, or professional organizations. In some cases, if a man is incarcerated, or in the court system, information from prison or the courts would also be required (Mok, D'Amato, & Witsken, 2010). Sadly, many ineffective intervention efforts have not worked well enough to keep men out of prison. Authors have advocated in ecological neuropsychology that we use multiple **Methods** in collecting information (D'Amato, Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005). This should include interviews, self-report data, direct observations, objective procedures such as adaptive rating scales and intelligence tests, projective measures (which we believe are critical in all of these situations with men), and behavior rating scales. Finally, a variety of **Sources** must be considered. Sources should include the individual under study, peers, family members, teachers or work supervisors, community members, and other school personnel if the individual is currently in the educational enterprise. If the individual is a college student, it is important to consider information from the university setting and other school personnel, and if the individual is currently employed, comprehensive information must be collected from the employer. Depending on the referral question, some of these sources of information may or may not be appropriate to contact.

What Areas to Evaluate for Men with Potential LD and ADHD

Ecological clinical neuropsychological assessment should be an approach to problem-solving in which the goal is to provide both *direct* and *indirect* services to boys and men to improve their mental health, and human development (D'Amato et al., 1999). For students in a classroom, data should be collected by the teacher and used to modify individualized instruction and behavioral programming. This would be seen as providing Level I or Level II RTI services. If intervention at Level I or Level II does not solve the problem under study, a clinical neuropsychological evaluation will be needed to look more intensely at the ability of an individual to process and learn information. This could be called a Level III assessment for intervention. Tasks and tests used to evaluate Levels I, Levels II, and Levels III will be discussed later in this chapter.

Evaluation of Brain-Based Areas. Table 1 presents a list of all the brain-based systems that should be comprehensively evaluated. It does not matter if you are

Table 1 Brain-based areas that should be formally and informally assessed in neuropsychological evaluations

1. Perceptual/Sensory skills	**6. Communication/Language Skills**
• Visual	• Phonological processing
• Auditory	• Listening comprehension
• Tactile/Kinesthetic	• Expressive vocabulary
• Integrated	• Receptive vocabulary
2. Motor Functions	• Speech/Articulation
• Strength	• Pragmatics
• Speed	**7. Academic Achievement**
• Coordination	• Preacademic skills
• Lateral preference	• Academic skills
3. Intelligence/Cognitive Abilities	Reading decoding
• Verbal functions	Reading fluency
Language skills	Reading comprehension
Concepts/reasoning	Arithmetic facts/calculation
Numerical abilities	Social studies
Integrative functioning	Language arts
• Nonverbal functions	Science
Receptive perception	Written language
Expressive perception	**8. Personality/Behavior/Family**
Abstract reasoning	• Adaptive behavior
Spatial manipulation	Daily living
Construction	Development
Visual	Play/Leisure
Integrative functions	• Environmental/Social
4. Executive Functioning/Attention	Parental/Family
• Sustained attention	School environment
• Inhibition	Peers
• Shifting set	Community
• Problem solving	• Student coping/tolerance
5. Memory	• Family/Interpersonal style
• Short-term memory	**9. Educational/Classroom**
• Long-term memory	Environmental/Employment
• Working memory	• Learning environment fit
• Retrieval fluency	• Peer reactions
	• Community reactions
	• Teacher/Staff knowledge
	• Learner competencies
	• Teacher/Staff reactions
	• Classroom dispositions

Adapted with permission from D'Amato et al. (1999) and Witsken et al. (2008)

doing an evaluation for a male or female, or an examination for a male with a potential ADHD or LD. The same brain-related areas should be evaluated. The only difference would be that clinicians should have a focus on the gender differences as shown in clinical practice, theoretical papers, and research (Bauermeister et al., 2007; Jackson & King, 2004; Mok et al., 2010; Rhee & Waldman, 2004; Semrud-Clikeman & Teeter Ellison, 2009).

The assessment should begin with an evaluation of **Perceptual Skills** followed by **Sensory Skills**—evaluation of each of these skills individually should take place as well as each skill when it is woven together with the other skills. **Motor Functions** should be evaluated remembering to consider that we are contralaterally wired. Lateral preference can be evaluated both formally and informally. While lateral preference is a commonly reported difficulty, it is often over emphasized with younger children. Lateral preference should not become an area of concern until a student has completed grade three. Hopefully, we have outgrown the old idea of attempting to force students to use a right or left hand.

The **Intelligence/Cognitive Abilities** domain should be evaluated next, with special focus placed on verbal functions including how they relate to language, concepts, and numerical abilities. Nonverbal functions must be evaluated in a similar fashion focusing on receptive *and* expressive abilities equally. Researchers have stressed the critical nature of completing a comprehensive nonverbal evaluation to aid in the identification of individuals who may have a Nonverbal LD (Semrud-Clikeman, Goldenring Fine, & Harder, 2005; Semrud-Clikeman & Teeter Ellison, 2009). **Executive Functioning/Attention** is an area that is often left out of traditional evaluations unless an individual is referred specifically for ADHD. Even when evaluating an individual for potential LD, this area is critical. Some individuals with Reading Disabilities have Executive Functioning Disorders which interfere with their ability to learn. It also is critical to evaluate **Memory**, with an emphasis on short-term, long-term, working memory, and retrieval fluency.

Communication/Languages Skills is one of the most important areas to evaluate. Seminal research has shown the importance of phonological processing and this should be an important component of any evaluation (D'Amato, Fletcher-Janzen et al., 2005). Listening comprehension also is sometimes left out of an evaluation. Depending on the age of the child, pre-academic skills or **Academic Achievement** should be evaluated. The differentiation between individuals who are LD or ADHD is not always easy to determine and a review of academic achievement data will help in understanding the major difficulties the student is experiencing. All traditional academic subjects should be evaluated depending on the age of the individual. If the examination takes place in a public school, typically a special education teacher will complete a comprehensive academic evaluation. If this is not the case, the clinical neuropsychologist will need to evaluate this area in order to understand the ability of the individual to learn and process different types of academic information. For example, an individual with a reading disability presents very differently than one with a written language disability (Chittooran & Tait, 2005; Joseph, 2005; Semrud-Clikeman et al., 2005). Once attention is controlled for, many individuals with

ADHD are found to *not* have significant problems learning (Semrud-Clikeman & Teeter Ellison, 2009; Tetter Ellison, 2005). However, it is noteworthy that many individuals with ADHD also meet diagnostic criteria for those with an LD. As previously discussed, in the US, many individuals with ADHD receive services in public schools classified as an individual with OHI. The diagnostic categories of LD and ADHD often overlap in that clients and individuals who are diagnosed with one disability often are also diagnosed with the other.

Personality/Behavior/Family is a critical area to evaluate for all referrals. But its importance cannot be overlooked when dealing with males in the area of LD and ADHD. Typically, Adaptive Behavior is considered first, looking at the individual's early development, daily living skills, and play/leisure abilities. This is followed by an evaluation of the Environmental/Social Abilities of the individual, including how the individual interacts in the school environment, with peers, with his family, and with himself. Student Coping/Tolerance is important because it tells us how the individual is dealing with current issues, as well as how they may do in the future. Finally, Family/Interpersonal Style should be considered, to help understand how the individual interacts within his world as well as to understand how his family relates to the school, community, and society at large. Obviously, this area will be a main focus for an individual potentially diagnosed as ADHD or even LD.

The final area considered is the area of **Educational/Classroom Environment/Employment**. This is, perhaps, the most important area considered for school-age individuals who are potentially diagnosed as LD or ADHD. We initially consider the individual's Learning Environment and how they fit within it, and evaluate Peer Reactions, Community Reactions, Teacher/Staff Knowledge, Learner Competencies, Teachers/Staff Reactions, and Classroom Dispositions. How the individual fits within the classroom environment or work setting as well as the family environment is imperative if we are to make an appropriate diagnosis and offer the correct evidence-based interventions (D'Amato et al., 1999; Witsken et al., 2008). For older individuals, the work setting can be a primary area of consideration and must be evaluated.

Linking Brain-Based Areas to Neuropsychological Assessment for Evidence-Based Intervention

Understanding the Critical Link Within Neuropsychological Assessment for Intervention

Previously, the main focus of this chapter has been on understanding the unique characteristics of male individuals who may be diagnosed as LD or ADHD. Throughout the chapter, we have argued for the importance of early intervention in the classroom, and advocated that initially, classroom teachers should intervene with students, and this intervention should be followed by specially trained teacher interventionists who work individually with students. As we have previously detailed, some students will not make progress even when provided with sustained individual instruction including curriculum modifications. When this happens, we have argued for the use of an ecologically based clinical neuropsychological examination. The most critical step when working with a child is to know which areas are strengths and which are weaknesses, and then to provide evidence-based interventions in the areas in which the student has displayed difficulties. We also can use strengths to work around or compensate for weaknesses.

To aid in this enormous undertaking, D'Amato and his colleagues have assembled a *comprehensive brain-based table* (Table 2) which lists the areas which must

Table 2 Formal and informal areas to evaluate or classroom and curriculum data to collect

Areas that should be evaluated	Evaluation tools
Reading	
Phonemic Awareness (e.g., Sound Comparison, Segmentation, Blending) D'Amato, Fletcher-Janzen et al. (2005), D'Amato, Crepeau-Hobson et al., (2005), Fletcher et al. (2007), Joseph (2005), and Shaywitz (2003)	DIBELS—initial sound fluency; phoneme segmentation fluency[a] IGDI—alliteration[a] IGDI—rhyming[a] CTOPP—elision[b] WJ-C—sound blending[b] H-R—speed-sounds perception[c] NEPSY—phonological processing[c]
Phonics (Letters Names/Sounds and Word Recognition) Shaywitz (2003), Fletcher et al. (2007), and Sousa (2005)	DIBELS—letter-naming fluency, nonsense word fluency[a] WJ-A—letter-word identification[b] WIAT—word reading, pseudoword decoding[b] WRAT-III—reading/word calling[b] GORT-IV[b] WJ-C—word attack[c] NEPSY—repetition of nonsense words[c]
Vocabulary D'Amato, Fletcher-Janzen et al. (2005), D'Amato, Crepeau-Hobson et al. (2005), Joseph (2005), Shaywitz (2003), and Sousa (2005)	DIBELS—word use fluency, word naming[a] IGDI—picture naming[a] PPVT-4[b] NEPSY—word generation[c] WISC—vocabulary[c] WISC—word reasoning[c]
Reading Fluency Fletcher et al. (2007), Shaywitz (2003), and Sousa (2005)	Classroom words correct per minute[a] DIBELS—oral reading fluency[a] WJ-A—reading fluency[b] Test of word reading efficiency[b] Test of reading fluency[b]
Reading Comprehension Fletcher et al. (2007), Shaywitz (2003), and Sousa (2005)	DIBELS—retell fluency[a] AIMSweb—maze passages[a] WJ-A—passage comprehension[b] WIAT—reading comprehension[b] GORT-IV[b]

(continued)

Table 2 (continued)

Areas that should be evaluated	Evaluation tools
Phonologic Access (or Rapid Automatic Naming) Hale and Fiorello (2004), Joseph (2005), and Shaywitz (2003)	Timed naming activities; naming numbers; naming letters; naming animals; naming foods[a] IGDI—picture naming[a] CTOPP—rapid letter naming, rapid digit naming[a] NEPSY—speed naming[c]
Oral Language/Listening Comprehension Shaywitz (2003), Semrud-Clikeman (2005), and Sousa, 2005	DIBELS—retell fluency[a] WJ-A—understanding directions[b] PPVT-4[b] NEPSY—comprehension of instructions[c]
Additional Neuropsychological Areas to Evaluate	**Assessment Tools**
Short-/Long-Term and Working Memory Fletcher et al. (2007), Hale and Fiorello (2004), and Shaywitz (2003)	Ability to follow two and three-part directions[a] WJ-A—story recall, story recall delayed[b] NEPSY—sentence repetition, narrative memory[c] H-R speech-sounds perception test[c] H-R tactile perception test[c]
Language Receptive/Expressive Shaywitz (2003), Semrud-Clikeman (2005), and Sousa (2005)	PPVT-4[a] EOWPVT, ROWPVT[a] CELF[a] Comprehensive assessment of spoken language[a] WJ-A—understanding directions, story recall[a] H-R aphasia screening test[c]
Attention/Executive Functions Fletcher et al. (2007), Hale and Fiorello (2004), and Semrud-Clikeman (2005)	WJ-A—understanding directions[b] WJ-C—numbers reversed, planning[c] NEPSY animal sorting, inhibition, auditory attention, and response set[c] H-R category test[c]
Visual-Motor D'Amato, Fletcher-Janzen et al. (2005), D'Amato, Crepeau-Hobson et al. (2005), Fletcher et al. (2007), and Hale and Fiorello (2004)	Copying and tracing classroom activities[a] NEPSY arrows, design copying[c] H-R finger tapping[c] H-R trails part A[c]
Math	
Math Computation D'Amato et al. (2005) and Fletcher et al. (2007)	Classroom problems correct per minute[a] WJ-A—calculations[b] WIAT—numerical operations[b] WRAT-III—arithmetic[b] WISC—arithmetic[c]
Math Problem-Solving D'Amato, Fletcher-Janzen et al. (2005), D'Amato, Crepeau-Hobson et al. (2005), and Fletcher et al., 2007	Classroom exercises correct per timing[a] WJ-A—applied problems[b] WIAT math reasoning[b] WISC—arithmetic[c]

(continued)

Table 2 (continued)

Areas that should be evaluated	Evaluation tools
Additional Neuropsychological Areas to Evaluate	**Assessment Tools**
Attention/Executive Functions Short-/ Long Term and Working Memory	See this category under Reading See this category under Reading
Writing-written language	
Handwriting D'Amato, Fletcher-Janzen et al. (2005), D'Amato, Crepeau-Hobson et al. (2005), and Fletcher et al. (2007)	Classroom work samples[a] WJ-A—writing fluency[b] WJ-A—writing samples[b] NEPSY—design copying[c]
Spelling Fletcher et al. (2007)	Classroom words correct per timing[a] WJ spelling[b] WIAT spelling[b] WRAT-III spelling[b]
Written Composition Fletcher et al. (2007)	Classroom timed work sample[a] TOWL[b] NEPSY—design copying[c]
Attention/Executive Functions	See this category under Reading
Short-/Long Term and Working Memory	See this category under Reading
Language	See this category under Reading

DIBELS Dynamic Indicators of Basic Early Literacy Skills, *IGDI* Individual Growth and Development Indicators, *CTOPP* Comprehensive Test of Phonological Processing, *WJ-C* Woodcock Johnson Tests of cognitive abilities—III, *H-R* Halstead–Reitan Neuropsychological Test Battery, *NEPSY II* Developmental Neuropsychological Assessment, *WJ-A* Woodcock Johnson Tests of Achievement—III, *WIAT-II* Wechsler Individual Achievement Test, *WRAT-III* Wide Range Achievement Test, *GORT-IV* Gray Oral Reading Test—4th Edition, *PPVT-4* Peabody Picture Vocabulary Test-Fourth Edition, *WISC-IV* Wechsler Intelligence Scale for Children—4th Edition, *EOWPVT* Expressive One Word Picture Vocabulary Test, *ROWPVT* Receptive One Word Picture Vocabulary Test, *CELF* Clinical Evaluation of Language Fundamentals, *TOWL* Tests of Written Language. (Adopted with permission from Witsken et al., 2008, pp. 792–794)

[a]Can be measured using classroom-focused, curriculum-related assessments or the DIBELS

[b]Can be measured using standardized academic assessments

[c]Can be evaluated using psychological or neuropsychological examinations

be evaluated to understand and intervene with an individual (D'Amato et al., 1999; D'Amato, Crepeau-Hobson et al., 2005; D'Amato, Fletcher-Janzen et al., 2005; Mok et al., 2010; Witsken et al., 2008). After the student is *informally* and/or *formally* evaluated by the teacher, special service provider, or clinical neuropsychologist, these individuals must offer evidence-based interventions in the area(s) of concern. All assessments, completed by individuals at any level, should include an evaluation of the following areas*:* **READING:** *Phonemic Awareness, Phonics, Vocabulary, Reading Fluency, Reading Comprehension, Phonologic Access (or Rapid Automatic Naming), Oral Language/Listening Comprehension, Short-/Long-Term and Working Memory, Language Reception, Expression, Attention/Executive Functions, Visual Motor Skills.* **MATH:** *Math Computation, Math Problem Solving.* **WRITING-WRITTEN LANGUAGE:** *Handwriting, Spelling,* and *Written Comprehension*. Each of these areas is followed by a reference which provides additional information about why the area is important and how it could be used when offering an evidence-based intervention. Obviously, it is impossible to list all tests that fall within these important areas. Clearly, measures could be added in each of our vital areas. The importance is to have a measure used in each area to evaluate if it is a strength *or* need of the individual. Worth mentioning is that under each of these areas, techniques or tests are offered which can be completed by teachers or other school or mental health professionals. Some of the listed tests can only be used by a school psychologist or clinical neuropsychologist. Each test is marked according to who may administer it. Remember, the area should be evaluated using whatever tests or informal measures are available. In addition, the goal should be not just to understand the individual, but to find an appropriate intervention using the individuals' strengths and needs to help them achieve in life.

Summary

Whether individuals admit to it or not, they use a psychological paradigm to guide them in the provision of services to clients in various environments. While many psychologists claim to be *ecological* they really have underlying beliefs which form the foundation of the services they offer to clients. This chapter has advocated that ***clinical neuropsychology*** is the most appropriate psychological paradigm to use when serving males who may have a potential LD or ADHD. One of the most important contributions of applied neuropsychology is the differentiation between offering an individual remedial activities versus compensatory activities. Remedial activities (e.g., use of direct instruction concerning material which has already been presented) should be offered when the individual is able to achieve the instructional goals within the curriculum. Compensatory activities (e.g., such as use of a calculator) should be used when individuals' brains are impaired and they need to learn how to work around skills related to the damaged areas of the brain. This is where the old adage of *dead tissue will not learn* comes from. While the differentiation of these two approaches appears simplistic, numerous educational institutions mistakenly use one approach when they should be using the other—with individuals who may be diagnosed as LD and/or ADHD. Men are unique, and the authors have pointed out a number of distinctive profiles which will help in the diagnosis and development of a rehabilitation plan for individual males.

We have argued for the use of an ecological neuropsychological approach which integrates all brain *systems* through the consideration of various Methods, Contexts, Sources, and Settings. In addition, the chapter authors believe that eight major areas must be evaluated to understand each individual. These areas include (1) Perceptual/Sensory Skills, (2) Motor Functions, (3) Intelligence/Cognitive Abilities, (4) Executive Functioning/Attention, (5) Memory, (6) Academic Achievement, (7) Personality/Behavior/Family, and (8) Educational/Classroom Environment/Employment. The authors have discussed the importance of using *formal* and *infor-*

mal techniques to evaluate individuals in the classroom as well as the instructional curriculum. They offered tests and tasks which can be quantitatively or qualitatively used by teachers in the classroom as well as tasks which are appropriate for clinical neuropsychologists. In this chapter, they have detailed critical knowledge and skills which must be evaluated for intervention. These include **READING:** Phonemic Awareness, Phonics, Vocabulary, Reading Fluency, Reading Comprehension, Phonetic Access or Rapid Automatic Naming, Oral Language/Listening Comprehension, Short-/Long Term and Working Memory, Language Receptive/Expressive, Attention/Executive Functions, and Visual Motor Skills. **MATH:** Math Computation, Math-Solving Problems, Attention/Executive Functions, Short-/Long Term and Working Memory. **WRITING-WRITTEN LANGUAGE:** Handwriting, Spelling, Written Composition, Attention/Executive Functions, Short-/Long Term and Working Memory, and Language. Furthermore, the use of a clinical neuropsychological paradigm offers clear support for individuals who work with students who may be diagnosed as LD and/or ADHD. This approach offers formal and informal tests and tasks for instruction, diagnosis, and/or rehabilitation planning and/or intervention. Over the years, it has become clear that all learning is related to the brain. Individuals will be served best if practitioners use an ecological clinical neuropsychological approach for individuals with difficulties in living.

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Understanding Disorders of Defiance, Aggression, and Violence: Oppositional Defiant Disorder, Conduct Disorder, and Antisocial Personality Disorder in Males

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Key areas of research in the neurosciences have produced evidence supporting the neurobiological underpinnings of the group of antisocial disorders characterized by externalization, aggression, and violent behavior. Studies utilizing neuroimaging methods have identified structural and functional deficits in frontal, temporal, and subcortical regions in antisocial children and adults—findings which are echoed to a large degree in neurological studies of brain injury in various types of antisocial individuals. Research utilizing neuropsychological approaches has revealed deficits in verbal, spatial, and executive abilities in adults and children characterized by antisocial behavior, and risk factors early in childhood appear to predict later forms of antisociality. Studies in endocrinology have focused on hormones such as cortisol and testosterone. A number of investigations from across the neuroscientific disciplines have recently begun to focus upon gender differences in the presentations of neurobiological deficits associated with the disorders of antisociality.

Introduction

While behavioral expressions of defiance, aggression, and violence are not unique to men, two lines of evidence suggest a more robust association between these behaviors and the male gender. First, oppositional, aggressive and violent behaviors appear over-represented among males in both childhood and

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adulthood. For example, studies often demonstrate that even in non-clinical samples, young and adolescent boys engage in more aggressive and oppositional defiant behavior when compared to girls (Kalmoe, in press; Lahey et al., 2000; Mireault, Rooney, Kouwenhoven, & Hannan, 2008), and score higher on scales measuring aggression (Cohen-Bendahan, Buitelaar, van Goozen, Orlebeke, & Cohen-Kettenis, 2005). This trend is consistent in adults as well with men demonstrating more violence and aggression compared to women. According to both the National Crime Survey and the National Crime Victimization Survey, men have higher rates of offending for simple assault, aggravated assault, and robbery (Lauritsen, Heimer, & Lynch, 2009). The National Crime Victimization Survey (2008) also shows that by far, men are characterized by more rape and sexual assault offenses compared to their female counterparts. Additionally, men in mentally disordered populations have demonstrated significantly higher rates of violent acts upon discharge from mental health facilities compared to women (Robbins, Monahan, & Silver, 2003).

Second, males of all ages appear over-represented among individuals characterized by the various disorders of antisociality. Prevalence rates of oppositional defiant disorder (ODD) and conduct disorder (CD) are much higher in male relative to female children (American Psychiatric Association, 2000; Lahey et al., 2000), and boys with these disorders have been known to exhibit more confrontational aggression and behavior and persistent symptoms than girls. Additionally, specific CD-related behavior problems appear to differentiate young males from females (with fighting, stealing, vandalism, and school disciplinary problems characterizing the former, and lying, truancy, running away, substance use, and prostitution associated with the latter; American Psychiatric Association, 2000). Furthermore, prevalence rates of antisocial personality disorder (ASPD; American Psychiatric Association, 2000) and psychopathy (Verona & Vitale, 2006) are far higher in adult males relative to females. In fact, in community samples, rates of ASPD for men are increased threefold compared to those of women (American Psychiatric Association, 2000).

The neurobiological underpinnings of antisociality—at both the behavioral and clinical disorder levels—have been the focus of neuroscientific research for the past several decades. Neuropsychological approaches (indirect indices of brain dysfunction and a methodological focus of this book) are but one of the areas of the neurosciences which have contributed to the empirical elucidation of the *antisocial brain*. This chapter will serve as an integrative review of findings from neuropsychology and other key areas of neurobiological research (including brain imaging, neurology, and endocrinology) on defiant, aggressive, and violent behavior; as well as disorders of antisociality such as ODD, CD, ASPD, and psychopathy. Additionally, it will provide an overview of studies which have examined gender differences in the neurobiological correlates of antisocial disorders, with a particular focus on how specific neurobiological deficits may uniquely characterize men and contribute to the predominance of males among disorders of aggressive and antisocial behavior.

Neuroimaging

Prefrontal Cortex

The strongest evidence to date for a relationship between brain structure and/or function and antisociality implicates the prefrontal cortex. This is not surprising, given the region's key multiple functions which include the inhibition of behavioral impulses and the regulation of emotions generated by underlying subcortical structures such as the amygdala. Structural imaging investigations have indicated significant gray matter reductions in the prefrontal regions of individuals characterized by aggression and antisocial behavior. For example, Raine, Lencz, Bihrle, LaCasse, and Colletti (2000), using structural MRI, found an 11 % reduction in prefrontal gray matter in individuals with ASPD compared to those without. Two prefrontal sub-regions—the orbitofrontal cortex (OFC) and dorsolateral prefrontal cortex (DLPFC)—have most consistently been found to be impaired in antisocial, violent individuals. Evidence from multiple sources suggests that the DLPFC mediates executive functions (Dinn & Harris, 2000), and is involved with the temporal integration of behavior. The OFC modulates sensitivity to reinforcement contingencies (Dinn & Harris, 2000), and is involved with the inhibition of inadequately motivated actions, and with the modulation of aggressive behavior and autonomic reactivity. In humans, this system contributes more to social and self-awareness than the DLPFC (Damasio, 1994. Laakso et al. (2002) in one of the few structural imaging studies to date examining prefrontal sub-regions found significantly reduced orbitofrontal and dorsolateral prefrontal cortex volume in individuals with ASPD, which is consistent with functional imaging studies that have indicated abnormal orbitofrontal and dorsolateral prefrontal functioning during performance of cognitive and emotional tasks in antisocial individuals (e.g., Müller et al., 2003; Raine et al., 1994; Schneider et al., 2000). Structural studies of white matter have also produced interesting, if at times inconsistent, findings. While Kruesi and Casanova (2006) found a trend toward reduced white matter/whole brain volume ratios in the corpus callosum but not in the prefrontal area in youth liars relative to antisocial controls and healthy volunteers, Yang et al. (2005) found a 22–26 % increase in prefrontal white matter along with a 36–42 % reduction in prefrontal gray/white matter ratios in adult pathological liars. Functional imaging studies have also provided evidence for prefrontal dysfunction in individuals with antisocial behaviors and disorders and have further implicated this region in anger and aggression in non-clinical populations. For example, utilizing fMRI in normal controls who were insulted, Denson, Pedersen, Ronquillo, and Nandy (2009) found general aggression to be associated with increased activity within the left anterior cingulate cortex (ACC; a region associated with anger intensity), while displaced aggression related to increased activity in the medial prefrontal cortex (an area linked to emotion regulation and self-reflections). Additionally, Goethals et al. (2005), using SPECT, found reduced regional cerebral blood flow (rCBF) in right temporal and prefrontal regions in individuals with borderline personality disorder and ASPD, compared to controls. Overall, these findings suggest that impairments in the prefrontal cortex, particularly the orbitofrontal and the dorsolateral prefrontal regions, may make key contributions to the pathogenesis of antisocial behavior in individuals with antisocial disorders.

Temporal Lobe

The prefrontal cortex, however, is not alone in its demonstrated associations with antisociality, crime, and violence. Temporal lobe damage has long been known to result in blunted emotional responses (Klüver & Bucy, 1939), similar to those seen in antisocial violent individuals. Indeed, a number of PET studies indicating prefrontal dysfunction in their antisocial, violent subjects also showed reduced temporal functioning. For example, Soderstrom, Tullberg, Wikkelsoe, Ekholm, and Forsman (2000) revealed reduced rCBF in both the frontal and temporal cortices in perpetrators of violence compared to controls. Hirono, Mega, Dinov, Mishkin, and Cummings (2000) also found decreased rCBF in the left anterior temporal cortex and bilateral dorsofrontal cortex in individuals convicted of impulsive violent offenses. In another PET study focusing on temporal regions, Volkow et al. (1995) found rCBF abnormalities in prefrontal and temporal medial regions in violent psychiatric patients. Finally, Juhász, Behen, Muzik, Chugani, and Chugani (2001) found a significant correlation between a higher severity of aggression and lower metabolism in the bilateral medial prefrontal and left temporal cortex in aggressive children with epilepsy.

Structural MRI investigations have also identified fronto-temporal abnormalities in antisocial individuals. De Brito et al. (2011) found decreased white matter concentrations in the right superior frontal lobe, right dorsal anterior cingulate, right superior temporal gyrus, and left precuneus in children (ages 10–13) with psychopathic tendencies. Sato et al. (2011) reported that structural gray matter differences in the superior temporal sulcus/gyrus region distinguish psychopaths from controls (Sato et al., 2011). Additionally, using structural MRI, Barkataki, Kumari, Das, Taylor, and Sharma (2006) found whole brain volume and temporal lobe reductions in men with ASPD compared to controls. Using voxel based morphometry (VBM), Huebner et al. (2008) found a 6 % gray matter volumetric reduction in the bilateral temporal lobes, including left amygdala, left hippocampus, and the orbitofrontal and ventromedial regions in boys with CD and ADHD-along with volumetric increases in cerebellar gray matter. Temporal but not frontal/prefrontal lobe reductions have also been observed in adolescents diagnosed with early-onset CD and histories of ADHD (Kruesi, Casanova, Mannheim, & Jonson-Bilder, 2004) and impulsive-aggressive men (Dolan, 2010—20 % volumetric reductions compared to controls in this study). Overall, imaging studies have demonstrated that the temporal lobe—alone or in concert with a larger fronto-temporal circuit—may make significant contributions to aggression, violence, and disorders of antisociality.

Subcortical Structures: Amygdala and Hippocampus

Within the temporal region, antisocial and violent behavior has been associated with deficits in subcortical structures such as the amygdala-hippocampal complex. The amygdala plays a key role not only in the reception and production of emotion, but also in the processing of fear conditioning, while the hippocampus is involved in emotional memory. Several studies have reported functional and structural abnormalities in the amygdala-hippocampal complex in antisocial aggressive individuals. Criminal psychopaths, for example, have shown decreased amygdala-hippocampal activations during the viewing of negative affective pictures (Kiehl et al., 2001). Reduced hippocampal rCBF has also been demonstrated in violent perpetrators compared to controls (Soderstrom et al., 2000). Other functional MRI studies (e.g., Dolan, 2010) have identified amygdala activation abnormalities to various angry/neutral/sad facial comparisons in adolescent and young adult males with early or late-onset CD (Passamonti et al., 2010). Using fMRI, Sterzer, Stadler, Krebs, Kleinschmidt, and Poustka (2005) found adolescents with CD showed reduced activation in the right dorsal anterior cingulate cortex (ACC) when viewing neutral and negative images compared to controls, and reduced amygdala activation when viewing negative images in those with high aggression. Additionally, recent structural MRI data has shown reduced whole brain and hippocampal volumes in individuals with schizophrenia with a history of violence (Barkataki et al., 2006), and reductions in hippocampal and parahippocampal volumes in murderers with schizophrenia (Yang et al., 2010) VBM data have also indicated bilateral amygdala volumetric reductions in adolescent males with early or late-onset CD (Fairchild et al., 2011). Together, these findings suggest that temporal lobe deficits, particularly in the amygdala and hippocampus, may predispose an individual to a lack of fear for punishment and result in the disruption of normal moral development.

Gender Differences

Gender differences in brain structure have been noted by numerous authors, with men (after correcting for body size and age) generally having larger brains than women (Burgaleta et al., 2012; Fan et al., 2010; Rushton & Ankney, 2009), attributed to the nearly four billion more neurons in the adult male brain (Pakkenberg & Gundersen, 1997, in Rushton & Ankney, 2009). While numerous imaging studies of antisocial disorders have utilized all-male participants (e.g., Bagcioglu et al., 2014; Barkataki et al., 2006; Fairchild et al., 2011; Huebner et al., 2008; Passamonti et al., 2010), those involving mixed-gender samples are much less common. In one rare imaging study of individuals with ASPD involving actual gender comparisons, Raine, Yang, Narr, and Toga (2011) used structural MRI to examine gender differences in regional brain volume between adult male and female temporary employment agency workers with and without diagnoses of ASPD, along with independently recruited female controls. Males with ASPD showed an 8.7 % reduction in orbitofrontal gray matter volume, a 17.3 % reduction in middle frontal gray matter volume, and a 16.1 % reduction in right rectal gray matter volume compared to male controls. In both males and females, orbitofrontal and middle frontal volumetric reductions were significantly associated with increased ASPD symptomatology and criminal offending. Compared to females, males overall had reduced orbitofrontal and middle frontal gray matter volume; and controlling for these volumetric differences reduced the gender difference in ASPD/antisocial behavior by 77.3 %. Based on these findings, the authors hypothesized that gender differences in antisocial behavior may be partly attributable to structural gender differences in the prefrontal cortex. In all, while this may be first imaging evidence for a brain structural profile of antisocial behavior unique to men, future investigations in this area are clearly needed.

Neurology

Current understanding of the pathogenesis of antisocial behavior and disorders has been significantly advanced by neurological studies of brain trauma in antisocial populations. Most-striking is evidence from classic case descriptions of individuals with frontal damage who subsequently developed significant antisociality [e.g., Phineus Gage (Harlow, 1848) and patient E.V.R. (Saver & Damasio, 1991); see also Damasio (1994) and Damasio, Tranel, and Damasio (1990)]—a condition known as *acquired psychopathy* (Granacher & Fozdar, 2007). Perhaps not by coincidence, age groups at highest risk for traumatic brain injury (adolescents, young adults, those over age 75, males; Ehrenreich, Krampe, & Sirén, 2007) overlap largely with those associated with increased antisociality (see Moffitt, 1993). Some populations of antisocial individuals are marked by an unusually high prevalence of adult and childhood brain injury (e.g., Andrews, Rose, & Johnson, 1998; Blake, Pincus, & Buckner, 1995; Lewis, Pincus, Feldman, Jackson, & Bard, 1986; Lewis et al., 1988; Pincus & Lewis, 1991), with rates increased compared to non-antisocial controls (e.g., Lewis, Pincus, Lovely, Spitzer, & Moy, 1987), and head injuries largely predating violence and contact with law-enforcement (Lewis et al., 1986; Sarapata, Herrmann, Johnson, & Aycock, 2008). Such brain trauma may result in a multitude of cognitive and emotional impairments, though studies have demonstrated that aggression occurs more frequently in these individuals following damage to the frontal and temporal regions. In another classic study, examining Vietnam War veterans, Grafman et al. (1996) found increased aggressive and violent attitudes in those who had suffered orbitofrontal lesions compared to lesions in other brain regions—with those with temporal injuries reporting more rage and hostility, and those with prefrontal (particularly orbitofrontal) injuries reporting increased violent and aggressive behavior. These echo imaging study findings on antisocial violent individuals, and suggest that brain damage to these two regions may impair cognitive and emotional regulation capability and force an individual to satisfy desires and achieve goals through aggression and violence, rather than socially acceptable channels (e.g., negotiation; León-Carrión & Ramos, 2003).

Regarding gender differences, what is known to date about the gender-specific effects of brain trauma—as they relate to disorders of antisociality—is largely limited to case studies of male head injury patients reported separately from females. Interestingly, the more well-known neurological studies associating brain damage with antisocial behaviors and disorders have largely involved males (i.e., Phineus Gage, E.V.R., and Grafman and colleagues' [1996] study of Vietnam War veterans). Anderson, Bechara, Damasio, Tranel, and Damasio (1999) reported case studies of both genders—two individuals (male and female) who suffered lesions to different regions of the prefrontal cortex (right polar-medial-dorsal in the former, and bilateral polar and ventromedial in the latter) before the age of 2 years. This, however, was not a comparison study, and both cases were characterized by similar cognitive and psychophysiological deficits (i.e., in autonomic functioning, decision-making, and learning from feedback) and early antisociality, which progressed into adolescent delinquency and adult criminality—including impulsive aggressive and nonaggressive forms of antisocial behavior. Other mixed-gender studies are of even less utility in understanding gender differences in the neurology of antisocial disorders. For example, Lewis et al. (1988) examined 11 boys and 2 girls in their sample of juvenile murderers, but did not specify participant gender in the reporting of neurological data. Still others (e.g., Andrews et al., 1998; Sarapata et al., 2008) have utilized mixed-gender samples of children or adults, in which gender composition is not reported.

It must be remembered that head injury, even in the frontal or temporal regions, does not automatically predispose an individual to antisocial behaviors or disorders. These likely result from a complex interaction of multiple factors (e.g., genetic predisposition, emotional distress, poverty, substance abuse, child abuse, and academic underachievement; Filley et al., 2001), in which brain trauma may act as a trigger, disrupting neural mechanisms that normally mediate and control behavior in persons sociologically predisposed to antisociality (León-Carrión & Ramos, 2003). Brain trauma and acquired psychopathy may also be risk factors for subsequent development of neurodegenerative disorders (Granacher & Fozdar, 2007; McKee & Robinson, 2014), which may exacerbate antisocial tendencies. Finally, one must consider the directionality of the brain trauma-antisociality relationship. For example, children characterized by problematic behavioral or temperamental characteristics may be more vulnerable to head injury by nature of increased exposure to situational adversities—such as recurrent physical fights, thrill-seeking behaviors (e.g., Lewis, Yeager, Blake, Bard, & Strenziok, 2004), or evoked severe parental corporal punishment (Teichner & Golden, 2000). Alcohol and illegal drug use in children and adolescents may also lead to acute brain impairment and long-term neuropsychological decline (Teichner & Golden, 2000). Thus, without adequate knowledge of the temporal sequence of an individual's head injury and antisocial behavioral development, it may become difficult (if not impossible) to ascertain which *causes* the other.

Neuropsychology

Research over the past several decades has highlighted an ongoing and growing interest in relating neuropsychological performance to antisocial behaviors and disorders. Neuropsychological studies of violence, aggression, and antisocial behavior have largely focused on specific domains of cognitive functioning such as verbal and spatial intelligence and executive abilities.

Verbal and Spatial Intelligence

While deficits in measures of general intelligence (e.g., IQ or Full Scale IQ) are the best-replicated neuropsychological correlate of antisociality, violence, and crime among non-mentally ill individuals (Wilson & Herrnstein, 1985), the identification of component verbal versus spatial/performance intelligence deficits has proven useful in understanding the etiological underpinnings of antisocial behavior. Widely reported among adult antisocial populations is reduced verbal as opposed to spatial/performance IQ—perhaps indexing deficits in left hemispheric functioning (Raine, 1993). Verbal IQ reductions appear largely characteristic of antisocial children and adolescents (Barker et al., 2007; Brennan, Hall, Bor, Najman, & Williams, 2003; Raine, 1993; Teichner & Golden, 2000; Vermeiren, De Clippele, Schwab-Stone, Ruchkin, & Deboutte, 2002)—including those with CD (Déry, Toupin, Pauzé, Mercier, & Fortin, 1999)—and have been shown to predict later delinquency at age 18 for persistent, high-level offending beginning in preadolescence (Moffitt, Lynam, & Silva, 1994). Verbal deficits may undermine the development of language-based self-control mechanisms (Luria, 1980), leading ultimately to failure of socialization (Eriksson, Hodgins, & Tengström, 2005), although the juvenile offender with verbal intelligence deficits may have a more positive prognosis, with environmental modifications and therapy (Teichner & Golden, 2000). Interestingly, general intellectual performance or verbal intelligence deficits have not been reported in individuals with antisocial personality disorder and psychopathy (Barkataki et al., 2006; Kosson, Miller, Byrnes, & Leveroni, 2007), although verbal dysfunction may be related to some specific psychopathic traits (i.e., criminal versatility and violence; Rasmussen, Almvik, & Levander, 2001). Thus, while global and/or verbal IQ deficits may be associated with adult antisociality in general, they may not be associated with specific subsets of antisocial trait constellations.

Additionally, the literature related to global verbal intelligence in juvenile psychopathy (itself a largely unexplored and controversial topic; Salekin, 2006) is scant. Verbal deficits were not observed by Loney, Frick, Ellis, and McCoy (1998) in children with conduct problems characterized by Callous-Unemotional traits (CU traits—related to adult psychopathy; Frick et al., 2003), and verbal intelligence was shown to be related positively with the superficial and deceitful interpersonal style traits and inversely with the affective processing-disturbance traits of psychopathy in juvenile prisoners (Salekin, Neumann, Leistico, & Zalot, 2004). Overall, verbal deficits in populations of antisocial youth appear relatively consistent, although future investigations of psychopathic youth may help clarify heterogeneous verbal IQ findings among antisocial juveniles.

Gender differences. While a significant number of neuropsychological studies have examined general, verbal, and performance IQ deficits in antisocial males and females across the lifespan, both combined and separately, few studies have attempted to identify a pattern of verbal and/or intelligence deficits unique to male antisocial populations. Examined separately, females with antisocial disorders have shown neuropsychological deficits comparable to those reported in antisocial males. For example, Pajer et al. (2008) found reduced performance across several neuropsychological domains, including intelligence (i.e., IQ), language, visuospatial skills, verbal memory, executive functioning, and achievement, in adolescent females with CD compared to normal controls. However, Goodman (1995) compared boys and girls (ages 5–16), grouped by behavioral problems (CD, mixed disorders of conduct and emotion, emotional disorders, and other disorders) to healthy controls; and results indicated increased IQ scores in males compared to females in each behavioral group, although group differences only approached significance. Arcia and Conners (1998), on balance, found no gender differences over the lifespan of individuals with ADHD with respect to IQ, neuropsychological performance, or teacher or parent ratings of disruptive behavioral problems. David Wechsler originally argued that the aforementioned performance IQ > verbal IQ discrepancy would be less-characteristic of delinquency in females, but this was based on results from only one study (Isen, 2010). In a recent meta-analysis of 131 studies of antisocial individuals from different age groups, Isen (2010) found the aforementioned PIQ > VIQ discrepancy to be characteristic of females as well as males. Furthermore, results across 14 studies of females with antisocial behavior indicated that this discrepancy is slightly larger for females. As such, it may be that specific patterns of verbal and performance deficits may characterize antisocial males and females separately, though more work is needed in this area.

Executive Functioning

Executive functioning (EF) is an umbrella term for the cognitive processes allowing for goal-oriented, contextually appropriate behavior, and effective self-serving conduct (Lezak, Howieson, Loring, Hannay, & Fischer, 2004; Luria, 1980). Deficits in EF, as indicated by performance errors on neuropsychological measures of strategy formation, cognitive flexibility, or inhibition (i.e., categorization, maze-tracing, Stroop interference, card sorting, verbal fluency, and tower tests; and go/no-go and gambling tasks), are thought to represent frontal lobe impairment. Morgan and Lilienfeld's now-classic (2000) meta-analysis of 39 studies found overall EF deficits in antisocial individuals compared to controls, and strongest effects for the

Porteus Mazes test Q score (i.e., crossed lines, pencil lifts, and changed directions—errors purportedly reflecting impulsivity).

Evidence for EF deficits in delinquent children and adolescents with CD has varied historically depending upon sample characteristics, control groups, assessment measures, operationalizations of EF, and methodology (Moffitt & Henry, 1989; Teichner & Golden, 2000). Findings have recently been mixed, with executive dysfunction characterizing some antisocial youths (Cauffman, Steinberg, & Piquero, 2005; Dolan & Lennox, 2013; Kronenberger et al., 2005; Nigg et al., 2004; White et al., 1994) and not others (Moffitt et al., 1994; Nigg et al., 2004). This may reflect, however, the development of EF along with the ongoing mylenation of the frontal cortex into adolescence and beyond (Nigg et al., 2004; Raine, 2002), which may explain differences in executive functioning deficits among children and adults. Nestor (1992), for example, found impairments in EF in older (i.e., middle-aged) but not younger (i.e., early adulthood) maximum security hospital patients. Blair (2006) found orbitofrontal task deficits to be more pronounced in psychopathic adults than psychopathic children. Additionally, comorbid hyperactivity and aggression may influence neuropsychological performance (Raine, 2002; Séguin, Nagin, Assad, & Tremblay, 2004). Furthermore, antisocial behavior and executive dysfunction may be related developmentally, and certain EF deficits may have serious developmental consequences such as inattention, impulsivity, and problematic understanding of the negative implications/impact of behavior. This may lead to an impaired ability to mentally maintain abstract ideas of ethical values and future contingencies while focusing upon immediate rewards, and inhibit modification of behavior in response to social feedback (Moffitt & Henry, 1989).

Executive dysfunction has also more recently been associated with aggressive (e.g., male batterers) and ASPD populations (Dolan & Park, 2002; Stanford, Conklin, Helfritz, & Kockler, 2007, property offending (Barker et al., 2007), and reactive versus instrumental violent offenders (Broomhall, 2005). Adult psychopathy has not demonstrated consistent associations with general EF deficits (Blair & Frith, 2000; Dinn & Harris, 2000; Hiatt & Newman, 2006; Kosson et al., 2007), although recent neuropsychological evidence suggests that psychopathy may be characterized more by deficits in orbitofrontal functioning (Blair et al., 2006). Additionally, uncaught (successful) psychopaths have demonstrated better dorsolateral prefrontal task performance compared to unsuccessful psychopaths and controls (Ishikawa, Raine, Lencz, Bihrle, & Lacasse, 2001).

Gender differences. Empirical support for a neuropsychological profile of executive dysfunction unique to males who are defiant, aggressive, or violent is mixed. Many neuropsychological studies utilizing all-male participants (e.g., Giancola & Zeichner, 1994; Séguin, Pihl, Harden, Tremblay, & Boulerice, 1995; Spellacy, 1977; see also Morgan & Lilienfeld, 2000, for a review) have identified similar deficits in executive functioning in individuals characterized by antisocial behavior and disorders. In fact, Speltz, DeKlyen, Calderon, Greenberg, and Fisher (1999) found that preschool boys with early onset conduct problems with both ODD and ADHD demonstrated reduced verbal and executive functioning abilities compared to those with ODD alone.

On balance, studies involving gender comparisons have produced findings which are somewhat discordant. For example, in a sample of children with aggressive behavior, Raaijmakers et al. (2008) found reduced executive functioning abilities in 4-year-old boys compared to girls, and increased impulse control and verbal skills in girls—thought to represent faster maturation in girls. Giancola, Roth, and Parrott (2006) found executive functioning mediated the relationship between difficult temperament and aggression (i.e., increased performance on executive functioning measures was associated with decreased negative temperament and aggression) for men but not women. Brennan et al. (2003), in a study of 370 Australian adolescents, identified an interaction of biological risk factors (i.e., low age 5 vocabulary ability, poor age 15 VIQ and executive functioning, prenatal/birth complications, maternal illness during pregnancy, and infant temperament) and social risk factors that predicted life-course persistent aggression in boys and girls, and predicted life-course persistent versus adolescent-onset aggression in boys. Social risk factors were stronger predictors of later aggression, although these authors suggest an interaction of early social risks with later biological risks to predict persistent aggression; and that lifetime, cumulative interactions of these risks are stronger predictors of persistent aggression in boys than are risks specific to childhood or adolescence. However, Herba, Tranah, Rubia, and Yule (2006) found no gender differences in performance on neuropsychological measures of motor response inhibition, verbal inhibition, and cognitive interference inhibition in adolescents marked by conduct problems. Overall, such heterogeneity in findings may reflect the aforementioned methodological limitations of EF studies in antisocial populations in general. Nonetheless, they are at least consistent with results produced by imaging and neurological studies of violent, aggressive, and antisocial persons.

Endocrinology

Studies in neuroscience have explored associations between antisocial behaviors and disorders and common hormones such as cortisol (a glucocorticoid stress reactivity hormone) and testosterone (a sex hormone that is part of the hypothalamic–pituitary–gonadal [HPG] axis). Numerous authors have noted that hormone level variations are associated with behavioral differences (Cohen-Bendahan et al., 2005; Dorn et al., 2009; Kornienko, Clemans, Out, & Granger, 2014; McBurnett, Lahey, Rathouz, & Loeber, 2000; Pajer et al., 2006; Shoal, Giancola, & Kilrillova, 2003). Though it has been suggested that testosterone may be linked to social dominance rather than aggression specifically (Archer, 2006), studies of both testosterone and cortisol show consistent relationships to aggression across genders and across development. In children, hormones including testosterone and cortisol have been consistently associated with aggressive behavior, and diagnoses of CD and ODD (Cohen-Bendahan et al., 2005; Dorn et al., 2009; McBurnett et al., 2000; Pajer et al., 2006; Shoal et al., 2003). In adult populations, similar findings relating hormones to aggression, antisocial personality, and psychopathy have been reported, and gender differences can be observed (Aluja & García, 2007; Banks & Dabbs, 1996; Dabbs, Carr, Frady, & Riad, 1995; Dabbs, Frady, Carr, & Besch, 1987; Dabbs & Hargrove, 1997; Dabbs, Karpas, Dyomina, Juechter, & Roberts, 2002; Dabbs, Ruback, Frady, & Hopper, 1988; Glenn, Raine, Schug, Gao, & Granger, 2010; Stålenheim, Eriksson, von Knorring, & Wide, 1998; van Honk & Schutter, 2007).

Cortisol. Studies have consistently shown that reduced cortisol levels are correlated with increased aggression in both boys and girls (Dorn et al., 2009; McBurnett et al., 2000; Pajer et al., 2006; Shoal et al., 2003). In a study by McBurnett et al. (2000), researchers found significant relationships between reduced levels of cortisol and aggressive conduct disorder and peer aggression. In addition, boys who had childhood onset CD (i.e., before age 10) had reduced cortisol levels compared to boys with adolescent onset CD. However, in another study specifically with boys at high risk for antisocial behavior, no correlations were found between cortisol and CD (McBurnett et al., 2005). Using longitudinal data, Shoal et al. (2003) found that cortisol levels measured at age 10–12 had a negative correlation with later aggressive behavior at age 15–17. However, the relationship between low level of cortisol and aggression could be mediated by the personality variable of self-control.

Studies have also shown that decreased levels of cortisol also relate to aggression in girls. However, these studies have examined the ratio of cortisol to dehydroepiandrosterone (DHEA; an endogenous steroid hormone) rather than cortisol alone, as antisocial girls are frequently characterized by low morning cortisol but high DHEA levels—making cortisol/DHEA ratios a more suitable way to measure this hormone (Pajer et al., 2006). Girls with CD have lower cortisol/DHEA ratios than normal controls (Pajer et al., 2006). Moreover, specifically within CD girls, those presenting with aggressive CD had lower cortisol/DHEA ratios than girls with nonaggressive CD (Pajer et al., 2006). Dorn et al. (2009) compared cortisol levels in boys and girls with and without CDD and ODD, and found that cortisol levels were lower in children with ODD than healthy comparisons. Furthermore, ODD boys had lower cortisol levels compared to ODD girls. Associations between low cortisol levels and aggression may be explained by stimulation-seeking theory, which proposes that a state of low arousal is physiological disagreeable; consequently, individuals increase arousal by actively seeking out stimulation. As such, the aggression and antisociality observed in boys and girls may serve to increase cortisol levels in order to reach a more pleasant physiological state (Raine, 2002).

Testosterone. Testosterone is another hormone regularly found to have a relationship with aggression, and this relationship is also found across genders (Cohen-Bendahan et al., 2005; Dorn et al., 2009; Pajer et al., 2006). Pajer et al. (2006), in a sample of girls with CD, found levels of testosterone to be positively correlated with aggression. A study by found a similar relationship between testosterone and aggression. These authors utilized same sex and opposite sex twin pairs to illustrate gender differences in testosterone-aggression relationships. Results indicated that boys of opposite sex twins had higher levels of testosterone compared to girls of same sex twins. In addition, boys demonstrated a significant positive correlation between morning levels of testosterone and scores on a forced-choice measure of aggression using written descriptions of interpersonal conflict situations. Boys of opposite sex twins consistently scored significantly higher on various measures of aggression than girls of same sex twins. Additionally, girls of opposite sex twins scored higher on measures of withdrawal and verbal aggression than girls of same sex twins. Furthermore, girls of opposite sex twins seemed to demonstrate behavior more in line with a masculine nature. Finally, Dorn et al. (2009) found that children with disruptive behavior disorders, including children with a diagnosis of CD or ODD, had significantly increased levels of androstenedione (another adrenal hormone) compared to healthy control participants.

Similar associations between testosterone and aggression have also been observed later in the human developmental course (Aluja & García, 2007; Banks & Dabbs, 1996; Dabbs et al., 1987, 1988, 1995, 2002; Dabbs & Hargrove, 1997; Glenn et al., 2010; Stålenheim et al., 1998; van Honk & Schutter, 2007). Increased male-to-female ratios of antisocial behavior (e.g., about 4:1 for ASPD and as large as 10:1 for violent crimes; van Honk & Schutter, 2007), along with the several-fold increase in testosterone levels in men compared to women, have supported this line of enquiry in adults. For example, Banks and Dabbs (1996) found increased testosterone levels in men compared to women, and that testosterone levels were higher in the delinquent group (i.e., those characterized by flamboyant dress, drug use, and violence) compared to the control group. However, testosterone levels for both genders were not found to be correlated to aggression. In two randomized double-blind placebo-controlled studies utilizing college undergraduates, Dabbs et al. (2002) found that participants who were administered testosterone had significantly higher levels of arousal and hostility compared to the placebo group and this was found across both genders. However, within the testosterone group, the increase of arousal and hostility was even greater for women compared to men. Interestingly, in a sample of healthy women, van Honk and Schutter (2007) found a significant decrease in the sensitivity toward threat faces (including anger, fear, and disgust) following administration of testosterone. Post hoc analyses showed that testosterone significantly reduced the recognition of anger, a finding that supported the authors' hypothesis that this hormone may facilitate social aggression by reducing the conscious recognition of facial threat (van Honk & Schutter, 2007).

The relationship between aggression and testosterone has also been demonstrated in adult male inmate populations. Two studies by Dabbs et al. (1995, 1987) found correlations between levels of testosterone and crime as reported in prison records (crime for which currently incarcerated and offenses while in prison/prison discipline records), specifically violent crime. Increased testosterone levels were significantly correlated with increased violence in crime (Dabbs et al., 1987). Increased testosterone levels were also found to be associated with specific types of crime, namely rape and homicide (Dabbs et al., 1995). In contrast, lower testosterone levels were more associated with crimes of theft and drug offenses (Dabbs et al., 1995). Similar results have been found in women. Researchers have found that in populations of female inmates, testosterone consistently correlated with aggression (Dabbs et al., 1988; Dabbs & Hargrove, 1997). Dabbs et al. (1988) found that increased testosterone levels were significantly higher in women who had crimes of unprovoked violence compared to women with crimes of defensive violence. In addition, another study with female inmates found that increased levels of testosterone were significantly correlated with increased levels of aggressive behavior, and showed a nonsignificant but positive trend toward increased criminal violence (Dabbs & Hargrove, 1997).

Several studies have also shown relationships between testosterone and disorders of antisociality (Aluja & García, 2007; Glenn et al., 2010; Stålenheim et al., 1998). Stålenheim et al. (1998) found that increased levels of testosterone were correlated with high scores for factor two of the Psychopathy Checklist-Revised (PCL-R; Hare, 2003). In addition, this study found that high testosterone levels were also correlated with cluster B personality disorders, which includes Antisocial Personality Disorder. In a sample of 89 inmates, Aluja and García (2007) found that those who recidivated had higher levels of testosterone. Glenn et al. (2010) found PCL-R scores to be associated with an increased ratio of testosterone (baseline) to cortisol responsivity to a stressor. Results also indicated no relationships with psychopathy and either of these measures independently or with baseline cortisol levels—suggesting that these highly interconnected hormone systems may work in concert to create a vulnerability to psychopathy. Taken together, findings from hormone studies of children and adults have provided additional evidence for underlying biological mechanisms of antisocial behaviors and disorders, and speak somewhat to differential associations between these mechanisms and the male and female genders.

Conclusions

Empirical investigations from various disciplines within the neurosciences—brain imaging, neurology, neuropsychology, and endocrinology—have produced converging lines of evidence implicating neural mechanisms underlying defiant, aggressive, and violent behavior, along with the various disorders of antisociality. While the prospect of a distinct neurobiological profile of antisociality unique to the male gender sounds tempting, there are some key considerations that transcend results from all neuroscientific disciplines. First, the over-representation of males among the antisocial disorders, and the preponderance of antisocial behaviors among males, may merely reflect the differential manifestations of aggression, violence, and antisociality observed among males and females at both the behavior and disorder levels. For example, as previously mentioned, different forms of aggression and delinquent behaviors have been noted in boy versus girls with CD and OD (American Psychiatric Association, 2000—see above). *Relational aggression* (i.e., manipulation of social networks—gossip, refusal of friendship, and ostracism) as opposed to overt aggression (i.e., kicking, hitting, and punching) is more common among females; and some psychopathy researchers have proposed that certain disorders (i.e., Borderline and Histrionic Personality Disorder and Somatization Disorder) may represent female expressions of psychopathy (Verona & Vitale, 2006). As such, differential prevalence rates among genders may reflect operationalizations of antisocial disorders based upon gender-specific behaviors (i.e., in this case—those predominantly found in males). More work is needed to elucidate and clarify the conceptualization of antisociality in females—and to see if any constellations of characteristic behaviors and traits comprise different forms of antisocial disorders unique to females.

Second, methodological limitations of neuroscientific investigations to date largely preclude any inferences about gender-specific neurobiological attributes of antisocial behavior and disorders. Neural characteristics of the disorders of antisociality unique to males may, on the one hand, be inferred by any number of studies of these disorders, which have (in some disciplines more than others, such as brain imaging) recruited all-male or predominantly male participants (likely given the preponderance of males among those diagnosed with antisocial disorders). On the other hand, studies utilizing all-female participants or employing gender comparisons would provide more suitable evidence for what may be male-specific neural correlates of antisocial behavior. Unfortunately, few studies of this type have been conducted to date (e.g., imaging studies of solely antisocial female participants—i.e., those who display aggressive traits or are diagnosed with aggressive disorders—appear nonexistent). Neuropsychological and endocrinological investigations appear to have made the lion's share of contributions to our current understanding of gender differences in the neural correlates of antisocial behavior and disorders, but more work in all areas of the neurosciences is clearly needed.

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Understanding the Neuropsychology of Substance Abuse in Men

Arthur MacNeill Horton Jr., Henry V. Soper, and Teri J. McHale

Introduction

Abuse of alcohol and drugs is a very important social problem (Horton, 1993; Horton & Horton, 2005). We are seeing an increase in deaths from prescription drugs, cocaine, or heroin (CDC, 2014). Research has documented that prolonged use of alcohol and illicit drugs can cause significant residual brain damage (Goldstein & Volkow, 2011; Horton & Horton, 2005; Yucel, Lubman, Solowij, & Brewer, 2007). In this chapter we address the residual neuropsychological effects on men who have abused alcohol and other drugs.

Substance abuse problems have a long history. Human beings have used alcohol and natural substances such as peyote from cacti, and leaves from the opium plant, and other substances to change their emotions for centuries. Pharmaceutical technology has added new drugs such as Morphine, Heroin, Cocaine, Amphetamine, Lysergic Acid Diethylamide, Phencyclidine, and designer drugs such as *Ecstasy* with addiction potential. Research has documented that abusive use of alcohol and illicit drug use can cause significant brain damage (Allen & Landis, 1998; Goldstein & Volkow, 2011).

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Overview

The fact that individuals who abuse alcohol and drugs can become brain damaged has important implications for the assessment and treatment of individual drug abusers (Horton & Horton, 2005; Spencer & Boren, 1990). Tarter and Edwards (1987) noted that little attention had been devoted to individuals with brain damage caused by substance abuse problems. Moreover, neuropsychological assessment can be used to provide a prognosis, assess potential for recovery, and provide recommendations for treatment planning and intervention. This chapter focuses on individuals with alcohol and drug abuse-caused neuropsychological deficits that are relatively enduring (Spencer & Boren, 1990) as opposed to select transient drug-related states such as intoxication and delirium. Neuropsychological effects on executive functioning, learning, memory, and perceptual and motor skills from intoxication and delirium are serious problems. For example, drunk driving and/or falls may produce life-threatening traumatic brain damage (Davis, 2011). These neuropsychological effects with intoxication and delirium are state dependent and remit after withdrawal from the abused substance or substances.

Brain Structures Related to the Addiction Processes

Human brains can include as many as 100 billion cells and function as an integrated whole through neural networks (D'Amato & Hartlage, 2008; Davis, 2011; Horton & Horton, 2005). The human brain can be subdivided structurally with different structures interacting to subserve multiple functions and behaviors and differences can be seen between male and female brains (Ruigrok et al., 2014).

Brain structures and related functions, to cite a few examples, include the hippocampus and short-term memory, the visual cortex and visual perception, and the hypothalamus and homeostasis (Horton & Wedding, 1984). Communications rely on neuronal interaction to allow for the sending and integration of information between brain regions transmitted via chemical and electrical signals. Information reception among neurons occurs at the level of the dendrites and soma. Human brains can undergo changes to the *reward pathway* when exposed to alcohol and psychoactive drugs such as cocaine, heroin, and marijuana. Normally, the human brain reward pathway enables positive conditioning of behaviors that precipitate the experience of pleasure. The human brain connects the behavior to the feeling, and an individual will be more likely to perform the behavior again in the future. The neurotransmitter dopamine has been identified in addiction because of its association with the reward pathway. The human brain reward pathway includes brain structures such as the ventral tegmental area, the nucleus accumbens, and the prefrontal cortex (among other brain structures) and is activated when positive reinforcement occurs with specific behaviors (e.g., see www.nida.nih.gov/pubs/Teaching/). Indeed, human beings are more likely to perform the behavior in the future if a reward follows the behavior. For example, effects of cocaine on the brain reward system can be seen as an example of how the brain reward system works.

Stimulation of the nucleus accumbens or ventral tegmental area with cocaine at transmitter receptor sites activates the human brain reward pathway. Activation does not occur when cocaine is administered to receptor sites of the human brain that are not part of the brain reward system.

Addictive drugs are psychoactive. That is, they activate portions of the human brain through specialized neurotransmitter receptor sites (Horton & Horton, 2005; Horton et al., 2001). Psychoactive drugs have the effect of facilitating relationships between intense feelings of pleasure and drug taking behavior through activation of the reward pathway. Activation can be so strong as to cause drug taking behavior to be selected over other important human behaviors (e.g., eating, child care, etc.; D'Amato, Fletcher-Janzen, & Reynolds, 2005; Davis, 2011). Alcohol and illicit drugs have the net effect of increasing firing patterns and activation of the reward pathway. The activation is associated with the reward. The effects on the reward pathway of substances of abuse are primarily responsible for the addictiveness of alcohol and psychoactive drugs. The drug (e.g., alcohol), or drugs, may also have neurotoxic effects on other human brain processes (Horton et al., 2001). For example, the abuse of cocaine disrupts the brain's ability to utilize glucose (its metabolic activity). Glucose in the human brain provides energy that enables the brain to function (D'Amato et al., 2005; Davis, 2011). Disruption of glucose metabolism, due to abuse of cocaine, can cause disruption of specific brain functions involved in executive functioning. Similarly, another area of the brain that can be compromised by addictive drugs is the hippocampus where multiple abused substances can reduce normal short-term memory functioning (Horton & Horton, 2005; Horton & Wedding, 1984).

Gender Differences in Alcohol and Drug Abuse

It is generally agreed that the majority of studies of alcohol and drug use had been conducted among males prior to the 1970s. It might also be agreed that most individuals diagnosed with alcohol and drug abuse disorders have been males (Brady & Randall, 1999). Simply put, more is known about alcohol and drug abuse by males than by females. In contrast, evidence suggests that ovarian hormones, particularly estrogen, are influential in producing sex differences in drug abuse (Anker & Carroll, 2011). Regarding prevalence rates, males consistently report higher rates of illicit substance abuse and alcohol abuse than females. It appears that drug use is not equally distributed by gender, as males use more illicit drugs, report using drugs earlier and longer than females, and use at a higher frequency in greater amounts. Similarly, with alcohol, males drink alcohol more frequently and more often than females and have a greater number of alcohol-related health problems (Grant & Dawson, 2000). The rate of *progression of addiction* related problems, however, is much quicker in females than in males (Davis, 2011). Males also appear to be less vulnerable than females to the reinforcing effects of psychostimulants and opiates during the addiction process. Males also have a lower prevalence of comorbid psychiatric disorders such as depression and anxiety than women do and while women may be thought to use alcohol to self-medicate mood disturbances the same may not be true for males (Brady & Randall, 1999).

In contrast, men have a higher death rate from illicit drug use including a higher rate of death from cocaine and heroin and alcohol in combination with other drugs (Davis, 2011; Farrell & Marsden, 2008; Horton & Horton, 2005, 2008). Women are more frequently prescribed psychotropic drugs and are more likely to die from antidepressant abuse. Women also have a higher rate of use of prescription drugs such as tranquilizers, sleeping pills, and over-the-counter medications. Men are more likely to be arrested for drug-related violent crimes, and more likely to participate in drug dealing and street crimes (Brady & Randall, 1999). With respect to *substance abuse treatment*, however, both males and females may respond equally well (e.g., see Kosten, Gawin, Kosten, & Rousaville, 1993).

In regard to neuropsychological assessment, an authoritative review (American Academy of Neurology, 1996) has suggested that gender has consistent, but minor effects on neuropsychological assessment test results. It has been noted that males performed less well than females on tests of verbal memory but better on motor measures (American Academy of Neurology, 1996; Horton, 1979). Similarly, men evidence greater decline in neuropsychological performance then women on most neuropsychological tests in the course of normal aging. However, the review concluded, *Gender effects are of modest magnitude compared to the influence of age and education on neuropsychological test performance* (p. 294). At the same time, a more recent study (Ersche, Clark, London, Robbins, & Sahakian, 2005) of executive and memory functioning associated with amphetamine and opiate abuse, demonstrated paradoxical effects depending on gender. Essentially, substance abusers (i.e., amphetamine and opiate abusers) were found to be neuropsychologically impaired on measures of planning, pattern recognition, and visual paired associate learning. In addition, current amphetamine abusers were noted to display a greater degree of neuropsychological impairment than opiate abusers. Similarly, in the control group, healthy men performed better than females on visual spatial tests, consistent with previous research showing a male advantage in visual spatial task performance. Surprising, however, in the drug user groups, the pattern of results was reversed and male drug abusers showed significant neuropsychological impairments compared to both female drug abusers and the healthy male control group. Indeed, the difference in neuropsychological test results of the female controls and the female drug addicts were not statistically significant. This suggests that much additional research will be necessary in the elucidation of sex effects on neuropsychological test performance in substance abusers. There does appear to be mild confirmation that chronic drug abuse has more adverse effects on the male than female human brain (D'Amato et al., 2005; Davis, 2011).

Assessment Issues in Psychoactive Substance Abuse

Age, gender, education, and ethnicity differences are potential assessment confounds in the research (Davis & D'Amato, 2014; Horton et al., 2001; Reed & Grant, 1990). A large number of neuropsychological tests are correlated with age, gender, education, and ethnicity (Heaton, Miller, Taylor, & Grant, 2004). While the availability of more accurate and comprehensive age, education, gender, and ethnicity norms for a number of neuropsychological tests may help to address this problem area (Davis & D'Amato, 2014; Heaton et al., 2004), others have averred that there are potential problems using age and education norms (Davis, 2011; Reitan & Wolfson, 2005). The issue of use of multiple substances of abuse by individuals who abuse alcohol and other drugs is another major assessment confound (Reed & Grant, 1990). The majority of substance users abuse alcohol as well as other psychoactive drugs. In reality, the daily consumption of addictive substances by an alcohol and drug abuser is primarily determined by alcohol and psychoactive drug availability. In research as well as in practice, the amount of alcohol and psychoactive drugs taken by alcohol and drug abusers is also a potential assessment confound (Horton et al., 2001; Reed & Grant, 1990). Objective methods for hair and blood analysis are complicated and expensive. Self-reports concerning substance use from alcohol and drug addicts are solicited after the ingestion of the substance of abuse has occurred. Also, substance abusers' recall of amounts of alcohol and drugs abused can be impaired by their acquired memory deficits as well as by use of the drugs themselves.

Furthermore, another potential assessment confound is that the mode of consumption can mediate the effects of the abused drugs (Reed & Grant, 1990). Intake of various psychoactive drugs through either needle injection, orally, or nasally can cause different effects of the drugs on the human brain (Horton et al., 2001). Drug effects that depend on the mode of consumption include immediate action of the drug, and the amount of the drug, and how quickly the drug enters the blood stream, among others. The mode of consumption mediates expected residual neuropsychological impairment. More possible confounds include premorbid and concurrent medical risk factors (Reed & Grant, 1990). Multiple premorbid and concurrent risk factors can influence a person's susceptibility to developing neuropsychological deficits after alcohol and drug abuse. These can include Learning Disabilities (LD) and Attention Deficit Hyperactivity Disorder (ADHD), genetic and metabolic disorders, and early brain injuries, and can compromise various body organ systems (i.e., liver, kidney, etc.), causing organ dysfunction, which can have secondary negative effects on brain functioning (Tarter & Edwards, 1987). Psychiatric conditions can also occur along with a drug addiction, a lack of certain nutrients, exposure to neurotoxic substances during child development, and in some cases subsequent brain dysfunction (Davis, 2011; Tarter & Edwards, 1987).

Neuropsychological Assessment

Clinical neuropsychological tests (D'Amato & Hartlage, 2008; Reitan & Wolfson, 1993) can discriminate individuals with brain damage from normal individuals (D'Amato et al., 2005; Horton & Horton, 2005, 2008). Neurotoxic disorders (i.e., caused by alcohol and certain psychoactive drugs) and brain injuries are examples of neuropsychological impairing conditions where clinical neuropsychological evaluation is the best method for assessing executive functioning, memory, attention, and perceptual-motor deficits (Horton & Wedding, 1984). Clinical neuropsychological screening tests have been empirically validated by numerous researchers (Davis, 2011; McCaffrey, Krahula, Heimberg, Keller, & Purcell, 1988; Mezzich & Moses, 1980; Reitan, 1973). Effective substance abuse neuropsychological screening measures have been identified (i.e., Trail Making Test [TMT], Symbol Digit Modalities Test [SDMT], Bender Gestalt Test [BGT], Hooper Visual Organization Test [HVOT], Canter Background Interference Procedure [CBIP], Benton Visual Retention Test [BVRT], etc.). The most widely used neuropsychological screening measure has been the TMT (Davis, 2011; Horton, 1979; Horton & Wedding, 1984; Mezzich & Moses, 1980).

The Halstead-Reitan Neuropsychological Test Battery (HRNTB) is the best validated set of neuropsychological assessment procedures currently available (D'Amato & Hartlage, 2008; Halstead, 1947; Horton & Wedding, 1984; Reitan & Davison, 1974). The HRNTB was empirically validated as a battery to be sensitive to the effects of brain damage early on (Halstead, 1947). The test measures from Halstead's (1947) neuropsychology laboratory at the University of Chicago Medical School are the Category Test—a measure of visual abstraction and concept information; the Tactual Performance Test—a measure of psychomotor/tactual perceptual-problem solving; the Speech Sound Perception Test—a measure of the ability to perceive speech sounds; the Rhythm Test—a measure of the ability to discriminate rhythms; and the Finger Tapping test—a measure of motor speed. A number of measures were added to the HRNTB by Reitan (Reitan & Davison, 1974) at his neuropsychology laboratory at the University of Indiana Medical School, including the Reitan-Indiana Aphasia Screening Test—a measure of language functioning; the Reitan-Klove sensory perceptual examination—a measure of sensory perception functioning; the TMT; intelligence testing; academic achievement testing; and personality testing. Also, the HRNTB is frequently supplemented with additional measures of language, memory, and attention functioning depending on the needs of the patient (D'Amato et al., 2005; Davis, 2011). Many research studies have comprehensively assessed alcohol and drug abusers with the HRNTB. In a landmark study, that used the HRNTB with drug and alcohol abusers, found alcoholics were significantly impaired on the HRNTB, with respect to the level of performance while drug addicts, considered as a heterogeneous group, were not. Alcoholics have shown neuropsychological difficulties with visual abstraction, set shifting, and visual spatial skills (Benedict & Horton, 1992). A subset of HRNTB measures has been found to be sensitive to adaptive abilities of alcoholics (Horton & Anilane, 1986; Schau & O'Leary, 1977). Specific patterns of neuropsychological impairment for drug addicts have been noted on measures of fine motor speed, auditory rhythm pattern recognition, visual abstraction, and set shifting abilities (Horton & Horton, 2005, 2008). Brief selective reviews of the residual neuropsychological impairment that follows abuse of specific psychoactive drugs in males are presented below.

Marijuana/Cannabis

The early work in the 1970s looking at neuropsychological impairments among marijuana abusers (Carlin & Trupin, 1977; Grant, Rochford, Fleming, & Stunkard, 1973; Mendelson & Meyer, 1972) did not find any residual deficits, leading one to believe that perhaps cannabis does not have a permanent deleterious effect on the cerebrum. But this has been challenged. Research over that past 40 years (e.g., Meier et al. 2012; Page, Fletcher, & True, 1988; Schwartz, Gruenewald, Klitzner, & Fedio, 1989), using more controlled studies, found that unquestionably after marijuana abuse memory and concentration functions were impaired. Just why the earlier studies failed to find this impairment is open to question, but one could question the samples and measures used. More recently, deficits in executive functioning, in addition to memory impairments have been found related to cannabis abuse (Bolla, Eldreth, Matochik, & Cadet, 2005; Horton & Horton, 2008; Horton & Roberts, 2001; Pope & Yurgelun-Todd, 1996).

To clearly answer this question, Grant, Gonzales, Carey, Natarajan, and Wolfson (2003) conducted a large meta-analytic study, synthesizing the empirical research on the residual effects of cannabis use among adults. Of 1014 studies they looked at, they retained only 15, eliminating the others because of various methodological flaws. Within these 15 studies, they looked at the performance of the 704 cannabis users and 484 non-users, and they found clear neuropsychological impairments only for learning and short-term memory. The deficits were sufficiently minor, leading the authors to conclude that the therapeutic effects of cannabis may outweigh the deleterious neuropsychological effects. This meta-analysis was limited to data from adults; children, with their developing brains, may be more vulnerable to the effects of cannabis. Although there was, unfortunately, nothing noted on the direct effects on children, Goldschmidt, Day, and Richardson (2000) and Fried and Smith (2001) found that prenatal exposure to marijuana resulted in neuropsychological deficits in offspring as children. Clearly, more research must be conducted in this area if clear conclusions are to be reached—indeed, given that states have legalized the use of this drug—and current issues, such as driving and reporting to work under the influence of the drug have been reported in the public press (National Institute on Drug Abuse, 2012).

Hallucinogens/LSD/Ecstasy

The neuropsychological effects of Hallucinogen/LSD abuse are not clear. In some of the earlier research, McGlothlin, Arnold, and Freedman (1969) and Acord and Barker (1973) found visual abstraction and concept formation neuropsychological impairments, but these findings have not been replicated more recently. These old results may well have stemmed from the peculiarities of and comorbid factors within the samples used. In addition, the impairments were relatively small. Obviously, further well-controlled research is needed to determine what, if any, *selective* neuropsychological impairments result from hallucinogen/LSD abuse (Horton & Horton, 2005). The effects of these drugs on the brain and the consequent behavior are so dramatic that one would expect permanent alterations in the brain following with abuse, and research needs to document if such effects exist (Horton & Horton, 2008).

Ecstasy (3,4-methylenedioxymethamphetamine or MDMA) is often considered a stimulant, but the hallucinogenic properties of this substance have been acknowledged (Reneman, Booij, Majoie, van den Brink, & den Heeten, 2001). Parrott (2001) found that *Ecstasy* has different properties from other hallucinogens, and Bolla, McCann, and Ricaurte (1998) and Zakzanis and Young (2001) found memory impairments even among those who had been abstinent for some time and Hollander et al. (2011) found smaller hippocampal volume (responsible for long-term memory) and overall less grey matter. Obviously, brain impairment from this drug is not questionable.

Opiates

The story of the residual neuropsychological effects of opiate abuse is also far from clear. Initially, Fields and Fullerton (1975) looked for neuropsychological impairments among a sample of heroin addicts and found none. In contrast, Rounsaville, Novelly, Kleber, and Jones (1981) did find brain impairment among heroin addicts, but these were with polydrug users. They also found that the addicts who had the most impairment tended to have difficulties in childhood with hyperactivity and poor academic performance. Curiously, a year later these authors (Rounsaville, Jones, Novelly, & Kleber, 1982) looked again at these participants who were addicted and found that the heroin abusers performed better than the matched controls on the neuropsychological tests. Possibly there were demographic variables not controlled for in the latter study. It is also possible that individuals who were addicted as a group may have initially been superior, or at least above average, in neuropsychological functioning, and hence even if there is some impairment the result is that they are still functioning above the controls on these tests. There have been few if any subsequent studies on the residual effects of such abuse. Again, more research is needed in this area if we are to understand the short- and long-term effects of drug use/abuse on neuropsychological functioning (Horton & Horton, 2008; National Institute on Drug Abuse, 2007).

Sedatives

There is substantial support for residual neuropsychological impairment among those who abuse sedatives, beginning with Judd and Grant (1975), who found that sedative abusers had clear neuropsychological impairment. However, these results have to be tempered because many of their subjects also abused other drugs (e.g., stimulants, alcohol, and opiates). This is a common problem in such research, for few of the abusers use only one drug. In line with this, Bergman, Borg, and Holm (1980) looked at subjects receiving treatment only for sedative abuse. Their findings were similar to those of Judd and Grant. By now the impairments following sedative abuse are well documented, and in fact the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2000) includes a diagnosis for sedative-hypnotic, amnestic impairment.

Phencyclidine (PCP)

Considering the clinical manifestations of PCP (or Angel Dust) ingestion one can wonder how it is possible that such a drug cannot have a severe and permanent effect on the brain; perhaps, our neuropsychological measures are limited (Horton & Horton, 2005, 2008). Whatever the reason, research in this area does not overwhelmingly show neuropsychological impairment or an Organic Mental Disorder among PCP users. In fact, the diagnosis of PCP organic mental disorder does not exist in the current DSM. In one early study, Carlin, Grant, Adams, and Reed (1979) were able to find minor deficits in neuropsychological functioning. However, they used a very small sample size and their results have not been replicated. The best summary for now is that there are no residual neuropsychological impairments following PCP abuse. If there are any, they appear to be at worst minor.

Cocaine/Stimulants

Neuropsychological impairment has been found consistently among those who abuse cocaine/stimulants. Early on, neuropsychological impairment was found by O'Malley and Gawin (1990) among individual chronic cocaine users. Strickland et al. (1993) correlated Single Photon Emission Computerized Tomography (SPECT) results in cocaine abusers to neuropsychological impairment. They hypothesized that the observed impairments were likely to be the results of seizures and small strokes. These authors provide a guide for how to conduct the much needed research related to other drug use/abuse.

In addition, frontal lobe deficits have been found in cocaine abusers (Fernandez-Serrano, Percales, Moreno-Lopez, Perez-Garcia, & Verdejo-Garcia, 2012; Volkow, Mullani, Gould, Adler, & Krajewski, 1988; Volkow et al., 1992). Additional research supports the findings of neuropsychological deficits following cocaine abuse (Jovanovski, Erb, & Zakzanis, 2005; Simon et al., 2002; Van Gorp et al., 1999) with one exception (Selby & Azrin, 1998). Although research with animals shows neuropsychological impairment following stimulant abuse, these results initially were not confirmed with studies using humans (Reed & Grant, 1990). More recent and better controlled studies have found neuropsychological impairment following methamphetamine use in human samples (Dafters, 2006; Horton & Horton, 2005; Kalechstein, Newton, & Green, 2003; Woods et al., 2005). In addition, neuroimaging studies have found structural abnormalities in the brains of those participants using stimulants. It seems that neuroimaging techniques may be able to shed light on the damage to individuals' brains from certain drugs that have not shown documented damage with neuropsychological tests in isolation.

Inhalants/Solvents

When compared to other drugs, inhalants/solvents easily found in a most households. Neuropsychological deficits have been found. Bigler (1979) found a generalized pattern of severe neuropsychological deficits. Likewise, Korman, Matthews, and Lovitt (1981) found obvious neuropsychological impairment with inhalant abusers. In addition, Howard, Bowen, Garland, Perron, and Vaughn (2011) reviewed findings that repeated inhalant abuse results in neurological disorders ranging from Parkinsonism, decline of cells in the brain resulting in diminished cognition (encephalopathy), reduction of brain cells (cerebral atrophy), and poor coordination and muscle strength (cerebellar ataxia).

Polydrug Abuse

Not surprisingly, neuropsychological impairment has been well established in polydrug abusers. In early studies, Grant, Mohns, Miller, and Reitan (1976) and Judd and Grant (1975) found that individuals who were polysubstance abusers had obvious neuropsychological impairment, findings which were confirmed by later researchers (Selby & Azrin, 1998). There is a potential methodological problem with studies of polydrug users with neuropsychological impairment due to factors that are medical and psychiatric in nature. As an example, many individuals among this population also abuse alcohol, which may result in the neuropsychological deficits observed rather than the illegal drugs (Bolla, Funderberk, & Cadet, 2000).

Neuropsychological Impairment in Male Alcohol and Drug Abusers

Evidence for residual neuropsychological impairment from alcohol and drug abuse in males has been well established (Horton & Horton, 2005, 2008; Spencer & Boren, 1990). Neuropsychological impairment from abused substances in males has been best documented for alcohol, inhalant/solvents, cocaine/stimulants, marijuana, sedatives, and polydrug usage. Neuropsychological impairment from abused substances in males involves more complex neuropsychological abilities such as executive functioning, short-term memory, attention, abstract problem solving and visual spatial skills. A pattern of neuropsychological impairment from abused substances in males suggests subcortical deficits, although this research is not clear and more studies are needed before comprehensive conclusions can be offered (Horton & Horton, 2008).

The day-to-day adaptive abilities of male substance abusers that are neuropsychologically impaired are worthy of comment. Male substance abusers with neuropsychological impairment can perform relatively well in non-demanding occupational positions but can show difficulties with mentally demanding employment positions (Horton & Horton, 2005, 2008). Neuropsychological impairment in a male substance abuser may impair social functioning but such impairment would depend on how demanding the social situations are. Male neuropsychologically impaired substance abusers' limitations in social and occupational roles will depend on the situational characteristics of the social and occupational roles to be played. Since the neuropsychological deficits of female substance abusers has not been studied in depth, the assumption is that they may have similar deficits but there may be some differences as there are sex differences in neuropsychological functioning as previously discussed.

Conclusions

We briefly discussed neuropsychological findings with individual male substance abusers. Difficulties involved in assessing the residual neuropsychological effects of various psychoactive substances were also discussed. We presented a selective review of neuropsychological test results with male drug addicts. The current research with respect to the neuropsychological effects of abused drugs with males is composed of a small number of studies, and we found some studies are flawed by methodological confounds. In brief, the neuropsychology of male alcohol and psychoactive drug abusers is an area that will require much additional work. Individuals who work with males who abuse drugs certainly need to study the effects of drug abuse given the fact that clients may present with a common clinical neuropsychological profile, which is prominent in the male population.

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The Neuropsychology of Men with Epilepsy

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Introduction

Epilepsy is a neurological disorder that is estimated to be active in about 1 % of the world population. It is diagnosed when an individual experiences two or more unprovoked seizures, and is broadly classified as generalized or focal (Commission on Classification and Terminology of the International League Against Epilepsy, 1989). Epilepsy is known to affect males and females in a roughly equivalent ratio. However, despite this equivalence in prevalence, there are some gender-specific differences in the occurrence of certain epilepsy types, and in the impact of epilepsy and epilepsy medication side effects. Specifically, males have a higher risk of epilepsy following traumatic brain injury (Yeh, Chen, Hu, Chiu, & Liao, 2012). In addition, they tend to develop certain sexual problems, including infertility and sexual dysfunction, due to their specific reproductive and hormonal characteristics (Pack & Gidal, 2007). These variables can in turn influence other aspects of functioning, including cognition and emotion.

The study of individuals with epilepsy has allowed neuroscientists the opportunity to examine and better understand gender-related differences in the organization of language functions, verbal and visual memory, and psychological repercussions of this condition.

Gender differences in language dominance and in the neuroanatomical function of language centers in the brain have been identified among individuals with epilepsy. Similarly, studies with individuals with epilepsy have contributed and confirmed reports of gender differences on tasks of verbal memory and visual memory. From a neuropsychiatric perspective, a significantly higher prevalence of identifiable

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psychiatric conditions has been reported in people with epilepsy as compared with the general population, and gender differences have been noted in this area as well (Alfstad et al., 2011a, 2011b; Kogeorgos, Fonagy, & Scott, 1982; Savic & Engel, 2014). In particular, dissimilarities with regards to externalizing behaviors, and rates of anxiety and depression, have been reported.

Understanding Epilepsy in Men from a Neurological Perspective

Relative to women, men with epilepsy are at greater risk for posttraumatic epilepsy (PTE), and are also at risk for certain types of sexual dysfunction, and infertility or reduced fertility, all of which may potentially impact quality of life (QOL), neurocognitive functioning, and treatment outcome (Mazzini et al., 2003; Pack & Gidal, 2007). They may also experience alterations in hormone levels, which may have multiple consequences.

Posttraumatic Epilepsy

Although men and women have a reportedly equivalent ratio of active epilepsy, men in particular are more likely to develop PTE (Yeh et al., 2012). PTE is a condition characterized by recurrent unprovoked seizures that occur 1 week or longer subsequent to a brain trauma. The incidence of PTE ranges widely, from 4 to 53 %, depending upon the severity of the injury, the age of the individual at the time of injury, and latency to examination post-injury (Frey, 2003). The critical determinant in the development of PTE is the severity of the brain trauma. Similarly, the severity of the traumatic brain injury rather than the presence or absence of epilepsy appears to be most influential in the development and extent of cognitive dysfunction. In other words, the more severe the brain injury, the greater the likelihood that neurocognitive deficits will be present, as indicated by changes in behavior (e.g., disinhibition, agitation, and aggression) and decreased cognitive efficiency (Luethcke, Bryan, Morrow, & Isler, 2011; Mazzini et al., 2003). It is hypothesized that men present with higher rates of posttraumatic epilepsy due to the fact that males tend to engage in risk-taking and physically perilous activities more often than women.

Sexual Dysfunction

Sexual dysfunction due to mechanical or hormonal deficits can have a profound effect on QOL and psychological well-being, and can secondarily impact neuropsychological functioning. Although the majority of men with epilepsy are able to enjoy a healthy sex life, both seizures and anti-epileptic drugs (AEDs) can have unwanted effects on sexual health and performance. Approximately 20–50 % of men with epilepsy have sexual dysfunction, manifested as decreased libido, erectile dysfunction, or anorgasmia (Pack & Gidal, 2007). Specifically, sex drive may be diminished (Morrell, 1994), sexual performance may be impaired, and psychological issues can arise (such as the fear of having a seizure during sex) that impair sexual relations. In a recent study, men with epilepsy were more likely to report lower sexual desire and more erectile dysfunction than controls (Mölleken, Richter-Appelt, Stodieck, & Bengner, 2009). The cause of sexual dysfunction in these individuals is most likely multifactorial. However, it is primarily physiological, and physiological etiologies of sexual dysfunction can be broken down into two categories: physical and medication side effects (Kanner, Soto, & Gross-Kanner, 2000; Talbot, Sheldrick, Caswell, & Duncan, 2008).

Physical. Arousal and intimacy are complex phenomena that require a great deal of brain activity, both subtle and obvious. There are many vital parts of the brain involved in these behaviors. Seizures can interfere with portions of the brain that control sexual desire and performance and/or alter the delicate hormonal balance required for a healthy sex life (Olafsson, Hauser, & Gudmundsson, 1998; Schupf & Ottman, 1996). Sexual dysfunction in men with epilepsy is suspected at least in part to be associated with the effects of epileptogenic discharges in or adjacent to the limbic system/temporal lobe. An association between partial epilepsy and decreased sexual drive during the postictal period has been reported (Kanner et al., 2000). In a study by Morrell, Sperling, Stecker, and Dichter (1994), the authors determined that genital blood flow was diminished in men with temporal lobe epilepsy (TLE) compared to controls when viewing a sexually erotic movie.

Medication side effects. Talbot et al. (2008) found that individuals with epilepsy taking enzyme-inducing AEDs had lower levels of testosterone compared with those taking non-enzyme-inducing AEDs. Certain medications such as phenytoin and carbamazepine can alter the actions of various hormones, resulting in a decrease in sexual desire and performance. Older seizure medications, such as phenobarbital and primidone, can make it difficult to achieve an erection due to their effects on male hormones (Schupf & Ottman, 1996). The mechanism found in enzyme-inducing AEDs is an increased clearance of free testosterone with increased circulating levels of sex-hormone binding protein (an inactive hormonal component) (Smaldone, Sukkarieh, Reda, & Khan, 2004). Men taking phenytoin or phenobarbital may also develop Peyronie's disease, which produces a painful, curved erection (although of note, while this problem has been associated with these medicines, it has not been definitively proven that they cause this condition). Fortunately, these side effects typically disappear when medications are changed.

Complaints of sexual dysfunction in men with epilepsy should be addressed with a thorough physical and neurological examination, and a possible referral for a urological evaluation. Treatments include sex education and behavioral therapy. Additionally, erectile dysfunction usually responds well to pharmacological intervention. Fortunately, sexual health can also, in some cases, be restored through hormonal treatments. For example, testosterone replacement can help reestablish a man's libido and may also be helpful in improving depressed mood. Additionally, in some cases, sexual dysfunction disappears after successful epilepsy surgery (Cogen, Antunes, & Correll, 1979).

Hormonal Changes

Seizures themselves, as well as interictal activity, can alter the level of hypothalamic and pituitary hormones, leading to changes in the secretion of gonadal steroids. Certain AEDs can also have an effect on hormonal levels. Thus, both the physiological effects of having epilepsy, and, medication-induced physiological changes, may potentially lead to changes in sexual functioning and other aspects of behavior. In men with epilepsy taking AEDs, baseline levels of luteinizing hormone (which stimulates the production of testosterone) may be lower than normal, with an exaggerated response to gonadotropin-releasing hormone (Dana-Haeri, Oxley, & Richens, 1984; Rodin, Subramanian, & Gilroy, 1984). There is also an interictal change in luteinizing hormone functioning, with a slower pulse rate (Morrell, 1994; Schupf & Ottman, 1996). Prolactin is elevated interictally in men with epilepsy (Levesque, Herzog, & Seibel, 1986; Rodin et al., 1984) and prolactin levels increase twofold after generalized convulsive seizures and after complex partial seizures involving limbic structures (Dana-Haeri, Trimble, & Oxley, 1983; Sperling, Pritchard, Engel, Daniel, & Sagel, 1986). However, whether there is a connection between changes in prolactin levels and hyposexuality is still unclear. There is also evidence of androgen deficiency in men with epilepsy. In men with epilepsy receiving cytochrome P450 (CYP) inducing AED's, such as phenytoin, the synthesis of sex-hormone binding protein is induced, leading to a decrease in free fraction (active) testosterone levels (Beastall, Cowan, Gray, & Fogelman, 1985). Individuals receiving gabapentin and lamotrigine (which do not induce CYP) have levels of steroid hormones similar to controls. These observations suggest that changes in steroid hormones are due to medications and are not secondary to seizures or epilepsy (Morell et al., 2001).

From a neuropsychological perspective, some studies have shown that optimal levels of sex hormones are associated with better global cognitive scores (Hogervorst, Matthews, & Brayne, 2010). Particularly in men, low testosterone levels have been reported as a risk factor for cognitive decline and, some have speculated, the onset of dementia (LeBlanc et al., 2010; Moffat, 2005). However, other reports have not found cognitive deterioration to be associated with lower testosterone levels in the elderly (Holland, Bandelow, & Hogervorst, 2011).

Infertility or Decreased Fertility

Reduced fertility in men is thought to be due to disturbances in the pituitary gonadal hormones. However, most men with epilepsy are able to father children (Herzog, 2007). Men taking CYP-inducing AEDs have reduced levels of testosterone and are also at risk for impaired spermatogenesis (Herzog, 2007). One study showed that men with epilepsy had reduced seminal fluid volume, spermatozoa concentration, and total sperm count compared with control subjects (Taneja, Kucheria, Jain, & Maheshwari, 1994). Thus, while larger scale studies of each of these areas are needed, there is growing evidence to suggest that males with epilepsy are at greater risk not just for sexual dysfunction, but also fertility problems, when compared to their healthy peers. Possible contributing factors include, but are not limited to, the direct effects of epilepsy, medication side effects, and hormonal changes. Fortunately, some of these problems appear to be reversible with the proper treatment once detected by a physician (Brodie et al., 2013). Nonetheless, from an emotional and neuropsychological perspective, hormonal alterations, sexual dysfunction, and infertility/decreased fertility have the potential to secondarily impact functioning in these areas for men with epilepsy.

Epilepsy in Men from a Neuropsychological Perspective

Epilepsy in Men: Language Functioning and Gender Differences

The understanding of language localization and functioning initially began over a century ago with observations of language deficits following stroke. Broca and Wernicke led the way, and through observation and pathological study, language was determined to be a left hemisphere function for most individuals, with different aspects of language positioned in different locations. Studies of individuals with epilepsy have provided additional understanding regarding the organization of language functions, including language dominance (through intracarotid amobarbital testing) and neuroanatomical function of language centers of the brain (through cortical stimulation, functional neuroimaging, and surgical resection). Neuropsychological testing has provided additional functional understanding of language deficits in individuals with epilepsy. Gender-related differences within each of these areas have been reported.

Cerebral language organization and dominance. The cerebral hemispheres in humans are known to be asymmetrically organized. In the majority of right-handed individuals, verbal functions are supported by the left hemisphere, whereas nonverbal functions may be more right-hemisphere dependent (Milner, 1975). In some individuals, however, language is dependent on the right or both cerebral hemispheres. Evidence for such atypical language organization is far more commonly observed in left-handed or ambidextrous individuals (Trenerry, 1995). Data on potential gender-related differences in cerebral language dominance are inconclusive. It has been proposed by some that language is more strongly lateralized in males than females (Hampson, 1992; Kimura, 1999; Levy, 1972). The most convincing evidence supporting this hypothesis is that males have a higher incidence of aphasia following lesions to the left hemisphere (McGlone, 1977). However, consideration of the anatomical evidence suggests a rather different conclusion, as the male brain tends to be anatomically more symmetrical, while the female brain is more asymmetrical (usually in favor of the left side; Galaburda, Rosen, & Sherman, 1990; Geschwind & Galaburda, 1985). A meta-analysis utilizing functional neuroimaging with healthy men and women suggested no gender differences in cerebral dominance for language (Sommer, Aleman, Bouma, & Kahn, 2004).

In the epilepsy population, hemispheric language dominance presents an even more complex picture. Atypical (i.e., right-sided or bilateral) hemispheric language dominance is more frequent in individuals with epilepsy in comparison to the general healthy population (Springer et al., 1999). This is not unexpected given that, in many individuals with epilepsy, the cause of focal epilepsy is a structural abnormality which is often developmental or acquired during early childhood; a time when there is greater potential for neuronal plasticity, and thus, cerebral reorganization (Rasmussen & Milner, 1977; Springer et al., 1999). Brain abnormalities associated with epilepsy have the potential to interfere with the normal neuroanatomical organization of cognitive functions, even if the abnormality is far from the speech centers (Staudt et al., 2001).

The gold standard for evaluating cerebral language dominance involves temporary inactivation of the left/right hemisphere by intracarotid injection of amobarbital (IAT; Wada, 1949; Wada & Rasmussen, 2007). This procedure determines the functions of a single hemisphere, as well as deficits resulting from deactivation of the contralateral hemisphere. Given the invasiveness of the procedure, it is restricted to patients with planned resective surgeries in, or close to, eloquent brain areas (Hamberger & Walczak, 1995). Although the results from individuals with epilepsy cannot be generalized to a healthy population, examination of individuals who have undergone the IAT has provided some insight into gender differences in language dominance.

Strauss, Wada, and Goldwater (1992) examined 94 individuals with epilepsy who had undergone the IAT in order to determine whether gender affected the pattern of hemispheric reorganization following cerebral injury. The study showed no sex differences in the overall incidence of atypical language dominance in those with left hemisphere seizure involvement (i.e., unilateral left or bilateral foci). However, the period in which hemispheric reorganization for speech appeared to occur was much shorter in females than in males. That is, in females, reorganization was most likely to occur within the first year of life, while males appeared to have a longer window, which extended until puberty. The authors postulated several possible reasons for the observed gender differences, with one possibility being sex differences in rates of maturation. The maturation process proceeds more slowly in boys than girls, and therefore, the authors suggested the slower maturation of the male brain during childhood leaves the right hemisphere available over a longer period of time for the acquisition of speech/language functions (Conel, 1939).

While Strauss, Wada, and Goldwater (1992) described a gender difference with regard to the period during which reorganization of language is likely to occur, other studies have not found similar results with regard to age of onset of epilepsy. For instance, Helmstaedter, Brosch, Kurthen, and Elger (2004) observed that women with left hemisphere epilepsy were more likely to display atypical language dominance than men with left hemisphere epilepsy, but found no significant interaction between gender, age at onset of epilepsy, and language dominance. Upon closer review of Strauss, Wada, and Goldwater's (1992) data, the authors noted that their results may have differed due to disparities in definitions of onset of dysfunction and different interpretations of atypical dominance in patients with right hemisphere epilepsy. Strauss, Wada, and Goldwater (1992) concluded that gender may affect plasticity for speech reorganization. If this were indeed the case, then more pronounced sex differences in patients might be expected with a functional disturbance affecting the original language-dominant hemisphere. However, Strauss, Wada, and Goldwater (1992) could not differentiate between the effects of functional disturbance of the dominant versus non-dominant hemisphere because patients with predominantly right hemisphere seizure involvement were not included in the sample.

Kurthen, Helmstaedter, Elger, and Linke (1997) evaluated sex-related differences in language dominance in a large sample of individuals with epilepsy with complex partial seizures. In this study, language dominance was considered a continuous variable based on comprehensive language testing during left- and right-sided IAT. The authors sought to determine whether: (a) there were sex differences in the mean degree of *atypicality* of language dominance in the total group, and (b) whether the side of major functional disturbance affected the occurrence and/or degree of sex differences in language dominance. The authors examined a sample of 267 individuals with complex partial epilepsy who underwent the IAT as part of a presurgical evaluation. They found a higher degree of atypicality in females in the total patient group, although the results were not significant. However, since it was assumed that language dominance would be affected by the epilepsy itself in all individuals with unilateral epileptic foci, the sample was separated and sex differences were examined with regard to left- and right-sided resection subgroups. The results demonstrated that females had a significantly higher degree of atypicality only in the left-sided resection group and that the correlation of age at onset of epilepsy and the degree of left hemisphere dominance was significantly positive for both males and females in the left-sided resection group, while there was a greater (albeit, non-significant) trend in the negative direction for females than males in the right-sided resection group. The authors concluded that gender differences in cerebral language dominance among individuals with epilepsy were detectable in the subgroup of those with left hemispheric resections, in which females were less strictly left hemisphere language dominant than males. They further suggest that females have a stronger disposition than males to develop atypical language dominance in the presence of left hemisphere impairment. Finally, they postulated that the fact that the sample of females with right hemisphere resection tended to be more atypically dominant with a later onset of epilepsy might imply a naturally higher tendency towards atypicality in females, but they acknowledged that there were limited data to support that hypothesis.

Thus, the data is inconsistent regarding whether cerebral language dominance is related to gender. While some of the studies described above found gender differences in cerebral language dominance in the epilepsy population, other studies have found no such differences. Some reports find that variables other than gender are more important. For example, in a functional MRI (fMRI) study comparing 100 healthy right-handed subjects to 50 right-handed individuals with epilepsy (Springer et al., 1999), atypical language dominance in the epilepsy group was associated with an earlier age of brain injury and weaker right hand dominance. However, language lateralization was not strongly related to gender, education, or task performance in the group with epilepsy. Janszky et al. (2003) investigated medial temporal lobe epilepsy (MTLE) due to unilateral hippocampal sclerosis. Using the IAT to determine language dominance, they found that atypical language dominance in left MTLE was associated with higher spiking frequency and with sensory auras representing an ictal involvement of the lateral temporal structures. Neither gender, nor age at epilepsy onset, nor age at initial precipitating injury was associated with atypical language dominance in left MTLE. The authors concluded that in individuals with focal epilepsy, the epileptic activity itself (i.e., interictal discharges and seizure spread) influenced speech reorganization.

The neuropsychology of language functioning in individuals with epilepsy. It has long been taught in developmental psychology classes that gender differences exist in cognitive functioning, with females having the advantage over males in a number of areas such as language abilities (Anastasi, 1958; Demo, 1982; Halpern, 1992; Maccoby, 1966; Maccoby & Jacklin, 1974). These initial conclusions were heavily drawn from normative data on aptitude measures, many of which were developed during the mid-twentieth century (Feingold, 1988). Greater rates of language-based reading disorders in boys than girls also supported this hypothesis (Flannery, Liederman, Daly, & Schultz, 2000) (see also D'Amatao and Wang in this volume). However, subsequent reviews of initial studies revealed discrepancies with regards to reported developmental timing of the onset of verbal differences, as well as which types of verbal abilities were stronger in females as compared to males. For instance, in the first meta-analysis of its kind in this area of research, Hyde and Linn (1988) reviewed 165 articles involving over 1,400,000 subjects in an attempt to statistically delineate gender differences in language functioning. Their findings indicated a gender difference favoring verbal ability in females of approximately one-tenth of a standard deviation, one they interpreted as "scarcely" warranting attention in "theory, research, or textbooks." Further, there was no significant difference between the genders with regard to the types of verbal ability (e.g., vocabulary, reading comprehension, verbal reasoning), as some authors had previously declared.

Nonetheless, some authors have continued to cite differential gender findings and a possible explanation for this has been provided by Ullman, Miranda, and Travers (2007), who suggested that they might be related to the stronger declarative memory of females when compared with that of males. According to these authors, this difference might allow females to better function on some language tasks. In epilepsy research, two diverse patterns appear in the literature, with one suggesting that no gender differences are found among the neuropsychology of language functioning, and the other revealing that men outperform women on language measures. Martin, Loring, Meador, and Lee (1990) studied verbal fluency among individuals with unilateral TLE and found no gender differences. However, Baxendale, Heaney, Thompson, and Duncan (2010) found that in childhood-onset TLE, gender effects were seen for verbal IQ and conformation naming, such that male subjects outperformed female subjects. No other cognitive measures differed by gender. Randolph, Lansing, Ivnik, Cullum, and Hermann (1999) also found that men with TLE outperformed women with TLE on a visual confrontation naming test; which they determined was related to the preponderance of male-biased items.

Cortical stimulation, functional neuroimaging, and surgical resection. In addition to the IAT, electrographic stimulation of cortex on and around the proposed surgical site in a patient who is a candidate for surgical resection for the treatment of medically refractory epilepsy has been helpful in understanding language localization in this particular population (e.g., Zhang et al., 2013). Mateer et al. (1982) found a higher proportion of naming sites in the anterior temporal cortex in males than females utilizing cortical stimulation mapping. Another study by Ojemann, Ojemann, Lettich, and Berger (1989) revealed that males were more likely than females to have naming errors arising from the parietal lobe. Further, of the small subgroup in which this pattern existed, they found that females were more likely than males to have language represented only in the frontal lobes. On the other hand, Devinsky et al. (2000) and Schwartz, Devinsky, Doyle, and Perrine (1998) found no such gender differences.

A meta-analysis of fMRI research did not support the presence of a gender difference in cerebral dominance for language (Frings et al., 2006). However, there is some evidence for gender-related differences in the utilization of language when undergoing memory tasks. Frings et al. (2006) found that in an approach to a spatial memory task, men estimated that their strategy was significantly more nonverbal than did women. This finding might have important clinical ramifications, such that for a non-dominant temporal lobe resection, women might fare better cognitively than men, as they tend to use left-lateralized activation patterns and employ more verbal strategies during spatial memory tasks than do men. Literature regarding language functioning and gender differences post surgical resection of epileptogenic tissue is largely lacking. There is a known link regarding impairment of visual confrontation naming ability following dominant temporal lobe resection postoperatively on neuropsychological measures (Busch, Frazier, Haggerty, & Kubu, 2005; Chelune, Naugle, Lüders, & Awad, 1991; Davies, Bell, Bush, & Wyler, 1998; Hermann, Seidenberg, Schoenfeld, & Davies, 1997). However, there either does not appear to be any difference in gender postoperatively related to the type and location of surgery performed, or postsurgical language outcomes related to gender effects are not delineated in the research to date.

In summary, while language lateralization per se may not differ in male versus female patients with epilepsy, data do suggest that the period in which hemispheric reorganization for speech occurs is much shorter in females than in males. With regard to language functions, contrary to earlier beliefs that females tended to demonstrate stronger verbal abilities, research in the area of epilepsy has generally not supported this view. However, there may be some evidence for gender-related differences in utilization of language when undergoing memory tasks that could have clinical ramifications in individuals with epilepsy who undergo non-dominant hemisphere surgery (Frings et al., 2006).

Epilepsy in Men: Memory Functions and Gender Differences

Research with individuals with epilepsy has proved immensely useful to the field of memory research, in terms of developing our understanding of relationships between areas of the brain and cognitive functions. Research in the area of memory among individuals with epilepsy has been particularly fruitful and given much to the understanding of learning and recall processes. Many initial studies focused on the relationship between the hemispheres, specifically on the relationships between temporal areas and memory function. The early work of Scoville and Milner (1957) focused on the relationship between the temporal areas and hippocampi, and cognitive amnesia, among individuals with bilateral hippocampal lesions, including one individual with epilepsy. Later work by Penfield and Milner (1958), Milner (1970, 1972), and Penfield and Mathieson (1974) with epilepsy surgical candidates demonstrated the importance of the hippocampi and neighboring temporal systems in memory. Studies such as these with individuals with TLE led to confirmation of the relationship between memory and the hippocampal and temporal structures (Novelly, 1992). This area has been well explored since then and continues to be an area of interest, with relationships observed between the left temporal area and story recall (Frisk & Milner, 1990; Sawrie et al., 2001), list learning and recall (Helmstaedter, Kurthen, & Elger, 1999; Hermann, Wyler, Richey, & Rea, 1987; Loring et al., 2008; Mungas, Ehlers, Walton, & McCutchen, 1985), and recall of paired word lists (Doss, Chelune, & Naugle, 2004; Saling et al., 1993). Research on the right temporal area and its relationship with memory has also been popular, if somewhat more elusive in meaning. The results have been less clear in their delineation of function relative to research in left temporal studies. Relationships have been suggested between the right temporal area and memory for visual characteristics of objects, memory for spatial composition, and detection of changes in spatial location of objects (Pigott & Milner, 1993); memory for details of pictured scenes (Doss et al., 2004); retention of complex information such as faces (Chiaravalloti & Glosser, 2004; Doss et al., 2004; Milner, 2003; Testa, Schefft, Privatera, & Yeh, 2004); spatial memory (Crane & Milner, 2005; Diaz-Asper, Dopkins, Potolicchio, & Caputy, 2006; Nunn, Polkey, & Morris, 1998); and topographical memory (Spiers et al., 2001). Yet the notion of a relationship between the right temporal lobe and spatial memory has been disputed as well, using studies with subjects with epilepsy (Barr, 1997; Chiaravalloti & Glosser, 2004; Kneebone, Lee, Wade, & Loring, 2007; McConley et al., 2008). Furthermore, multiple studies have not been able to find differences between left and right temporal groups on the Wechsler Memory Scale (WMS)/Wechsler Memory Scale – Revised (WMS-R) Visual Reproduction subtests (Naugle, Chelune, Cheek, Lüders, & Awad, 1993), the Rey-Osterrieth Complex Figure Test (RCFT) (Barr et al., 1997; Kneebone et al., 2007; McConley et al., 2008), the Continuous Visual Memory Test (Snitz, Roman, & Beniak, 1996), and the Brief Visuospatial Memory Test – Revised (Barr, Morrison, Zaroff, & Devinsky, 2004).

More recent research has focused on the notion that verbal and non-verbal memory functions are not completely lateralized (Saling, 2009). Furthermore, research among individuals with mesial temporal lobe epilepsy (MTLE) has found that deficits extend beyond memory to more general intellectual and language abilities (Hermann et al., 1997; Marques et al., 2007). Researchers in these areas have underscored the subtleties and interconnectedness of the various brain systems and downplayed the notion of a simple, one-to-one relationship between areas and abilities.

Epilepsy, Verbal Memory, and Gender Differences

Research among individuals with epilepsy has also contributed to our understanding of sex differences in terms of memory functions, as well as possible psychological processes or even physiological variables underlying these differences. As noted previously, some studies find that females tend to do better than males on tests of verbal abilities, whereas males tend to do better than females on measures of arithmetic and spatial abilities (Estes, 1974; Maccoby & Jacklin, 1974; Mann, Sasanuma, Sakuma, & Masaki, 1990; McGlone, 1978; Oerzel, 1966; Weinderholt et al., 1993). Research among the normal population has also found gender differences for memory. Using memory tasks involving words, pictures, and designs, Hart and O'Shanick (1993) found that neurologically intact females performed better on verbal memory measures than on visual memory measures. For males on the other hand, the opposite pattern was found. List learning studies have been particularly consistent in terms of women's superiority for verbal memory (Ganung, 1972). Ganung (1972) found female superiority on a serial list learning task and male superiority on a spatial memory task. Bolla-Wilson and Bleecker (1986) also found female superiority on all learning trials of the Rey Auditory Learning Test. Wiederholt et al. (1993) determined that women performed better than men on the Buschke Selective Reminding Test, another task of verbal memory. In addition, Kramer, Delis, Kaplan, O'Donnell, and Prifitera (1997) examined boys and girls 5–16 years of age without epilepsy and found that girls performed better on the five learning trials and delayed free recall trials of the California Verbal Learning Test for Children (CVLT-C). Other studies have also demonstrated consistent female superiority on verbal memory tasks such as word list or paired word associate tasks (Berenbaum, Baxter, Seidenberg, & Hermann, 1997; Kramer, Delis, & Daniel, 1988; McClone, 1994). Some have found female superiority on the Weschler Memory Scale (WMS), particularly on the Logical Memory and Paired Associates subtests (Ivison, 1977; Verhoff, Kaplan, & Albert, 1979). Other studies have also shown male advantage for visuospatial memory (e.g., performance on the RCFT) (Herlitz, Airaksinen, & Nordstrom, 1999; Lewin, Wolgers, & Herlitz, 2001). Yet other research has demonstrated female superiority for aspects of both verbal memory (word recall/recognition, object recall, and story recall) and visual memory (object locations and face recognition) (Bleecker, Bolla-Wilson, Agnew, & Meyers, 1988; Chipman & Kimura, 1998; Duff & Hampson, 2001; Hassan & Rahman, 2007; Postma, Izendoorn, & De Haan, 1998; Ragland, Coleman, Gur, Glahn, & Gur, 2000). Perhaps not surprisingly, similar findings have been reported in terms of memory among individuals with epilepsy. Research in epilepsy has shown that women with left TLE also have an advantage over men on verbal memory tasks (Berenbaum et al., 1997; Helmstaedter et al., 2004). Moreover, Berenbaum et al. (1997) determined that women were able to recall more words than men on the California Verbal Learning Test (CVLT), a list learning task, before and after surgery, regardless of extent of hippocampal damage. Baxendale et al. (2010) found that females with a history of MTLE outperformed males on a story recall task (on the Adult Memory & Information Processing Battery;

AMIPB). Smith, Elliott, and Naguiat (2009) also looked at gender differences among children and adolescents with a history of intractable epilepsy and found that girls performed better than boys on delayed story recall and learning of word lists.

Epilepsy, Visual Memory, and Gender Differences

In contrast to studies involving the left temporal area and verbal memory, results of research on sex differences regarding the right temporal area and visual memory utilizing epilepsy samples have been inconsistent (Helmstaedter et al., 2004; Strauss, Hunter, & Wada, 1995; Trenerry et al., 1996). More specifically, figural recall studies have been more discrepant. This inconsistency is also observed in non-clinical populations. In a study with normal subjects ages 55 and older, Wiederholt et al. (1993) determined that males performed better than females on the Visual Reproduction Test. In a study with individuals with epilepsy using the Benton Visual Retention Test, Helmstaedter (2004) found women's performance to be lower than that of men. In contrast, Smith et al. (2009) studied children and adolescents with a history of intractable epilepsy and did not find any male advantage over females on the RCFT delayed recall trial. Conversely, Baxendale et al. (2010) found that females with a history of MTLE outperformed males on the design learning and complex figure recall tasks of the AMIPB, although not at a level of significance. Facial recognition studies have also been inconsistent. Bengner et al. (2006) found female superiority for delayed recognition of faces, regardless of epilepsy laterality. However, Smith et al. (2009) did not find any gender differences on visual memory tasks involving delayed facial recognition, among children and adolescents with epilepsy. The inconsistency and in some cases lack of difference between groups have been suggested to be possibly related to a confounding effect of using verbal encoding techniques during certain visual memory tasks (Helmstaedter, Pohl, & Elger, 1995). That is, certain visual memory tasks may not be as purely visual as they were designed to be.

Epilepsy, Gender, Memory, and Surgery

Research has also focused on post-surgical gender differences in memory. Some studies have suggested that men and women differ in terms of the risks of memory decline following anterior temporal lobectomy (Bengtson et al., 2000). McMillan, Powell, Janota, and Polkey (1987) found a tendency for men to experience decline in verbal memory following left anterior temporal lobectomy and women to demonstrate significant visual memory decline following right temporal lobectomy. Similarly, Geckler, Chelune, Trenerry, and Ivnik (1993) found that following left anterior temporal lobectomy, women demonstrated greater performance on measures of verbal memory than men. Consistent with this, Trenerry, Jack, Cascino, Sharbrough, and Ivnik (1995) found that following left anterior temporal lobectomy, females demonstrated an improvement in story recall whereas men demonstrated signs of decline. Bengston et al. (2000) found that regardless of side of surgery, females demonstrated better memory performance than males following surgery on the WMS Logical Memory task, although the difference was modest and both groups demonstrated small performance improvements.

Helmstaedter et al. (2004)) examined the relationship between atypical dominance among men and women and memory function. They found that post surgery, women with atypical language dominance and LTLE showed better preserved verbal memory function (using the RAVLT) than women with left hemisphere language dominance and LTLE, men with atypical language dominance and LTLE, and men with left hemisphere language dominance and LTLE (a finding also seen in Helmstaedter, 2004). In fact, women's verbal memory was largely unimpaired and within normal expectations. However, they also found poor figural memory performance for women using a task requiring repetitive learning and immediate reproduction of a set of nine abstract designs over six learning trials. Post surgery, figural memory did not change for left hemisphere dominant men; they showed no signs of impairment. However those men with atypical dominance showed a significant decline. Women with atypical dominance showed improvement. Those with left hemisphere dominance showed slight worsening. This mirrors previous findings of greater verbal memory for women and greater visual memory for men.

Epilepsy, Gender, Memory, and Age

Other research on memory and gender among those with epilepsy has factored age and development into an understanding of sex differences. Some research has examined possible maturation issues. Strauss, Wada, and Hunter (1992) examined the possibility of greater vulnerability among boys for early cerebral damage. The authors looked at a sample of individuals with epilepsy in their 20s with a history of left hemisphere dysfunction early in life (before 1 year of age), with both typical and atypical language dominance. The authors found that males with atypical speech did not differ from those with typical speech on any given memory tasks (which included the WMS Logical Memory and Visual Reproduction tasks). Among females, significant differences were noted on all of the memory tasks. A relatively small follow-up study noted that those with later lesions tended to perform better than those with early damage, on all given tasks, including the above mentioned memory tasks. Kramer et al. (1997) examined whether sex differences in boys and girls change as a function of age or environmental factors and found an age effect for recall, recognition, semantic clustering, serial position effects, and errors on the CVLT-C, with the younger children most different from the older children. While they did not find a sex by age group interaction, as girls tended to outperform boys in numerous test variables, a trend was noted for increase in the size of sex difference for total recall, with age group, suggesting an increase in gender differences for verbal memory over time.

Certain research has determined greater decline among men with epilepsy on memory tasks. Bleecker et al. (1988) examined age-related changes for verbal memory for women and men, ages 40–89, using the RAVLT. The authors found a significant age-related decrease in performance on all of the learning trials of the RAVLT. It was also found that women consistently had higher scores for each trial over age, and the differences increased with age. Wiederholt et al. (1993) studied subjects age 55 and older and found that performance on the Selective Reminding Test and the Visual Reproduction Test decreased progressively from the youngest to the oldest age group (55–64, 65–74, 74–84, and 85 and older). The authors also found that men declined more rapidly than women on these tests.

Theories Behind Observed Gender Differences

Theories behind the observed sex differences have covered a number of different areas including genetics, hormones, neuroanatomical differences, and environmental factors. Specific research into the reasons for female superiority on verbal tasks has been conducted. Bolla-Wilson and Bleecker (1986) suggested that women do better on verbal learning tasks because of different or more verbally mediated strategy use. Sherman (1974) suggested that girls' earlier development of language abilities orients them towards verbal problem solving strategies. Similarly, when Cox and Waters (1986) found a developmental lag for males in the initial use and subsequent generalization of organizational strategies (i.e., among elementary school children, girls were more likely than boys to use a semantic organization strategy during a list recall task), they suggested that female semantic development might proceed at a faster pace than males' and that a more elaborate semantic network therefore encouraged the use of organizational strategies during memory tasks. Kramer et al. (1988) examined differences in neurologically intact males versus females on performance on the CVLT and found greater use of semantic clustering in females. For males, these authors found a greater use of serial clustering, which is deemed to be a less effective and efficient strategy. Kramer et al. (1997) also found that girls were more likely than boys to use a semantic clustering strategy. Therefore, females' greater use of such strategies may be the result of increased time and hence familiarity in using such, as compared to males. For those tasks for which semantic clustering would not provide clear benefit, it is possible that other more efficient encoding strategies, such as elaboration, imagery, and depth of semantic processing might also be used more often by women (Berenbaum et al., 1997).

Early on, O'Connor (1943) suggested that genetic factors might be involved in sex differences in cognition, given the finding that 25 % of observed females scored above the median for males on a spatial ability test. Stafford (1961) suggested that aptitude for spatial visualization had a hereditary component transmitted by a sex-linked recessive gene, a possibility also raised in other studies (Bock & Kolakowski, 1973; Yen, 1975). However, this has not been a consistent finding, particularly in studies with larger sample sizes (DeFries, Vandenberg, & McClearn, 1976).

Other research has linked hormones with levels of intelligence and spatial ability (Broverman, Klaiber, Kobayashi, & Vogel, 1969); however, this connection has also been criticized and not well-replicated (Klaiber, Broverman, Gogel, Abraham, & Cone, 1971; Klaiber, Broverman, & Kobayashi, 1967; Parlee, 1972; Singer & Montgomery, 1969). Geschwind and Galaburda (1985) suggested that testosterone slows the development of the left hemisphere and Kramer et al. (1997) suggested that higher levels of prenatal testosterone in males result in the right hemisphere being more developmentally advanced than the left, and in turn accounts for male superiority in some spatial skills and a female superiority for some verbal skills.

Some studies have demonstrated differences in neuroanatomical correlates of specific cognitive functions such as language, visuospatial skills, memory, and attention (Lansdell, 1961; Witelson, Glezer, & Kigar, 2007). Dekaban (1978) noted that brain size is approximately 10 % larger in men than in women. Given such, there may be greater numerical density of neurons in women than in men. Some have suggested that adult males show signs of greater brain asymmetry than females (Desmond et al., 1994; Howard, Fenwick, Brown, & Norton, 1992; Kramer et al., 1988). Wada (1974) found the left temporal lobe larger than the right for males, whereas for females, the lobes were more symmetrical. Some research has suggested that men might therefore be more lateralized than women (Harshman, Remington, & Krashen, 1975; Kail & Siegel, 1978) although this too has not been consistently shown (Harshman et al., 1975; Lansdell, 1962, 1968; Lansdell & Urbach, 1965; McGlone & Kertesz, 1973).

Studies have shown that boys demonstrate hemispheric specialization before girls (Buffery, 1971; Geffner & Dorman, 1976; Jones & Anuza, 1982; Witelson, 1976; Wolff & Hurwitz, 1976), although the hemispheres themselves may also mature at different rates across gender. For example, in children 5–8 years of age, Levy (1976) found that the left hemisphere matures earlier than the right for girls and the right hemisphere matures earlier than the left for boys, regardless of handedness. Trenerry et al. (1995) found that following left anterior temporal lobectomy, females demonstrated an improvement in story recall whereas men demonstrated signs of decline. The authors suggested that the findings might be attributable to greater bilateral hippocampal representation of verbal memory in females compared to males. Therefore, female's more asymmetric brains may provide a cushioning effect from the impact on memory to damage in one area, given that the areas involved in such are more diffuse than that of more localized male brains. In contrast, Bengston et al. (2000) did not find any relationship between post-left anterior lobectomy performance on the WMS-III Logical Memory task and hippocampal asymmetry value and gender. Berenbaum et al. (1997) suggested that sex differences in verbal memory were not due to structural differences in the hippocampus. The authors determined that women were able to recall more words than men on a list learning task before and after surgery, regardless of extent of hippocampal damage.

Strauss, Wada, and Hunter (1992) observed different consequences for men and women following early left hemisphere lesions. For men, early damage resulted in general deficits, particularly involving language, learning, and memory, regardless of language dominance. For women, cerebral speech pattern was important, as for those with continued left hemisphere dominance following an early lesion, a lesion effect was found, with some verbal functions affected and nonverbal functions typically not. Whereas, for those with atypical language dominance, both verbal and nonverbal functions were affected, likely due to a crowding effect. The authors suggested that these differences might be due to sex-related differences in rates of maturation. That is, the relative immaturity of the male brain might leave it more vulnerable to early damage than females. Baxendale et al. (2010) noted that the onset of left TLE in childhood seems to have a particular impact on girls versus boys in the development of general intellect and naming skills. They suggested a number of possible responsible factors, including inherent vulnerability to effects of TLE in the female brain, specific effects of antiepileptic medications on the female brain, and different social pressures during education.

Epilepsy in Men and Boys: Psychological Characteristics and Gender-Specific Symptomatology

In recent years, an increasing amount of research has examined the psychological functioning of the epilepsy population. It has been well demonstrated that diverse psychiatric conditions are more prevalent in people with epilepsy than in the general population, with rates ranging from 30 to 60 % (Grabowska-Grzyb, Jedrzejczak, Naganska, & Fiszer, 2006; Kanner, 2011; Yousafzai, Yousafzai, & Taj, 2009). Gender issues have also long been considered an important dimension of psychosocial development and psychiatric comorbidity, and although psychiatric issues in women with epilepsy have been well studied, the same cannot be said for boys and men with epilepsy.

Influence of Gender on Psychological Issues in Male Children with Epilepsy

As in their adult counterparts, children with epilepsy have a higher risk of developing psychiatric disorders as well as behavioral problems (Austin & Caplan, 2007), with prevalence rates ranging from 16 to 77 % (Plioplys, Dunn, & Caplan, 2007). Physicians working with this population typically encounter a variety of mood, anxiety, and behavioral problems, which, if left untreated, can lead to difficulties in the child's academic, emotional, and social functioning and can have a profound and long lasting effect on their psychosocial development. When in the process of developing a male identity, young males with epilepsy face additional challenges including the possibility of problems in sexual development and function as discussed above, dependence issues resulting from restrictions in driving and physical activities, and difficulties with the development of a *strong* self-image. With regard to the latter, the vulnerability that accompanies seizures, the need for medications, and regular doctor visits, and the importance of self-care (avoidance of seizure triggers) can all seem contradictory to a strong male persona.

Some studies examining potential risk factors for psychiatric symptomatology in children with epilepsy note that the unpredictability of seizures and severe stigma are among the most significant variables (Weisbrot & Ettinger, 2001), followed closely by other contributing factors including reaction to the diagnosis, degree of seizure control, and type and number of AEDs. The question of whether the child's gender is a contributory factor is still in the early stages of examination. Although some researchers have concluded that gender is not a risk factor for the development of psychiatric symptoms in children with epilepsy (Ettinger et al., 1998; Plioplys et al., 2007), others have suggested otherwise. Turky et al. (2008) have proposed that gender may be an individual predictor of depression in children with epilepsy. Of note, while girls with epilepsy have higher levels of depression (Austin, Huster, Dunn, & Risinger, 1996), boys may struggle with other difficulties, such as higher levels of overall problems and peer difficulties (Alfstad et al. 2011a). In a follow-up study, Alfstad et al. (2011b) determined that boys with epilepsy, as compared to healthy controls, have significantly higher rates of daily alcohol consumption (8.3 % in children with epilepsy versus 1.0 % in a control sample), experimentation with illegal substances (12.4 % versus 5.5 %), and reported participation in criminal offenses (19.7 % versus 8.5 %), while girls with epilepsy did not exhibit risk-taking behaviors more frequently than their matched controls. Other researchers have found that anxiety levels are lower in boys with epilepsy than in girls (Austin et al., 1996), while some have gone as far as to suggest that male gender may be protective against anxiety (McDermott, Mani, & Krishnaswami, 1995). Although this research points to interesting future directions, larger scale studies are needed to support conclusive statements regarding the psychological development of young boys with epilepsy.

Influence of Gender on Psychological Issues in Adult Men with Epilepsy

Epilepsy in adults of both genders is associated with an increased risk of psychopathology, including mood, anxiety, and psychotic disorders. A proposed bi-directional influence between epilepsy and depression (Kanner, 2008) suggests that significantly elevated rates of depression precede epilepsy just as high rates of epilepsy precede depression. A recent review by Hauser and Hesdorffer (2001) suggested that depression can be between 7 and 17 times more likely to occur in people with epilepsy as compared to matched controls, while anxiety disorders are reported in 15 % (Edeh & Toone, 1987) to as high as 50 % (Mittan & Locke, 1982) of this population. Thus, there may be commonalities in the pathways leading to psychiatric illness and epilepsy (Kanner et al., 2012).

Differential incidences of psychiatric comorbidities in adult men with epilepsy have received comparably less attention in the literature than the area of psychological dimensions of women with epilepsy. With regard to the potential effect of gender on the prevalence of anxiety in adult men with epilepsy, some researchers have reported no significant differences between the genders (Brandt et al., 2010), while others have argued that men tend to experience lower levels of anxiety than do their female counterparts (Gopinath, Sarma, & Thomas, 2011). These findings are similar to those reported in the pediatric epilepsy population.

With regard to depression, some researchers have noted that the most severe levels of symptomatology in individuals with epilepsy are observed in males (Kogeorgos et al., 1982; Mendez, Cummings, & Benson, 1986), particularly those with TLE, and even more so for those with a left-sided temporal lobe focus (Altshuler, Devinsky, Post, & Theodore, 1990). Yousafzai, Yousafzai, & Taj (2009), in a cross-sectional design in Pakistan, found that while 60 % of individuals with epilepsy met criteria for a depressive episode, the variables that were most strongly associated with being depressed included married status, having a lower income level, and male gender. In addition to differences in the psychiatric diagnoses of men and women with epilepsy, potential differences in the risk of suicide have been indicated. Since the psychiatry literature suggests that depression and other psychiatric conditions place an individual at a higher risk of attempting suicide and, because individuals with epilepsy have higher rates of depression, it is not surprising that they have been reported to have an increased risk of suicidal ideation, suicidal behavior, and completed suicides compared to the general population (Kalinin & Polyanskiy, 2005). Easy access to powerful and potentially fatal drugs increases the risk of suicide attempts. Some researchers have suggested that this may be due to the fact that suicidality and epilepsy share common neurobiological pathogenic mechanisms, including disturbances of several neurotransmitters such as serotonin, norepinephrine, glutamate and GABA, as well as disturbances within the hypothalamic–pituitary–adrenal axis (Hecimovic & Popovic 2014). However, the notion of suicidal ideation and attempts as a reaction to living with disruptive seizures, medication side effects, and cognitive deficits should not be understated. Whether men with epilepsy are at an increased risk of suicide remains unclear. What the literature has established so far is that differences do exist between the genders. Kalinin and Polyanskiy (2005) found that early age of epilepsy onset and seizure frequency were risk factors for suicidality in males but not females, and that risks also varied by gender depending on AED. The literature also suggests that similar to patterns in the general population, there exist differences in method and success rates of suicide attempts, with men with epilepsy tending to use more lethal methods and thus having higher rates of completed suicide as compared to women (Janicack, Davis, Preskorn, & Ayd, 2001).

With regard to comorbidity with schizophrenia, some authors have suggested that a bidirectional relationship exists, suggesting a possible mutual susceptibility between these two conditions. Chang et al. (2011), for example, reported both a higher incidence of epilepsy in their schizophrenia cohort versus non-schizophrenia cohort, as well as a higher incidence of schizophrenia in the epilepsy cohort versus their non-epilepsy cohort. With regard to differential prevalence rates between the genders, Chang and colleagues are some of the few researchers who have examined this variable. They concluded that the association between epilepsy and elevated incidence of schizophrenia was more pronounced in men.

Quality of Life

It is only in the last two decades that the construct of QOL has been formally defined and measured in the epilepsy population. QOL is a multidimensional construct which encompasses various domains of a person's life and includes many secondary effects of epilepsy, including the physical effects of the illness, side effects of the medications, psychological distress, academic and occupational difficulties, and social issues such as stigma and isolation. Other domains that can potentially affect a person with epilepsy's QOL include level of seizure control, age of seizure onset, attitude towards their epilepsy, changes in self-perception as a result of the diagnosis, medication adherence, loss of self-confidence, rapport with treating professionals, fear of stigma, and adverse effects on their social life (Buelow & Estwing Ferrans, 2001). Although there are numerous well-studied factors that influence self-reported QOL in individuals with epilepsy (e.g., seizure frequency, number of prescribed AEDs, adverse effects; Luoni et al., 2011), few studies have examined the role of gender on this construct. Yue et al. (2010) studied a group of 204 individuals with epilepsy and concluded that among men, epilepsy duration and seizure frequency are associated with self-reported levels of QOL and self-reported "social function" scores. They also found that for women with epilepsy, the number of AEDs was significantly correlated with QOL. A second study noted that for men, the strongest predictors of QOL were self-reported levels of anxiety, frequency of seizures, and Adverse Event Profile (Privitera & Ficker, 2004). A separate study revealed that psychological distress, anxiety and depression in men had the greatest impact on QOL and sexual desire (Duncan, Talbot, Sheldrick, & Caswell, 2009). However, other studies have in fact not found that gender plays a significant role in QOL in epilepsy (Auriel et al., 2009). Identified psychological contributors to sexual dysfunction in men with epilepsy were anxiety in general, performance anxiety, depression, and the effects of stigma. Elliott and Mares (2012) reported that a combination of biomedical, psychological, and social factors played a significant role in male QOL.

Conclusions

Males with epilepsy represent an unexamined subpopulation in epilepsy. Despite there being few published studies in this area, this review of the existing literature indicates that there are appreciable gender differences and future lines of research. From a medical perspective, an association between infertility, sexual dysfunction, cognitive and emotional problems, and specific reproductive and hormonal characteristics in males with epilepsy has been reported. From a neuropsychological perspective, gender-related differences in the organization of language functions as well as visual and verbal memory in epilepsy have been documented.

While language lateralization per se may not differ in male versus female patients with epilepsy, data do suggest that the period in which hemispheric reorganization for speech occurs is much shorter in females than in males. With regard to language functions, contrary to earlier beliefs that females tended to demonstrate stronger verbal abilities, research in the area of epilepsy has generally not supported this view. However, there may be some evidence for gender-related differences in utilization of language when undergoing memory tasks that could have clinical ramifications in epilepsy patients who undergo non-dominant hemisphere surgery.

With regard to memory functions in men with epilepsy, many studies appear to mirror other studies of gender differences in cognitive functioning. That is, women tend to perform better on tasks of verbal memory, and men tend to perform better on tasks of visual memory. The differences between the groups grow more striking with age. However, results have at times been inconsistent, indicating the need for further study, particularly regarding the role of the right temporal area in memory. Research into possible reasons for gender differences have covered a number of different areas including aspects of executive functioning (that is, more efficient learning strategies), genetic factors, hormonal influences, differences at a neuroanatomical level, and environmental effects. Future research into environmental factors may be particularly useful in minimizing differences among the genders. Future research in the area of strategy use may be particularly useful for rehabilitation specialists working with men to help teach more efficient means of improving and compensating for memory difficulties.

From a psychological perspective, children and adults with epilepsy are known to have a higher risk of developing psychiatric disorders as well as behavioral problems. The specific psychological repercussions of this condition in males have just begun to be examined, but initial reports indicate that men with epilepsy tend to show comparably increased externalizing and self-destructive behaviors as well as depression. Findings remain inconclusive regarding suicidality in males as compared to females. It has been suggested that men and boys with epilepsy are less affected by anxiety than their female counterparts, but again, this is also still not clearly defined (Brandt et al., 2010; Gopinath et al., 2011). QOL in males with epilepsy is likely multifactorially influenced by challenges faced in the development of a strong male identity, sexual dysfunction, unemployment or underemployment and loss of independence in many areas of life. Contradictory findings with regards to the association between QOL and gender require further study. This information serves to heighten the awareness of epilepsy center staff (epileptologists, neuropsychologists, mental health professionals) to the unique characteristics of epilepsy in men. Routine screening within each professional's scope of practice for issues that may require intervention or treatment should become part of standard practice. In such, epileptologists should consider questioning their patients about sexual health and QOL factors and select specific treatment options considering gender factors. Cognitive (memory and language) differences between the genders represent fruitful areas of future research for the field of neuropsychology. Mental health professionals should screen carefully for the psychological and QOL issues that are specific to males (in particular, externalizing, self-destructive, and depressive factors) in order to help implement more targeted treatment approaches. All of these areas of assessment and treatment have the final goal of improving patient care.

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Serving Men with Traumatic Brain Injuries

Jesse J. Piehl and Andrew S. Davis

It is estimated that 1.7 million people suffer a traumatic brain injury (TBI) every year in the United States, and while most are treated and released, 52,000 die as a result (U.S. Department of Health and Human Services, 2010). Traumatic brain injury has a significant impact on children, and about 750 of 100,000 children experience a TBI every year (Anderson, Brown, Newitt, & Hoile, 2011). Although these numbers are concerning, improvements in technology as well as other advances are resulting in decreased mortality, albeit with increased morbidity, which means that neuropsychologists are likely to see more patients with TBI going forward. The Centers for Disease Control and Prevention (CDC; 2011) noted that the decrease in TBI-related deaths could be due to the increased use of seat belts, child safety seats, and motorcycle helmets, as well as changes in driver's licensing and education programs, and improved pre-hospital triage and hospital care. The prevalence, severity, and functional implications of TBIs vary depending upon factors such as the patient's age, the type of TBI, the number of previous TBIs, the location of the injury, the duration of coma and Post Traumatic Amnesia (PTA), secondary injuries, the degree of mechanical trauma, environmental risk, ethnicity, and resiliency factors, as well as other considerations (Davis & D'Amato, 2014; Lezak, Howieson, & Loring, 2004). The cognitive deficits that arise following a TBI can have a substantial impact on social, behavioral, and academic and/or vocational functioning, as well as the ability to independently perform activities of daily living. Furthermore, the cognitive and physical limitations associated with TBI may trigger or exacerbate stress within the family. In addition to these considerations, patient gender plays a

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significant role in the diagnosis and treatment of TBI. For example, males are nearly twice as likely as females to suffer a TBI (Bruns & Hauser, 2003), which also places them at increased risk for subsequent TBIs. Men may also suffer greater deficits following a TBI (Schopp, Shigaki, Johnstone, & Kirkpatrick, 2001), although the research on outcomes related to sex are somewhat mixed (and are reviewed later in this chapter). Other concerns that should be considered when working with men and TBI are related to comorbid psychiatric conditions such as depression or Post-Traumatic Stress Disorder (PTSD) that can impact the sequelae of TBI. For example, Carlson et al. (2011) reviewed the literature regarding TBI and PTSD and noted that in three studies evaluating Iraq and Afghanistan war veterans, the frequency of probable PTSD/mild TBI ranged from 5 to 7 %, although among the war veterans with probable mild TBI the frequency of probable PTSD ranged from 33 to 39 %. These results suggest that the presence of mild TBI is a significant risk factor for comorbid PTSD. This can be troublesome for treatment planning given the overlap between some of the symptoms of PTSD and TBI. Similarly, Vasterling et al. (2012) evaluated 760 soldiers pre- and post-deployment and found that 17.6 % of the soldiers with TBI screened positive for PTSD and 31.3 % had positive depression screens. In summary, the understanding of sex differences in TBI should be an important consideration of neuropsychologists and other members of the treatment team. An understanding of sex differences can result in a more appropriate understanding of the mechanism of injury, and may affect the approach to neuropsychological assessment, as well as facilitate improved care for the patient and their family.

Overview of Traumatic Brain Injury

Traumatic brain injuries can be broadly divided into two categories. The first, Closed Head Injuries (CHI), occur when the traumatic event does not result in significant penetration of the skull by a foreign object, and the brain injury and subsequent effects are related to translational and rotational forces acting on the brain (Greve & Zink, 2009). As such, in closed head injuries, the brain is not directly exposed to an outside object; rather, the mechanical forces inside the skull arising from the traumatic event are what cause brain damage. The other category of TBI, Penetrating Head Injuries (PHI) or Open Head Injuries (OHI) is present when penetration of the skull occurs such as in a gunshot wound. Neurocognitive deficits and outcome resulting from these injuries can be varied; although the type of deficits may be easier to predict based upon the focal site of the injury. In both types of TBI, it is also important for the treatment team to consider secondary effects of the brain injury as well.

Closed Head Injury. Damage from a closed head injury can occur in two stages: the primary injury and the secondary injury (Hannay, Howieson, Loring, Fischer, & Lezak, 2004). The first phase, or the primary injury, is the direct and immediate damage caused by mechanical forces operating on the brain. Contact force occurs as the result of an impact to the skull. This can occur via a static injury where the victim receives a blow to the head while remaining still. Damage initially occurs at the point of impact, with additional injury due to mechanical forces. Inertial forces may result in the brain moving with (translational acceleration), or rotating around (rotational acceleration), its center of gravity. This movement of the brain within the skull can cause the soft tissue of the brain to *crash* into the hard bony skull.

An additional concern with closed head injuries is cerebral contusions, which are the result of damage to the brain tissue and vascular structure; indeed, disruption of the vascular structure during closed head injuries can represent a substantial immediate threat to the patient's life. *Coup* lesions are the result of damage at the point of impact and are associated with functional deficits in the domains associated with this area of the cortex. C*ontrecoup* injuries are lesions opposite the site of the initial blow and are thus associated with neurocognitive deficits associated with the area of cortex opposite of the initial blow. Understanding the nature of the coup-contrecoup relationship is critical to neuropsychologists and the treatment team when working with men with CHI and is facilitated by a thorough understanding of functional neuroanatomy (see Chapter "Imaging and Development: Relevant Findings in Males" in this volume by Semrud-Clikeman & Robillard, in press) as well as how those deficits are expressed by men. Another significant concern with closed head injuries are the rapid acceleration and deceleration forces that act upon the neuronal axons, forces which can result in Diffuse Axonal Injury (DAI; Hannay et al., 2004). That is, the force of the injury may cause axons in the white matter to stretch, tear, or sheer. Patients with diffuse axonal injury may suffer significant deficits, in addition to the cortical impairments associated with the coup-contrecoup concerns, including slowed processing speed (Felmingham, Baguley, & Green, 2004), executive dysfunction (Fork et al., 2005; Scheid, Walther, Guthke, Preul, & von Cramon, 2006), and memory deficits (Chang, Kim, Kim, Bai, & Jang, 2010; Scheid et al., 2006).

The second phase of a closed head injury, the secondary injury, occurs as the result of the trauma the brain incurs following the initial impact and can represent the most immediate danger to the patient following the TBI. Secondary injuries may be the result of elevated intracranial pressure (ICP; Badri et al., 2012), edema (Greve & Zink, 2009), hypoxia (Padayachy et al., 2012), fever (Thompson, Pinto-Martin, & Bullock, 2003), or infection (Kourbeti et al., 2012). Increased ICP can arise from elevated blood volume in the skull and is of great concern to first responders arriving at the site of the trauma (Hannay et al., 2004). Effects of increased ICP on the brainstem can result in disruption of vital functions and cause death. Another significant concern following TBI is cerebral hypo-oxygenation, which is the leading cause of preventable death in patients sustaining a severe TBI (Arellano-Orden et al., 2011).

Penetrating Head Injury. Penetrating head injuries result from a foreign object penetrating the skull. Blood loss from the injury may result in hypotension (low blood pressure; Berry et al., 2012) and hypovolemia (low blood volume; Hannay et al., 2004). Contusions, especially at the site of entry, and hematomas, are also common (Ambrosi, Valenca, & Azevedo-Filho, 2012), as are effects of shockwaves that may be caused by the penetrating object (Hannay et al., 2004). The damage and functional implications resulting from the injury depend on the mass and velocity of the object, the site of the injury, the severity of the damage, as well as secondary effects. As with CHI, sequelae of PHI are also impacted by risk and resiliency factors, including psychiatric symptomatology. The prognosis in PHIs tends to be worse than CHIs in regard to mortality. As the damage resulting from these injuries is likely focal, survivors tend to have more localized cognitive deficits, although diffuse cognitive impairment may also be present; attention difficulties, memory deficits, and slowed processing are common in patients with PHI (Hannay et al., 2004). Seizure disorders may arise following PHI, and the effects of seizures, as well as the effects of anti-seizure medication, may also impact cognitive and behavioral functioning, and are further important treatment considerations.

Severity of Traumatic Brain Injuries

There are multiple ways to assess the severity of a TBI. One widely known measure of TBI severity is the Glasgow Coma Scale (GCS; Teasdale & Jennett, 1974). The GCS measures the level of consciousness on a 15-point scale and is assessed via verbal, nonverbal, and motor responses (Semrud-Clikeman & Bledsoe, 2011). However, given the complex sequelae that may accompany a TBI, the use of a single measure of TBI severity may be misleading, and longitudinal assessment is crucial. Additionally, an important caveat when using the GCS, as well as other measures of TBI severity, is that they can be influenced by other variables, such as alcohol intoxication (Schutte & Hanks, 2010), which may erroneously lead to lower scores at the time of injury. Duration of Loss of Consciousness (LOC) and length of Post-Traumatic Amnesia (PTA), or loss of memory for events following injury, are other measures of severity. Post-traumatic Amnesia, which is measured from the injury to the point where the patient can continuously form new memories, correlates highly with GCS (Hannay et al., 2004) and tends to last about four times as long as LOC (Hannay et al., 2004). Retrograde amnesia (not being able to recall events prior to the injury) may also accompany PTA.

Traumatic brain injuries typically fall into three categories of severity. Mild TBI can be defined in several ways, including PTA of generally less than one hour, or brief periods of LOC. Mild TBIs account for approximately 75 % of all head injuries (U.S. Department of Health and Human Services, 2010). Neuropsychological deficits associated with mild TBI typically include those in attention (Blanchet, Paradis-Giroux, Pepin, & Mckerral, 2009; Kwok, Lee, Leung, & Poon, 2008), memory (Kwok et al., 2008; Rohling et al., 2011; Tsirka et al., 2010), and processing speed (Johansson, Berglund, & Ronnback, 2009; Kwok et al., 2008). Of note, such cognitive deficits may be complicated by other TBI-related symptoms, such as headaches (Chaput, Giguere, Chancy, Denis, & Lavinge, 2009; Finkel, Yerry, Scher, & Choi, 2012), dizziness (Kaufman et al., 2006), sleep difficulties (Chaput et al., 2009; Milroy, Dorris, & McMillan, 2008), fatigue (Norrie et al., 2010), and irritability (Chaput et al., 2009). In most cases, symptoms from a mild TBI usually subside within the first few months and a return to premorbid activities is generally expected (Lange et al., 2012; Rohling et al., 2011), although some symptoms may persist (Fourtassi et al., 2011).

Moderate TBIs are generally characterized by PTA of less than 24 h (Hellawell, Taylor, & Pentland, 1999). Glasgow Coma Scale scores for moderate TBI generally fall between the range of 9 and 12. These injuries account for roughly 8–10 % of all TBIs (Hannay et al., 2004). Quick recovery is less likely in this group, with many still reporting memory disturbance (Colantonio et al., 2004; Horneman & Emanuelson, 2009) and daily functioning deficits (Colantonio et al., 2004) after injury.

Less than 10 % of all brain injuries fall in the severe category (Hannay et al., 2004), which may be classified as PTA of greater than one day. As with other classifications of TBI, cognitive and behavioral deficits vary depending upon the location of the injury, secondary factors, and other variables, although overall impairment tends to be more pervasive and persistent. One of the most common deficits in severe TBI is attention difficulties (Mathias & Mansfield, 2005; Satz et al., 1998; Zgaljardic & Temple, 2010). Processing speed (Colantonio et al., 2004; Horneman & Emanuelson, 2009) and memory deficits (Colantonio et al., 2004; Horneman & Emanuelson, 2009; Mathias & Mansfield, 2005; Satz et al., 1998; Zgaljardic & Temple, 2010) are also common in severe TBI. Many may also suffer executive dysfunction (Beauchamp et al., 2011; Demery, Larson, Dixit, Bauerand, & Perlstein, 2010; Krishnan, Smith, & Donders, 2012; Mathias & Mansfield, 2005; Zgaljardic & Temple, 2010) and word finding difficulties (Hough, 2008). The presence of subarachnoid hemorrhage has also been shown to indicate poorer visual-spatial abilities following severe TBI (Hanlon, Demery, Kuczen, & Kelly, 2005). Motor functioning problems may also persist and are likely to be present 6 months after injury (Satz et al., 1998).

Gender Differences in Prevalence of TBI

From the period of 1997–2007, TBI-related mortality decreased for both males and females, with an 8.5 % decline in males (30.5 per 100,000 to 27.9 per 100,000) and a 9.5 % decline in females (9.6 per 100,000 to 8.7 per 100,000). However, for each of these years the prevalence of TBI-related deaths for males was higher than for females, particularly among males aged 20–24 (Centers for Disease Control, 2011). Similarly, Bruns and Hauser (2003) found males at greater risk for TBI than females, with a male-to-female ratio of 1.5:1 to 1.7:1. They also determined that the pattern of greater prevalence of TBI in men relative to women is observed in other parts of the world, including South Africa (>4:1), Australia (2.7:1), France (2:1), and China (1.3:1). According to Bruns and Hauser, this substantially increased risk is due mostly to interpersonal violence and motor vehicle collisions during adolescence and young adulthood. They determined that in these age ranges, the male to female ratios were the highest, reaching 3 to 4:1. These ratios become smaller, or even inverted, at extreme ages.

Collins et al. (2013) examined 342 children who had experienced a TBI and found that sex differences in TBI were present beginning in infancy and progressed into adolescence. They determined that while falls were the leading cause of TBI in children, boys were less likely than girls to experience a fall resulting in a TBI (51–66 %). Interesting details emerged when the statistics were studied closely. Although boys were less likely than girls to experience a TBI as a result of a fall, boys were more likely to fall from a height: boys were more likely to fall more than 2 m, or 10 steps (29–12 %). Boys were also more likely to be injured on the road (30 % of boys in their sample) or struck by or against an object (17 % of boys in their sample). Boys were less likely to be injured at home compared to girls. Although their study did not show a difference in TBI severity using the GCS, boys were more likely to incur an extradural hematoma and girls were more likely to sustain a subdural hematoma.

There tends to be a reversal in gender rates of TBI in the elderly. In a study of 22,560 adults 65 years of age and older who suffered nonfatal fall-related injuries, 70.5 % were women (Stevens & Sogolow, 2005). Injury rates for the head and neck were highest among both men and women, although the rate for women was 33 % higher than for men. Men's rate of TBI was exceeded by women above the age of 65, and women over 85 years of age had the highest rate. Stevens and Sogolow argued that the cause of this difference was related to the increased physical activity of men compared to women. The muscle weakness and decreased lower body strength associated with less physical activity in women puts them at higher risk of falls, and thus brain injury. Kraus, Peek-Asa, and McArthur (2000) found that men were significantly younger than women in a sample of moderate to severe TBI patients, with only 19.5 % being over the age of 50, compared to 32.9 % of women. They also found that men were more likely to be injured from assaults and bicycle crashes, while women were more likely to suffer injuries from motor vehicle accidents. There was no sex difference in injuries due to falls or from multiple traumas. Women in the sample presented with significantly higher Glasgow Coma Scale scores, despite having lower survival rates.

More and more media attention is being focused on the short- and long-term effects of traumatic brain injuries/concussions in sports and there appear to be sex differences in this area as well. Colvin et al. (2009) found that soccer players ranging in age from 8 to 24 years with a history of concussion performed significantly worse on cognitive tasks following a concussion, and men performed significantly better than females. Similarly, Covassin, Schatz, and Swanik (2007) found that despite no differences in neurocognitive functioning at baseline, following a concussion, females did more poorly on visual memory testing although men were more likely to report vomiting and sadness following concussion. Another study investigated sex differences in a group of males and females who had experienced concussions across nine different sports. Frommer et al. (2011) discovered that males and females reported about the same number of symptoms, although males reported more memory problems and confusion/disorientation while females reported more drowsiness and sensitivity to noise. Both groups reported headaches as the most prevalent symptom.

Sex Differences in Cognitive Deficits Following Traumatic Brain Injuries

In general, cognitive deficits related to TBI depend on a myriad of factors, including the type of head injury, the location of the injury, secondary factors, demographic variables, comorbid medical and psychiatric conditions, as well as other risk and resiliency factors. As such, despite having a good idea of the location of the injury, it can still be difficult to extrapolate neurocognitive deficits and the sequelae of recovery of those deficits. A common deficit observed in patients with a TBI is attention difficulties, which may be due in part to small lacerations throughout the brain; this damage may also result in slowed processing speed. Persisting attention and processing speed deficits can have the net effect of reduced cognitive efficiency, which in turn may present behaviorally as the patient requiring more effort to complete formerly simple tasks, resulting in fatigue and frustration.

Another potential consequence of TBI is language problems (Russell, Arenth, Scanlon, Kessler, & Ricker, 2012; Vu, Babikian, & Asarnow, 2011). However, the presence and extent of language problems largely depends upon the location of the injury, with obviously more expressive and receptive language deficits occurring in dominant hemisphere lesions. Word finding deficits have been shown to be present for all severities of TBI (Hough, 2008; King, Hough, Walker, Rastatter, & Holbert, 2006). Conversely, visual-spatial deficits are likely to be disproportionately present for non-dominant hemisphere injury.

Memory difficulties can be found in all types of TBI and sex differences in memory post-TBI are common, although the direction of these findings is inconsistent. Moore, Ashman, Cantor, Krinick, and Spielman (2010), in analyzing results of the Cambridge Neuropsychological Test Automated Battery (Morris, Evenden, Sahakian, & Robbins, 1986), found that men with mild traumatic brain injuries performed significantly worse than women on tasks of visual memory (Moore et al., 2010). They found no significant differences in visual memory in the moderate to severe TBI group and neither severity group showed significant gender differences in processing speed and executive functioning. On the other hand, in a study by Raskin, Mateer, and Tweeten (1998), in individuals with mild traumatic brain injury, men performed significantly worse than women on verbal learning tasks on the basis of results of the Wechsler Memory Scales—Revised (Wechsler, 1987) and California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987), but not on visual memory tasks. Further, men had significantly lower scores than women on tasks of attention based on the Symbol Digit Modalities Test (Smith, 1982) and Visual Speed and Accuracy Test (Grimsley, Ruch, & Warren, 1971), and on tasks of executive functioning, according to the Wisconsin Card Sorting Test (Grant & Berg, 1948) and Stroop Color Word Interference (Stroop, 1935). Men also showed deficits in reading speed when compared to women participants. Similar results have been found in children. Donders and Hoffman (2002) evaluated 60 children (30 males and 30 females) who had been diagnosed with a TBI using the California Verbal Learning Test—Children's Version (CVLT-C; Delis, Kramer, Kaplan, & Ober, 1994).

Boys performed significantly worse than girls, although the effect size for this difference was modest.

In considering the results of memory assessment in TBI, not only is the stimulus modality of material to be remembered important, but the memory processes themselves need to be considered. For instance, functional magnetic resonance imaging (fMRI) has shown greater activation during encoding tasks for a group of patients with a TBI compared to a control group, who in turn showed greater activation during recognition tasks (Arenth, Russell, Scanlon, Kessler, & Ricker, 2012). Prospective memory, or remembering to perform a certain task at a later time (Mathias & Mansfield, 2005; Pavawalla, Schmitter-Edgecombe, & Smith, 2012), and verbal declarative memory (Mathias & Mansfield, 2005) have also been shown to be impacted in patients with severe TBI.

Executive dysfunction has also been observed in patients with TBI, including deficits in planning (Krishnan et al., 2012) and cognitive flexibility (Zgaljardic & Temple, 2010), which may contribute to observed personality changes in patients with TBI. Poor response inhibition following TBI has been noted, although it may be attributed to slowed processing speed, fatigue, and under-arousal (Marco, McDonald, Kelly, Tate, & Johnstone, 2011). Working memory deficits may also be present (Vallat-Azouvi, Weber, Legrand, & Azouvi, 2007), although even in the absence of such deficits, neuroimaging can still reveal under-activation in working memory circuits (Chen et al., 2012). Executive dysfunction has been shown to result in greater social dysfunction and has been linked to social competence following TBI (Ganesalingam et al., 2011; McDonald, Saad, & James, 2011), which is not surprising given that many appropriate social interactions require inhibition, planning, and cognitive flexibility. Neuropsychologists working with men with TBI should factor in the age of the patient, their level of support, and their available coping resources when attempting to determine how these executive dysfunctions are likely to interfere with decision making, social interactions, driving, and independent completion of activities of daily living.

Studies examining multiple aspects of cognitive functioning have also found sex differences in performance. Ratcliff et al. (2007) found that men performed significantly worse than women on tests of attention, working memory, and language one year after traumatic brain injury. However, men appeared to perform better with visual analytic skills. Ratcliff et al. determined that the gender differences were not due to premorbid differences by analyzing normative data of the Controlled Oral Word Association Test (COWA; Benton & Hamsher, 1978), Symbol Digit Modalities Test (Smith, 1982), and Block Design test on the Wechsler Adult Intelligence Scale—Third Edition (WAIS-III; Wechsler, 1997).

Interestingly, the severity of overall deficits may vary between men and women. Koponen et al. (2002) found that all 8 of 58 patients with a mean post-injury time of 30 years with severe cognitive impairment according to the Mild Deterioration Battery (Portin et al., 2001) were men. Schopp et al. (2001) found that following traumatic brain injury, men, relative to women, experienced greater cognitive impairments on the Wechsler Adult Intelligence Scale—Revised (WAIS-R;

Wechsler, 1981), greater general memory deficits on the Wechsler Memory Scale—Revised (Wechsler, 1987), and greater deficits in cognitive flexibility on the Trail Making Test B (Reitan, 1986). However, an analysis of decline from estimated levels of premorbid functioning revealed a greater decline for women in the areas of overall intelligence and attention, attributed by the authors to a greater rate of depression in women. Conversely, there was a greater decline in cognitive flexibility experienced by men, which was posited to be due to gender differences in the brain's response to injury.

Sex Differences in Emotion and Personality in Patients with Traumatic Brain Injuries

Sex differences are widely found in patients with psychiatric disorders who have not experienced a TBI (e.g., Bos et al., 2005; Robichaud, Dugas, & Conway, 2003). Thus, it is not surprising that the same results are found in patients with a TBI, although findings are inconclusive and more research is needed. Koponen et al. (2002) studied 60 patients an average of 30 years after a traumatic brain injury using *Diagnostic and Statistical Manual of Mental Disorders—Fourth Edition, Text Revision* (DSM-IV-TR; American Psychiatric Association, 2000) criteria for Axis I and II disorders. Participants had a mean age of 60.8 years, with a mean age of 29.4 years at the time of injury. Of the 60 subjects, 41 were male. Koponen et al. found that women had a slight, but insignificantly, higher, percentage of major depression (31.6 %) compared to men (24.4 %) after brain injury. Interestingly, none of the 16 participants with major depression had an onset prior to the injury. Koponen et al. (2005) examined 54 subjects (36 males and 18 males) and found that men were significantly more likely to experience alexithymia following TBI compared to women. They also found alexithymia to be more common in the 54 TBI patients compared to 54 controls. Schopp et al. (2001) found that men experienced less depression than women following TBI based on responses to the Beck Depression Inventory (Beck, Ward, Mendelson, Mock, & Erbaugh, 1961). However, they also found that men's responses on the Brief Symptom Inventory (Derogatis, 1993) revealed greater levels of emotional distress. They argued that these elevated scores may be due to hyper-reactivity to post-TBI symptoms. Further, Schopp et al. surmised that while men and women may experience similar levels of psychological distress, their responses to this distress may be different.

Regardless of whether or not men experience greater/more psychiatric symptoms than women after suffering a TBI, men do seem to have trouble adjusting to limitations following a TBI. Colantonio, Harris, Ratcliff, Chase, and Ellis (2010) evaluated self-reports of men and women 8–24 years post-TBI. Men reported more difficulty setting realistic goals than did women. Further, men reported a higher sex drive and greater levels of restlessness. Men also reported more sensitivity to noise and sleep disturbance impacting daily functioning.

Difficulty in post-TBI adjustment may also be evident in studies examining satisfaction with gender roles after brain injury. Gutman and Napier-Klemic (1995) performed six one-hour sessions with four subjects, two men and two women, ages 33–46, in a residential facility for persons with head injury, to evaluate their gender identity following a TBI. All subjects were at least 10 years post-injury and were employed prior to injury. Gutman and Napier-Klemic found that the men in the study displayed a greater sense of inadequacy than the women. They attributed this inadequacy to an absence of rites of passage, such as marriage, the fathering of children, and careers. The men also reported a reliance on masculine activities such as sports, auto mechanics, pool playing, card games, and military service to support their masculinity before and after injury. The women reported less of a reliance on feminine activities to define their femininity. The men also reported participating in fewer activities following their injury than the women, and fewer than prior to their injury. The study also found that women were more likely to engage in activities with other people than the men, while men reported a greater degree of loneliness. Gutman and Napier-Klemic argued that the reason for the men's greater sense of inadequacy was related to their lack of activities used to define their masculinity following injury.

Hibbard et al. (2000) found that men were significantly more likely to present with antisocial personality disorder and narcissistic personality disorder post-TBI (Hibbard et al., 2000), which they argued could be due to more severe TBI in men in the sample, resulting in less awareness of the extent of deficits. There was no gender difference in the prevalence of other personality disorders. On the whole, these findings suggest that there are important sex differences in adjustment following TBI, differences with important implications for neuropsychologists working in treatment and accommodation planning for men with TBI.

However, other research has minimized sex differences in acquired disability following TBI. Jocobsson, Westerberg, Malec, and Lexell (2011) looked at 66 TBI patients 6–15 years post injury. Using the Mayo-Portland Adaptability Inventory—4th version (MPAI-4; Malec et al., 2003), a measure of disability following acquired brain injury, with measures of sensory, motor, and cognitive abilities (Ability Index); mood and emotional factors (Adjustment Index); and social, management, and financial skills (Participation Index); no gender differences were found on any of the MPAI-4 indexes. Further, they found no differences in responses to the Sense of Coherence Scale (Antonovsky, 1987), a measures of the *sense of coherence* concept associated with the preservation of good health despite outside difficulties. Finally, Jocobsson et al. (2011) did not find gender differences on ratings of life satisfaction post-injury on the Satisfaction with Life Scale (Diener, Emmons, Larsen, & Granger, 1985).

Outcome Following TBI in Males

Although the findings are somewhat mixed, the sex differences discussed so far in this chapter would appear likely to result in different outcomes for men, and that does appear to be the case in much of the research, although contradictory findings are present. For example, Kraus et al. (2000) studied 795 inpatients with moderate to severe brain trauma, of whom 82 % were male. Data were collected at less than one hour post-event, one to six hours post-event, more than six hours post-event, and post-discharge. Men exhibited a greater survival rate at all points, although at no point were the differences significant. Men were 1.75 times less likely to die from their injuries than women. The difference in death rate was most pronounced after the six-hour period. Following discharge, women were 1.57 times more likely to have a poor outcome than males, although this difference was not statistically significant. Women were more likely to have severe cognitive disabilities, while men were more likely to be in a persistent vegetative state. Increased age also increased the likelihood of poor outcome in both genders, as did lower initial GCS scores and presence of penetrating head injury. On the other hand, Leitgeb et al. (2011) investigated 134 female and 305 male patients who had sustained a TBI and did not find significant sex differences in mortality (hospital mortality was 39.6 % for females and 32.5 % for males). Similarly, Renner et al. (2011) investigated 427 patients with a TBI and determined that there was not a sex difference in injury severity as assessed via the Glasgow Outcome Scale (GOS; Jennett & Bond, 1975), employment status, living situation or anterior pituitary functioning. Regardless, biological sex differences likely play a role in TBI outcome and this seems to be an area ripe for further exploration. For example, one report found that men and women with severe TBI had different levels of cerebral oxygenation following Red Blood Cell Transfusion. Women had a greater increase following this treatment, which may in turn increase cerebral oxygenation in anemic TBI patients (Arellano-Orden et al., 2011). This is an important finding given hypo-oxygenation is associated with mortality following a TBI. Other biological factors requiring consideration include neuroendocrine changes, since changes in sex hormones have been shown to be present in patients with a TBI. For instance, Vagnerova, Koerner, and Hurn (2008) suggest that male patients with a TBI could benefit from restoration of testosterone and progesterone treatment.

Some of the research suggests that men do have better outcomes than women after sustaining a TBI. Bazarian et al. (2010) evaluated a large group of patients who had sustained a mild TBI (643 females and 782 males) with a mean age of 30.0 (standard deviation was 19.5 years) and found that 3 months following the TBI, males had a significantly lower chance of being placed in a high post concussion symptom score category, although there was not a significant sex difference for the number of days of work missed or the number of days it took to return to normal activity levels. Similarly, a meta-analysis conducted on eight studies involving 20 variables revealed somewhat similar findings, with men doing better than women on 85 % of the measured outcome variables in all types of TBI (Farace & Alves, 2008); the authors of this meta-analysis note that these findings are divergent from the clinical opinion that men tend to do worse after TBI. The outcome variables on which women performed better included death, days of PTA, length of hospitalization, impaired memory, dizziness, fatigue, irritability to noise and light, impaired concentration, insomnia, double vision, headache, anxiety and depression. Farace and Alves also noted they were only able to include a small number of studies in their meta-analysis due to the dearth of outcome data classified by sex in the literature.

Other studies have yielded a divergent pattern of sex differences. Slewa-Younan et al. (2008) examined 45 men and 25 women at the time of injury, 7 days after injury, and 3 months after injury. When adjusted for initial injury severity and age at injury, women had better outcomes post-injury based on Glasgow Outcome Scale scores. Additionally, women also had significantly shorter Intensive Care Unit lengths of stay than men. Functional outcome also was worse for men in a study by Groswasser, Cohen, and Keren (1998). They examined the ability of patients with a TBI to return to school or place of employment following discharge and noted that predicted functional outcome was significantly better in women. Similarly, Ratcliff et al. (2007) looked at 325 patients (225 males and 100 females) in the TBI Model Systems of Care National Database, ages 16–45, with neuropsychological follow-up data one year post-injury. They found that patients with shorter hospital stays performed better in attention and working memory, verbal memory, language, visual analytic skills, problem-solving, and motor functioning, and that women had significantly shorter hospital stays following TBI than men. McMordie, Barker, and Paolo (1990) examined 177 patients (138 males and 39 females) with acquired neurological insults who returned to work following injury, including 134 with closed head injuries, 15 post-stroke, 11 with open head injuries, 10 with a tumor, and four who had a brain infection. They sent questionnaires to patients or their families asking about demographic information, patient characteristics, familial reactions, and professional service. Men fared worse in returning to work following their injury than women. While McMordie et al. noted that this might have been due to men sustaining more severe head injuries than women (i.e., the length of hospital stay for men averaged 5.3 months, compared to 3.8 months for women), they also suggested that it might simply reflect less cognitive impairment experienced by females.

Conclusions

Sex differences in a number of salient factors related to TBI warrant consideration when working with men who have incurred a TBI. These differences include prevalence and cause of TBI, outcome, as well as cognitive, biological, and personality concerns following the TBI. Research on many of these factors should be considered ongoing as data has tended to yield mixed results. This is especially true in the area of ethnicity. It is critical for clinical neuropsychologists to consider these issues when working with men with TBI, because the determination of sequelae and prognosis is already impacted by so many risk and resiliency factors. Thus, narrowing these factors by sex variables is likely to facilitate improved treatment planning. Serving returning veterans has also significantly increased the need for comprehensive services. It is also important for the patient's treatment team to consider psychiatric issues as these have the potential to exacerbate TBI symptoms. The most cost-effective approach to intervention is to prevent a problem from occurring. As such, those who are in the position to take a preventative approach when working with men should also consider the issues discussed in this chapter. For example, it is important to remember that one TBI makes a second TBI more likely and thus, therapists, physicians, school psychologists, educators, and clinical neuropsychologists should consider the risk factors when working with patients with a history of TBI.

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Men at Risk: Special Education and Incarceration

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Introduction

The estimated percentage of individuals who are incarcerated with Traumatic Brain Injury (TBI) ranges from 25 to 87 % depending on whether one is considering a county jail, or a state or federal prison (Morrell, Merbitz, Jain, & Jain, 1998; Schofield et al., 2006; Slaughter, Fann, & Ehde, 2003). Many individuals are incarcerated with either an identified or unidentified TBI, while others sustain some type of head injury while incarcerated. In addition, many incarcerated individuals have a history of receiving special education services, with a small percentage falling within the TBI classification category. This chapter will discuss the percentage of incarcerated individuals who received special education services, the types of crimes often associated with incarcerated individuals with developmental and psychological disabilities, and prevalence of TBI among incarcerated individuals. The discussion related to TBI will focus on outlining the difficulties in accurately estimating the percentage of individuals with TBI and the difficulties in identifying TBI among incarcerated individuals. Finally, the need for screening, assessment, and treatment of individuals with TBI within the correctional system is reviewed.

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Special Education Statistics in the United States

In the United States, during the 2010–2011 school year, 13 % of all students enrolled in public schools between the ages of 3 and 21 received special education services (U.S. Department of Education, National Center for Educational Statistics, 2013). When looking at the special education population by disability category, 36.7 % have a specific learning disability, 21.7 % have a speech or language impairment, 7 % are categorized as having an intellectual disability, 11.1 % have an other health impairment, and 6.1 % are afflicted with an emotional disturbance (National Center for Educational Statistics, 2013). Of students exiting their enrollment in special education, only 62.7 % graduated with a high school diploma while 20.9 % dropped out of the special education program (Office of Special Education Programs, 2011). Statistics indicate the majority (about 70 %) of students served by special education programs are male (U.S. Department of Education, 2011).

Disability Characteristics Among the Juvenile Justice Population

It is generally known when examining the juvenile justice population that there is an over-representation of youth with disabilities. According to Burrell and Warboys (2000), one out of every three juveniles who enter a correctional facility receive special education services. However, once in a correctional facility, only 80 % of those identified as having a disability receive the appropriate services. The distribution of youth across disability categories in correctional facilities differs significantly compared to the general population. Specific learning disabilities are still the most prevalent, making up 45 % of the special education population in correctional facilities. As stated previously, 6.7 of the general special education population is composed of individuals with emotional disturbances. This is in strong contrast to the 42 % of the incarcerated juvenile population identified as having an emotional disturbance. Seven percent of cognitively disabled youth in juvenile facilities have intellectual disabilities, three percent have a speech or language impairment, and three percent have other disabilities. All of these disabilities can have implications in matters such as the services students receive, whether detention is appropriate, waiver into adult court, and youths' ability to understand court proceedings and Miranda Rights.

Disability Characteristics Among Incarcerated Adults

A high rate of learning disabilities also have been identified in adult male prisons, which is not surprising when taking into account the fact the majority of learning disabilities are identified in males and there is an over-representation of cognitive disabilities among individuals in prisons. A study conducted in the United Kingdom, examining cognitive disabilities in the largest Western European prison, found 45.3 % of the prisoners had communication problems that could limit their understanding of courtroom procedures, making it extremely difficult to comprehend (Hayes, Shackell, Mottram, & Lancaster, 2007). Additionally, they discovered the mean for adaptive behavior and intellectual functioning as measured on the Vineland Adaptive Behavior Scales Interview Edition (Balla, Cichetti, & Sparrow, 1984) and the Wechsler Adult Intelligence Scale—III, UK Version (Wechsler, 1999), respectively, fell below that of the general population. Simpson and Hogg (2001) found individuals with cognitive disabilities are more likely to commit a criminal offense when they fall within the borderline classification and when there is a history of offending and/or behavioral problems.

Psychiatric disorders are also widespread in the prison population. A systematic review of 62 surveys from 12 countries revealed 3.7 % of incarcerated males have a psychotic illness, 10 % suffer from major depression, and 65 % have a personality disorder with antisocial personality disorder being the most predominant (Fazel & Danesh, 2002). Fazel and Danesh (2002) also noted that prisoners are several times more likely to suffer from depression and psychosis than the general population, as well as 10 times more likely to have antisocial personality disorder.

Types of Crimes Committed by Incarcerated Individuals with Disabilities

Research studying the types of crimes committed by individuals with disabilities has been published with varying results (Hassan & Gordon, 2003; Simpson & Hogg, 2001). Specifically, Simpson and Hogg (2001) did a systematic review looking for patterns of offending among individuals with intellectual disabilities. Four important points were discovered. First, the authors determined that there is no convincing evidence that the prevalence of offending is higher among individuals with a cognitive disability. They did, however, find evidence that suggests the relative prevalence of sexual offending, criminal damage, and burglary are higher among people with borderline intelligence when compared to the general population. However, more serious offenses, such as murder and armed robbery, seem to be underrepresented in this population. Lastly, they discerned that criminal offending is rare among people with an IQ below 50.

Hassan and Gordon (2003) conducted a literature review to determine whether there was an association between crime and developmental disabilities. They determined that the results were inconclusive, with some researchers stating offenders with developmental disabilities commit property offenses more often than crimes against a person, while other researchers found the opposite pattern. The literature review did determine that individuals with developmental disabilities are overrepresented in the prison system. Hassan and Gordon (2003) attributed this discrepancy to the differential treatment developmentally disabled offenders receive.

A more recent study investigating offenders with intellectual disabilities determined that this group was more likely to be delinquent at an earlier age compared to individuals without disabilities (Barron, Hassiotis, & Banes, 2004). Furthermore, they found violent offences and petty crimes to be the most frequent transgressions, although arson and sex crimes were also common. There also appears to be a higher likelihood for individuals who have received special education services to be repeat offenders (Barrett, Katsiyannis, & Zhang, 2010).

Association Between TBI and Crime

Criminal-like behaviors, such as aggression, violence, and deficits in emotional regulation, can occur as the result of sustaining a TBI (Baguley, Cooper, & Felmingham, 2006; Brower & Price, 2001). A longitudinal study conducted by Brooks, Campsie, Symington, Beattie, and McKinlay (1986) discovered that one-year post severe TBI, 7 % of their sample had become involved with the legal system. Furthermore, this legal involvement significantly increased by 5 years post-TBI, with 31 % reporting legal involvement. Although no causal relationship has been established, taken together, evidence of the increase in criminal-like behavior post-TBI, longitudinal evidence of legal involvement after TBI, and the high prevalence of TBI in the prison population compared to the general population, implies that individuals who have sustained a TBI have a greater likelihood of committing a crime. Additionally, not only are individuals with TBI more likely to commit crimes, but once in prison they have a higher rate of behavioral infractions (Shiroma, Pickelsimer et al., 2010). A longitudinal study discovered incarcerated men with TBI have a higher rate of all behavioral infractions compared to their non-TBI counterparts, whereas incarcerated women with TBI have a higher rate of violent behavioral infractions (Shiroma, Pickelsimer et al., 2010).

Overview of Traumatic Brain Injury

TBI is a result of or caused by influences that alter the structure or function of the brain that had been developing normally up to the onset of injury. Given that severe disabilities may develop later in life due to head trauma caused by automobile, bicycle, and boating accidents, falls, child abuse or assaults, it should be noted that a wide variety of conditions may exist that are classified by the type of injury (open vs. closed), by the degree of damage suffered to the brain, and by the location of the injury.

When an individual acquires an open head injury it may be due to the penetration of the skull due to bullet wounds, or forceful blows to the head with a hard or sharp object causing blunt force. Typically, open head injuries that are not considered fatal often result in the loss of behavioral or sensory functions that are controlled by a specific part of the brain. One example may be an insult to the Frontal lobe, which controls one's emotions, reasoning, or problem solving abilities. Another area that could be affected is the Temporal lobe, which is responsible for hearing, speech, memory acquisition, or simply the categorization of objects.

It should be noted the most common type of head injury does not involve blunt force or trauma to the skull. A closed head injury occurs when the skull hits or is hit by an object with such force that the brain crashes against the inside of the cranium. The rapid movement and impact caused by the blunt force typically tears nerve fibers, or axons. Most major causes are due to automobile accidents, loss of balance while riding a bicycle, and accidents associated with playing contact sports. For incarcerated individuals, a large percentage of reported head injuries are gang-related, and some incidences of TBI are self-inflicted by the individual hitting his head against the door or wall of a prison cell.

The effects of TBI, though not always visible, more often or not appear minor or inconsequential, which can make a determination quite complex. Typically, mild brain injury will result in a concussion associated with a brief or momentary loss of consciousness anywhere from seconds to 30 min or more. It should be noted that repeated mild TBIs over a period of months or years can result in cumulative neurological and cognitive deficits. More severe causes of head trauma almost always result in a coma that may last for days, weeks, or even longer.

Effects and impairments caused by TBI fall into three major categories. One is physical/sensory concerns associated with vision and hearing impairments, seizures, and reduced motor performance. Cognitive impairments may be associated with short/long-term memory deficits affiliated with concentrating or simply the inability to plan, disorganization, and pacing while completing a task. The third area of concern is associated with social, behavioral, and emotional domains. Effects may include chronic agitation, irritability, or anxiety. Typical recovery is not only a long process, but unpredictable at best due to how side effects manifest themselves in daily living, work or social interactions.

TBI defined. The terms concussion and mild traumatic brain injury (mTBI) are often times used interchangeably to refer to one of the most common neurological conditions encountered in children (Karr, Areshenkoff, & Garcia-Barrera, 2014). There are many different definitions of mTBI, but it is generally agreed upon that mTBI occurs when an external force causes *an alteration in brain function, or other evidence of brain pathology* (p. 1637) (Menon, Schwab, Wright, & Maas, 2010). In their report to Congress, the Nation Center for Injury Prevention and Control (2003) recommended the use of the following conceptual definition of mild traumatic brain injury: *mTBI is an injury to the head as a result of blunt trauma or acceleration or deceleration forces that result in one or more of the following conditions: 1a) transient confusion, disorientation, or impaired consciousness; 1b) dysfunction of memory around the time of injury; or 1c) loss of consciousness lasting less than 30 minutes; or 2) observed signs of neurological or neuropsychological dysfunction* (National Center for Injury Prevention and Control, 2003).

However, for a student to qualify for services under IDEA the following definition of impairment must be satisfied. *Traumatic brain injury means an acquired injury to the brain caused by an external physical force, resulting in total or partial functional disability or psychosocial impairment, or both, that adversely affects a child's educational performance. Traumatic brain injury applies to open or closed head injuries resulting in impairments in one or more areas, such as cognition; language; memory; attention; reasoning; abstract thinking; judgment; problem-solving; sensory, perceptual, and motor abilities; psychosocial behavior; physical functions; information processing; and speech. Traumatic brain injury does not apply to brain injuries that are congenital or degenerative, or to brain injuries induced by birth trauma* (Assistance to State for the Education of Children with Disabilities, 2004). What these two definitions have in common is they both are referring to an acquired condition, not a condition present since birth. Additionally, they both require the brain injury to stem from an external force that leads to impairment. The main difference between the two definitions is the educational definition of TBI requires the neurocognitive dysfunction resulting from the injury to have a direct impact on the person’s academic performance.

Due to the federal handicapping code for TBI, which requires interventions based upon best practices, students must now not only have access to services, but they must make educational progress as well, as outlined in the reauthorization of IDEA, which has ultimately increased the educational assistance to this population of students. Students with special needs can qualify for special education services by having proper documentation of their injuries and establishing a relationship between the nature of their TBI and their areas of academic concern.

Teachers responsible for designing effective Individualized Education Plans (IEP), which contain appropriate goals, modifications, and accommodations, will need to educate themselves as to the common physical, cognitive, and social-emotional side effects associated with a diagnosis of TBI (Morrison, 2010). The same is true for prison staff members responsible for accurately identifying inmates with a history of TBI.

Many children with mild to moderate head injuries experience multiple cognitive impairments, including memory problems, lack of concentration and attention to detail, irritability and anxiety. More specific higher-order executive functions manifest as the inability to organize, plan, problem-solve or make sound judgments—skills that are critical for academic and occupational success. Individuals with TBI may appear distracted, become confused easily, and have difficulty concentrating and attending to detail. Schutz and McNamara (2011) reported *most school professionals are operating under a number of important misconceptions about TBI, for example, the myth of complete recovery from a brain injury* (p. 65). Hence, as early as 1995, pediatric neuro-rehabilitation specialists have encouraged educators to develop fully functional TBI intervention programs for students who were formerly served in the healthcare system (Blosser & DePompei, 2003; Walker, 1997).

Traumatic Brain Injury Among Youth and Adults

The incidence of TBI is reported in nearly one-in-five youths (18.3 %) (Perron & Howard, 2008). According to Faul, Xu, Wald, and Coronado (2010), each year an estimated 1.7 million individuals sustain a traumatic brain injury. Specifically, children between the ages of zero and four, older adolescents aged 15–19, and adults aged 65 and older are most likely to sustain a TBI. Regardless of age group, males have a higher rate of TBI than do females, with males aged zero to four having the highest rates of TBI-related emergency room visits, hospitalizations, and deaths. According to the Centers for Disease Control and Prevention (2012), at least 5.3 million Americans are living with TBI-related disabilities. The National Center for Education Statistics (2013) indicated over 23,000 students were classified as having a TBI using the TBI handicapping code. This means during the 2010–2011 school year 0.1 % of students receiving a public education qualified for services due to TBI. Although there is a difference between the total number of students coded as TBI compared to the US child/adolescent population with a TBI (e.g., it is estimated that over 1.5 million children between the ages of 5–19 have an TBI), many do not receive necessary services due to a number of variables, including being unable to return to the public school setting, not informing school districts of their specific needs due to TBI insult, or simply not meeting the criteria as outlined by IDEA (Coelho, Youse, & Le, 2002).

Young adults who have experienced TBI often lack adequate or appropriate support systems, which increases their risk of social and academic failure. They also may face barriers in becoming independent and productive citizens in society. Often, youth who experience TBI are inappropriately classified due to misdiagnosis resulting in a different placement category (e.g., learning disability, other health impaired, emotional disability). Some individuals feel so frustrated and alienated they simply drop out of school and/or become involved with other social agencies.

Adult and youth service agencies provide services for those with serious communicative, intellectual or emotional disturbance. These inter-agency collaborations typically include special education, juvenile justice, and child welfare. Generally, males receive services at an earlier age and have more frequent contact with the juvenile justice system than do females. This may explain why males with TBI were disproportionately represented among the study population reported by Perron and Howard (2008). Unfortunately, incarcerated school-age youth with TBI typically fare worse than their counterparts in the public school system. Incarcerated youth today who have experienced TBI often present an insurmountable challenge to school psychologists and school-based special education practitioners. This complicates the management and treatment of inmates to such an extent that the Centers for Disease Control and Prevention (Faul et al., 2010) has recognized TBI as an important public health problem with many long-term ramifications, especially among school-age and young adult populations.

Traumatic Brain Injury Among Incarcerated Individuals

Obtaining an accurate estimate of mild traumatic brain injury (mTBI) prevalence rate among incarcerated individuals is difficult (National Center for Injury Prevention and Control, 2003). The NCIPC determined that there is a lack of standardized definitions and that no health data systems exist for special populations related to mTBI. However, a few studies have provided estimates of TBI among general prison populations (Morrell et al., 1998; Schofield et al., 2006; Slaughter et al., 2003). Depending on whether one is referring to a county jail, or a state or federal prison, the incidence of TBI in the prison population ranges from 25 to 87 %, compared to an incidence of 8.5 % for the general population (Morrell et al., 1998; Schofield et al., 2006; Slaughter et al., 2003). An ever-growing population of inmates diagnosed with TBI is challenging service providers who are searching for effective treatment and management of their conditions. Various jail and prison studies reported a higher percentage of inmates having experienced TBI than their non-incarcerated counterparts (Farrer & Hedges, 2011; Shiroma, Ferguson, & Pickelsimer, 2010; Slaughter et al., 2003).

TBI Screening and Assessment Procedures Within the Correctional System

When considering specific barriers for both training staff and the screening of individuals with TBI in the prison system, initial concerns abound pertaining to initial screening procedures, assessment practices, and the lack of personal knowledge on the part of the inmate pertaining to what TBI entails. Screening for traumatic brain injuries should be an ongoing process, starting at intake, in the prison system, due to the impact that brain dysfunction can have on prisoners' behavior and psychological wellbeing. The Department of Corrections (2013) views screening for TBI as an essential element of the prison intake process because it allows for the identification of offenders who may need accommodations in order to understand rules and communications from officers, in addition to making sure these prisoners stay safe and have appropriate housing. It also is important to note that intervention for inmates with a TBI often starts with screening, assessment, and identification. Without an accurate screening for TBI and assessment of the neurocognitive effects resulting from the TBI, it is difficult to determine a treatment plan.

Currently, there is not a universal protocol used to identify a history of TBI and the associated neurocognitive effects by prison staff. Systematic review of the literature on TBI in prisons revealed that screening procedures generally include in-depth interviews, medical record review, and short questionnaires (Shiroma, Ferguson et al., 2010). Furthermore, according to the National Center for Injury Prevention and Control (2003), retrospective self or third party interview is considered best practice for the identification of the history of TBI. However, caution should be noted that the individuals themselves may have an inadequate awareness or understanding of the nature of their symptoms as observed by other people due to their cognitive deficits resulting from the TBI. This is further supported by Bogner and Corrigan (2009) who stated the problem with self-report is it requires the individual to *self-diagnose* their head injury and in order to do this they must have a working knowledge of terms such as *head injury*, *loss of consciousness*, etc. Under reporting of TBI by prisoners may be due to a minimum amount of knowledge about what a head injury entails.

Not only is it a concern that the inmates themselves have a lack of knowledge about brain trauma, but often times correctional staff are unware or possess a lack of training for the identification and intervention when working with this unique population of prisoners. Without a working knowledge of TBI and the neurocognitive deficits associated with brain trauma, critical questions can go without being asked or answers may not be evaluated at the critical level of importance. This is why having knowledgeable, well-trained staff is necessary in order to accurately use structured interviews that probe for relevant medical history and personal experiences followed by an examination of medical records.

In recent years, research has been conducted on specific structured interviews in an attempt to develop a measure that identifies a history of TBI at a reliable and valid level. One such tool is the Ohio State University (OSU) TBI Identification Method (Bogner & Corrigan, 2009). The OSU TBI Identification Method is a structured interview that attempts to elicit whether a person has a history of brain trauma, its severity, and associated symptoms. This particular structured interview starts out very broad asking about all past injuries that required or should have required medical attention and gets more specific by then focusing on head traumas, and eventually, on the specific deficits caused by those head traumas. According to Bogner and Corrigan (2009), the structure of this interview allowed them to identify *number of injuries, injury severity, effects (symptoms and functional limitations, both initially and persisting), age at injury, and time since most recent injur*y (p. 282) at a reliable and valid level within a prison sample. However, they did discover that the OSU TBI Identification Method was capable of identifying severe traumas at a more reliable level than frequent mild traumas.

Ideally, a structured interview, like the one described above, should be conducted at prison intake and if it is found the inmate has a significant history of TBI, they should be referred for further evaluation by a psychologist or neuropsychologist. The psychologist or neuropsychologist would then perform a more in-depth evaluation examining the inmate's cognitive abilities, executive functions, psychological wellbeing, and substance abuse. A comprehensive evaluation allows for the identification of deficit areas related to the TBI in which the prisoner may need accommodations or treatment (such as in the case of substance abuse or psychological disorders). Although screening can be accomplished with several instruments in a short period of time, the necessary follow-up neuropsychological assessments needed to identify specific neurocognitive deficits can be time consuming and costly.

When an inmate sustains a new head injury it is necessary to assess loss of consciousness (LOC) and post-traumatic amnesia (PTA) as a means of assessing the severity of the injury. LOC and PTA can be monitored through the use of the

Glasgow Coma Scale (GCS). The GCS systematically measures a person's level of awareness by examining eye openness, verbal responses, and motor responses. Although this monitoring is normally done by a medical professional, it is important for prison staff to know what to look for when an inmate sustains a head injury, so that they can provide accurate information about the length of unconsciousness to the medical professional. Accurate estimates of LOC and PTA can lead to more accurate identification of TBI severity and the necessary post-trauma care.

Neuropsychological assessments now include a variety of tests of abilities and functions in the domains of cognitive/intellectual, language, visual-perceptual, academic, motor, sensory, and emotional/behavioral. These measures are typically administered by a psychologist. Commonly used tests are the Wechsler Intelligence Scale for Children—IV (Wechsler, 2003) and Wechsler Adult Intelligence Scale—IV (Wechsler, 2008). Assessments of adaptive functioning can be done with the Vineland Adaptive Behavior Scales, Second Edition (Sparrow & Cicchetti, 2005). The Bender Visual-motor Gestalt Test—Second Edition (Brannigan & Decker, 2003) and Benton Visual Retention Test—Fifth Edition (Sivan, 1991) can be used for detecting brain damage. Lobe functions are typically evaluated using neuropsychological test batteries like the Luria-Nebraska Neuropsychological Battery (Golden, Purisch, & Hammeke, 1985). It also is not uncommon for speech and language pathologist to perform assessments for communication and language disorders stemming from the TBI.

Based upon the assessment results, a correlation is then drawn between a profile of strengths and weaknesses and known brain functions. Specific deficits in language/verbal learning, reading, written language, verbal reasoning, verbal memory, arithmetic computation, and processing speed have been associated with left hemisphere dysfunction. Deficiencies in spatial function, nonverbal reasoning, nonverbal cues, social skills, and social/emotional information have been associated with right hemisphere dysfunction. Difficulties in psychosocial adjustment appear to be the major social-emotional manifestations of individuals with TBI. Children and adults with open or closed head injuries experience fewer acceptances, lower popularity, more peer rejection, and increased neglect by peers than do normally achieving children or low-achieving peers. It is not unusual for social skill deficits that begin in childhood to persist into adulthood.

In addition to traditional neuropsychological evaluations focused on neurocognitive deficits, more attention should be placed on evaluation for violent and aggressive tendencies (Farrer & Hedges, 2011). Knowledge that these long-term disabilities are related to TBI as opposed to other etiologies like emotional behavioral disorders would also assist case management team members in devising more effective rehabilitation interventions to ensure successful re-entry into the community. Federal grant money has been awarded to selected partnerships to promote collaboration among state agencies and departments of corrections. These demonstration projects were specifically designed to screen offenders for TBI. For example, in 2006 Minnesota received the State TBI Implementation Partnership Grant to fund a three-year study, *TBI in MN Correctional Facilities: Strategies for Successful Return to Community*, aimed at improving ways TBI is identified in correctional facilities with the goal of increasing facility and community safety (Wald, Helgeson, & Langlois, 2008). The study contains three phases, with phase one consisting of screening prisoners in MN for TBI. The second phase targeted identifying best practices in regard to interventions that can be utilized with this unique population. The final phase focused on implementing the TBI identification and intervention strategies in an effort to evaluate sustainability of the program.

Treatment of TBI Within the Correctional System

Several different groups of professionals, namely neuropsychologists, speech and language pathologists, and occupational therapists, find it difficult to treat TBI and related problems, especially within the prison population. Treatment outcomes and recovery are often measured by the progress that is not only gained, but also maintained over a long period of time. It is not unusual for inmates to make sustained initial progress only to see them regress to lower levels of performance. Commonly, these individuals will reach a plateau in their recovery process where no improvement is noted over long periods of time. It is important to note plateaus are not to be thought of as permanent or the end of functional improvement.

When making a differential diagnosis and prior to developing a treatment plan, background information and assessment results should be considered when generating diagnostic impressions. Specifically, it is critical that all the facts and assessment results be assembled and reviewed when formulating a diagnosis and when considering comorbid conditions. It is important to take into account the individual's areas of strengths and weaknesses. The strengths have to be capitalized on and the weaknesses have to be supported. An individualized treatment plan is developed. Treatment should be multimodal and judiciously utilize medical intervention, psychopharmacological treatment, behavioral management, physiotherapy, psychotherapy, counseling, remedial teaching or vocational training, The treatment team would ideally be comprised of: developmental specialists, neuropsychologist, psychologist, remedial teachers, physiotherapist, occupational therapist, speech and language therapist, social workers, nurse counsel or therapists. Other professionals may need to be consulted depending on the nature of the insult to the brain.

Regardless if the individual is a student or an inmate they both require a comprehensive program that supports the academic, psychological, and social needs of the individual so they may benefit from their academic or incarceration setting. It is not uncommon that specific IEP goals or personal/social goals of an inmate may require that services are monitored over a period of 30 days to determine if services need to be modified, redesigned, or adjusted. Simple considerations may include: providing simplified instructions, maximizing perceptual modality teaching and/or training instruction or behavioral management and counseling to address personal judgment, aggression or impulsiveness. Typical approaches used in the education and training of individuals with TBI typically focus on determining what are the specific skills that should be taught that will benefit the student/inmate in the long term with the goals of maintaining independent and positive social skills development.

Treating inmates with TBI is a challenging task because of the functional impairments often displayed by these individuals. Typical TBI consequences may entail memory and attention deficits that appear most commonly and are easier to detect. Unfortunately, when prescribing treatment plans for inmates, due to their difficulty and inability to focus on and respond to required tasks or directives, they often appear to be noncompliant. Specifically, memory deficits manifest themselves in ways in which the inmate has difficulty in understanding or comprehending rules and directives given to them. Couple this with irritability and anger, inmates are often noted for having incidences with other inmates and correctional officers. In incarcerated settings, it is not unusual for correctional officers to shout out verbal commands for compliance or safety concerns. When an individual with TBI possesses slow verbal and/or physical responses they may appear to be uncooperative, disruptive, or even defiant. These outward behaviors present the inmate with challenges in maintaining control over their anger and attention deficits. This may be due to the individual's impulsive behavior, which directly stems from the TBI.

Transition Back into the Community

Enhanced screening procedures (e.g., intake interviews) lead to better diagnosis and subsequent treatment practices, ultimately increasing the likelihood for successful reintegration of inmates into community, work, and/or educational settings. Transition specialists affiliated with the prison system could develop more comprehensive behavior and treatment plans specifically designed to reduce recidivism upon community re-entry.

Poorly coordinated transition back into the community commonly leads to further failure. Recidivism rates are higher when needs have not been met for individuals with TBI exiting the correctional system. Transition and community re-entry services are often times the most neglected components of the correctional education system (Baltodano, Mathur, & Rutherford, 2005). Having deficits associated with TBI can make exiting the juvenile justice system or adult prison system and reintegrating into the community more challenging. For any juvenile or young adult, and especially those with TBI, returning to home and school is an important goal intended to enhance the person's quality of life, but the means or purposes may not be the same for the younger or older individual with TBI. For the school-aged individual, exiting the system may represent positive opportunities to acquire a driver's license, earn money through a job, learn appropriate social skills, and acquire strategies for becoming independent. These positive changes may enhance family and peer relationships of young adults. Variables that can boost transition success include: preplanning, the perception of an internal locus of control, engagement in school and/or work, positive peer influences, and adult mentoring and support.

Summary

Children and adolescents who have experienced a TBI are more likely to struggle within the educational system and are more likely to become involved with the legal system. Research has shown adults who have experienced a TBI are significantly more likely to commit crimes. The percentage of incarcerated men who have sustained a TBI is significantly higher than the general population; however, obtaining an accurate estimate is difficult due to the current screening and assessment procedures. Not only is accurate identification difficult due to assessment, but also because of a lack of trained support staff, inconsistent treatment modalities, and the differential use of terminology relating to brain damage. There are many obstacles that make this population difficult to diagnose and treat. Within the prison system, individuals with TBI are more likely to display behavioral infractions. This indicates a need for universal training and screening to assist correctional facilities in identifying incarcerated individuals with TBI and the accommodations they may need to be successful in prison life. These screenings need to be conducted at the point of initial incarceration and periodically while individuals are in prison. Follow-up assessments need to be conducted in order to identify the specific deficits that may contribute to the inmate being unsuccessful in rehabilitation and transition back to the community.

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The Neuropsychological Basis of Emotion and Social Cognition in Men

Charles M. Zaroff and Lisbeth Ku

Emotion and Its Relation to Psychopathology in Men

Behavioral Findings

The expression of emotion is limited in intensity and scope in boys and men relative to girls and women (Buck, 1977). Boys, but not girls, follow a developmental trajectory in which they increasingly inhibit facial expressions of emotion with age (Buck, 1977). In adulthood, men experience their emotions as less intense than women, particularly negative emotions, regardless of whether their emotional experience is measured via standardized self-report, behavioral observation, or physiological measurement (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Schulte-Ruther, Markowitsch, Shah, Fink, & Piefke, 2008; Vrana & Rollock, 2002). They also require more intense stimuli to produce an emotional response, relative to women (Li et al., 2008). Men's reactions to the emotional states experienced by another, i.e., empathy, may also be less intense than that experienced by women, although the methodology utilized may affect results. Empathy can be divided into two constructs, cognitive (Piaget, 1932) and affective empathy (Eisenberg & Miller, 1987). Cognitive empathy refers to the ability to understand the intentions and desires of another. Affective empathy refers to a more emotional and experiential level of empathy in which one literally feels the emotions experienced by another. While boys are not as strong as girls in either of these two skills, the gap is wider for

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affective empathy (Mestre, Samper, Frias, & Tur, 2009). On the other hand, recent findings indicate that while men rate themselves as less empathic than women (i.e., a *subjective* measurement), they may actually possess similar levels of empathy as defined by emotion recognition, perspective taking, and affective responsiveness (i.e., *objective* measurements; Derntl et al., 2010). Such results reveal the difficulties in measuring empathy. Self-reports are subject to social desirability, and gender differences are smaller for indices that are less self-evident regarding the skill being measured (Eisenberg & Lemaon, 1983).

Nonetheless, this relative lack of emotional experience and expression in men compared to women may be associated with sexually dimorphic patterns of psychopathology. If men tend to experience emotions less intensely, it should not be surprising that they are less susceptible to specific forms of psychopathology, such as depression (Marcus et al., 2005). This relative constriction in emotional intensity might also help to explain why, in comparison with women with depression, men with depression experience less symptom recurrence, milder comorbid affective and neurocognitive symptoms, and less perceptual biases towards negative stimuli (Barry, Allore, Guo, Bruce, & Gill, 2008; Bos et al., 2005; Marcus et al., 2005; Sarosi, 2011). This hypothesis is corroborated by hormonal data showing that in depressed samples, men do not respond as strongly as women to stimuli that are only moderately negative, as reflected by a less intense stress-related cortisol response, and by less difference in cortisol levels in recurrent versus non-recurrent depression (Bos et al., 2005; Peeters, Nicholson, & Berkhof, 2003). A similar hypothesis might be applied to bipolar disorder. While bipolar disorder is thought to have a more obvious genetic/physiological etiology than unipolar depression, it is nonetheless theorized that psychosocial stressors may trigger the onset of subsequent episodes of bipolar depression (Cohen, Hammen, Henry, & Daley, 2004). Thus, the lesser intensity of emotional experience in men may also serve as a buffer against these initial or future depressive episodes. In fact, compared to women with bipolar disorder, men are less likely to suffer from depressive symptoms, rapid cycling, or more severe forms of psychosis (Braunig, Sarkar, Effenberger, Schoofs, & Kruger, 2009; Curtis, 2005). Interestingly, men with bipolar disorder report lower levels of masculinity than those without the disorder (Sajatovic, Micula-Gondek, Tatsuoka, & Bialko, 2011), further evidence for a female susceptibility to affective disorders, one that is perhaps based on gender schema.

Men are also less susceptible to specific anxiety disorders, particularly panic disorder with agoraphobia. Again, the less expansive nature of emotional experience and expression in men may serve as a protective factor against anxiety, as men show lower normative levels of worry and rumination (Nolen-Hoeksema, 1991; Robichaud, Dugas, & Conway, 2003). Similar to what is observed in bipolar disorder, there is an association between lower levels of masculinity and greater levels of experienced psychopathology, in this, case social anxiety (Moscovitch, Hofmann, & Litz, 2005), suggesting that a less masculine gender role, or a more feminine gender role, may predispose one to anxiety.

Social Cognition and Its Relation to Psychopathology in Men

Behavioral Findings

Not only are the experiential and expressive aspects of emotion less intense in men relative to women, but men also possess a relative weakness compared to women in another area with important implications for psychological functioning and wellness, social cognition (Hall & Matsumoto, 2004; Hampson, van Anders, & Mullin, 2006). Social cognition refers to cognitive skills that enable the understanding of another's thoughts and feelings (Brothers, 1990). In various domains of social cognition, men perform worse than women throughout their lifespan (Hu, Chan, & McAlonan, 2010; Lee et al., 2013; Walker, 2005). While recent data with more precise methodology have raised questions about the consistency of these findings, when a sex-linked strength in social cognition exists, it is often in a direction that favors girls/women, relative to boys/men (Hall & Matsumoto, 2004; Hampson et al., 2006; Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005; Rehnman & Herlitz, 2007). Additionally, the functional neuroanatomical basis of social competence differs across the sexes. While the *social brain*, a reference to the neural networks needed for social perception, may be similar across gender, how and when these networks are utilized, and to what extent they are utilized in a manner towards achieving positive social outcomes, appear to differ in a sexually dimorphic manner (Koch et al., 2007).

One area of social cognition that has received much study is the processing of facial stimuli. Sex differences in the processing of facial stimuli are evident quite early in development. At five years of age, boys exhibit a level of facial emotion decoding that girls possess more than a year and a half earlier (Boyatzis, Chazan, & Ting, 1993). These findings are not unequivocal, and may vary depending upon methodology and task parameters. For instance, girls from 7 to 13 years of age displayed greater speed in processing facial information but also compromised accuracy (Rosenberg-Kima & Sadeh, 2010). Regardless, the weight of the evidence suggests that boys and men are simply not as skilled as girls and women in recognizing, recalling, or labeling emotions in facial expressions (Hall & Matsumoto, 2004; Hampson et al., 2006; Montagne et al., 2005; Rehnman & Herlitz, 2007), and tend to rate emotions expressed in faces as less intense (Biele & Grabowska, 2006; Knyazev, Bocharov, Slobodskaya, & Ryabichenko, 2008). There is also a subgroup of men with specific deficits in the processing of certain facial expressions, deficits that are as severe as those observed in cases of damage to the amygdala (Corden, Critchley, Skuse, & Dolan, 2006). Interestingly, the female advantage for facial processing is reduced when faces are inverted (McBain, Norton, & Chen, 2009). This suggests a possible bias towards local feature processing of faces in men, a somewhat unexpected finding given reports showing a more piecemeal approach to spatial cognition tasks in women relative to men (Roalf, Lowery, & Turetsky, 2006). On the other hand, it is suggestive of findings in individuals with autism spectrum disorders (ASD). In ASD, there is a piecemeal approach to facial processing that results in deficits compared to typically developing peers, deficits which are eliminated when faces are presented upside-down (Tantam, Monaghan, Nicholson, & Stirling, 1989). Thus in men, it is possible that social stimuli represent a unique category of stimuli to which typical rules of cognitive processing may not apply.

The relative weakness men possess in perceiving emotions is not limited to the perception of emotional stimuli in faces. Theory of mind is a broader construct which refers to the ability to attribute mental states to oneself and to others, and to recognize that the mental states of others (e.g., beliefs, desires) may differ from one's own. By three years of age, boys lag behind girls on tasks measuring theory of mind (Walker, 2005), and continue to lag behind girls throughout later childhood and early adolescence (Calero, Salles, Semelman, & Sigman, 2013; Hu et al., 2010). In adulthood, men have other difficulties in social perception relative to women, such as in reading nonverbal cues in body language, although these difficulties vary with the emotion expressed (Sokolov, Kruger, Enck, Krageloh-Mann, & Pavlova, 2011). Men also have relative difficulties differentiating friendliness from sexual interest and vice versa (Farris, Treat, Viken, & McFall, 2008).

Not only do men show weaknesses relative to women in specific social cognitive skills, but they also display less interest in social situations, a finding evident developmentally from a very early age. That is, in the days following birth, male infants show less eye contact than female infants (Geary, 2002), and prefer to look at toys rather than faces, whereas the opposite pattern is observed in female infants (Connellan, Baron-Cohen, Wheelwright, Batju, & Ahluwalia, 2000). Interestingly, women also tend to view themselves through a more social lens than do men (Cross & Madson, 1997). Markus and Kitayama (1991) discussed *self-construals* as the ways in which individuals perceive themselves and their larger role in society. They applied this construct to a comparison of eastern and western cultures. Individuals from eastern cultures construe the self as inseparable from society at large, resulting in an interdependent self-construal. In contrast, individuals from western cultures perceive themselves as separate from their broader social context, and therefore, as more autonomous, resulting in an independent self-construal. These concepts have been studied across gender and results reveal that women are more likely to develop interdependent self-construals while men are more likely to develop independent self-construals (Cross & Madson, 1997).

The relative deficits in social cognition, the greater interest in non-social stimuli, and the tendency to possess a more independent self-construal, all evident in men relative to women, may have implications for gender-specific findings in the field of psychopathology. Attention has been given to the manner in which specific forms of psychopathology, such as depression, lead to social isolation, which subsequently serves to reinforce pathological thoughts and behaviors (e.g., Coyne, 1976). Conversely, little attention has been given to the ways in which the *lack* of a social bias might also serve as a buffer against specific manifestations of psychopathology. For instance, men, relative to women, may be less likely to come into contact with others with personal problems because they are less socially oriented. Furthermore, if affective empathy in men is somewhat unrefined, they may be less likely to internalize the problems of others in their immediate social circles (Schuster, Kessler, & Aseltine, 1990). Similar findings may apply to anxiety. For instance, women but not men show salivary cortisol increases during a social isolation task (Stroud, Salovey, & Epel, 2002). The sexually dimorphic response to acute threat has led to a revision of the *fight-or-flight* hypothesis describing reactions to acute stress. That is, facing an acute threat, men may utilize aggression or fear, respectively, to directly confront or flee from the threat. However, the tendency of women to affiliate with, and nurture others, has led some to suggest that women possess a *tend and befriend* reaction to such stress (Taylor et al., 2000). Theoretically, the fight-or-flight response typically exhibited by men might lead to a discharge of potentially dysphoric feelings, and thus, a subsequent resolution of sensations of anxiety, whereas in women, their tendency to affiliate and nurture might result in residual anxiety and no immediate resolution of dysphoria.

In contrast to what may be observed in depression and anxiety, the absence of a social bias has negative connotations in other disorders and characterological pathologies such as schizophrenia and sociopathy. This is the case irrespective of whether a non-social orientation is a risk factor for the psychopathology, a potential agent for symptom exacerbation, or simply a manifestation of underlying psychopathology. For example, in schizophrenia, men exhibit greater difficulty with social intimacy (Mulligan & Lavender, 2010) and greater deficits in social cognition (Van't Wout et al., 2007). These findings are important because social withdrawal is characterized as a negative symptom of schizophrenia, and negative symptoms have greater predictive power for functional outcomes than do positive symptoms such as hallucinations (Rabinowitz et al., 2012). This may be one reason why men with schizophrenia tend to have worse functional outcomes than women (Seeman, 1986). Deficits in other aspects of social cognition, specifically empathy, are the defining features of other forms of psychopathology dominated by males, such as ASD and sociopathy. Thus, in one report, in males, but not females, the antisocial behavior observed in Conduct Disorder and Antisocial Personality Disorder was directly correlated with an inability to subjectively experience the emotions of others (Dadds et al., 2009).

Neuroanatomical Findings

The neuroanatomical correlates of emotional experience differ in men and women (see Semrud-Clikeman and Robillard in this volume), with effect sizes that are comparable to those found in other areas of neuroscience research (Cahill, 2006). Compared to women, men show a less intense degree of neural activation to emotion-provoking stimuli (Schirmer, Zysset, Kotz, & Yves von Cramon, 2004), although as in behavioral studies, some of this is modulated by the specific emotion elicited (Wrase et al., 2003) (e.g., men tend to exhibit a greater degree of activation to pleasant pictures than do women; Sabattineli, Flaisch, Bradley, Fitzsimmons, & Lang, 2004; Wrase et al., 2003). Broad findings include a greater degree of lateralization in men relative to women during emotional perception (Killgore & Yurgelun-Todd, 2001). There are also regional differences. In a study by Lee, Liu, Chan, Fang, and Gao (2005), men consistently activated the right insula and left thalamus, whereas women's activation patterns differed depending upon the emotion induced. Based on data showing that insular activation is associated with the induction of internal emotions, and based upon their own analysis of cognitive processes reported by participants during the task, the results were interpreted by the authors to suggest that men relied upon past emotional experiences when perceiving emotions in pictures or scenes, whereas women were able to engage brain structures responsible for emotion more directly.

Sex-linked divergence in neural activation patterns occurs with stimuli of mild intensity that are likely to induce only modest shifts in mood, if any at all. For instance, during performance of a working memory task, presentation of noxious stimuli in the form of particularly strong and unpleasant odors compromised performance across genders but did not change the neural activation patterns in men (Koch et al., 2007), which remained centered on areas associated with working memory, specifically prefrontal and parietal regions. However, in women, the same condition resulted in significantly stronger activation in brain regions responsible for processing emotion, such as the amygdala and orbitofrontal cortex. Similarly, when perceiving humor, activation patterns in women centered on a ventral limbic system directly connected with emotions, such as the amygdala, insula, and anterior cingulate cortex (Kohn, Kellermann, Gur, Schneider, & Habel, 2011). In contrast, men undergoing this task also displayed activation of a dorsal system associated with a greater degree of cognitive evaluation of the humorous stimuli. In a study by Yuan et al. (2009), both men and women displayed electrophysiological responses indicating a similar degree of conscious emotional processing of particularly negative images. However, men, but not women, lacked this electrophysiological response when viewing stimuli that were only moderately unpleasant. These results may be identifying the electrophysiological basis in the brain for the susceptibility to depression, which is thought to increase with increased exposure to relatively minor daily hassles. There also appears to be a sexually dimorphic neuroanatomical basis to the regulation of emotions. In men, conscious regulation of emotion results in lower activation in the amygdala compared to women (McRae, Ochsner, Mauss, Gabrieli, & Gross, 2008). These findings in sum appear to suggest a neuroanatomical etiology for why men are less susceptible to the emotional influences of stimuli that either lack an obvious emotional component, or whose emotional relevance is minor at best. Perhaps as a result, when attempting to regulate their emotions, men show less need for brain structures associated with emotional processing.

Sex-linked differences in neural activation have been observed during completion of empathy tasks. These differences provide some clues to the underlying thought processes in men and women concerning empathy, and further suggest that men experience lower levels of empathy. For instance, in one study, when led to believe that an unfairly behaving confederate was receiving an electric shock, female participants displayed empathy-associated activation in pain-related neural regions (i.e., fronto-insular and anterior cingulate cortices), while men showed activation in brain regions associated with reward, such as the nucleus accumbens and orbitofrontal cortex (Singer et al., 2006). Men and women react differently when playing a gambling game that results in monetary gain for themselves at the expense of monetary loss for a confederate. Women, but not men, display a medial frontal negativity component on an event-related potential, which is thought to reflect emotional categorization (Fukushima & Hiraki, 2006). Thus, even when benefitting from this outcome, women still display evidence of an emotional reaction whereas men do not.

One neural network candidate for empathy that may differ in men and women is the mirror neuron system. The mirror neuron system is a network of brain areas that becomes activated when watching another execute an action, in a regionally specific manner that correlates with the region that would be activated if the individual themselves executed the action. Based upon these findings, researchers have suggested that this system may help form a foundation for the neural basis of social cognition and empathy (see Preston & de Waal, 2002 for a review). Studies have shown differences in the pattern and intensity of neuroanatomical activity in men relative to women on tasks designed to provide behavioral correlates of this system. For instance, men relative to women show considerably less suppression of the mμ EEG rhythm when watching hand actions but this difference does not occur when the stimulus is a moving dot (Cheng et al., 2008). The mμ rhythm results from firing of sensorimotor neurons in synchrony. However, when an individual executes an action or watches another do the same, the firing becomes asynchronous and as a result the mμ rhythm is suppressed. This suppression that occurs when observing others is theorized to reflect one component of the mirror neuron system (Hari et al., 1998). Interestingly, mu suppression in the study by Cheng et al. (2008) positively correlated with a self-report measure of interpersonal distress, and negatively with a measure of systemizing tendencies. These findings suggest electrophysiological correlates of the extreme male brain theory of autism, in which men show less understanding and subjective experience of the intentions and emotions of others. Another report found that compared to women, men also showed less activation of mirror neuron system components (i.e., right inferior frontal cortex and superior temporal sulcus) when processing their own emotional expressions, while there was increased neural activity in the left temporoparietal junction in males (Schulte-Ruther et al., 2008). Furthermore, when the activation pattern that occurs during the perception of one's own emotions is contrasted to the activation pattern that occurs during the perception of the emotions of another, only women show a difference (Schulte-Ruther et al., 2008). Thus, there are clear distinctions across the sexes in the neuroanatomical and neurophysiological basis for empathy which may contribute to sex-linked differences in behavior.

There are temporal differences in emotional processing and empathy between the sexes which have been demonstrated in electrophysiological studies. Men have been shown to possess a bias towards a pre-cognitive processing stage correlating with coarse analysis, whereas women have been shown to display a bias towards a later and more cognitive stage of processing focused on fine-grained stimulus analysis (Knyazev, Slobodskoj-Plusnin, & Bocharov, 2010). Thus, while both men and women become consciously aware and capable of cognitive processing of stimuli at equal points in time following stimulus presentation, women apparently give greater attention to stimuli at a conscious level, particularly with emotional stimuli. This may be why under certain experimental conditions, women's P300, the portion of an evoked potential considered to reflect cognitive activity, is modulated by emotional context to a greater extent than men's (Garcia-Garcia, Dominguez-Borras, SanMiguel, & Escera, 2008). Emotional contagion studies reveal similar results. Emotional contagion refers to a form of empathy that is behaviorally similar to what is theorized to occur neuroanatomically via the mirror neuron system. When observing the emotional state of others, such as manifested in a facial expression, an individual begins to subjectively experience the emotion represented by that expression. In one report, when stimuli were displayed for 23 ms, a duration short enough that no conscious cognitive processing is possible, no differences in responses to emotional stimuli were observed across the sexes on either the basis of verbal report or objective measurement of facial musculature (i.e., electromyography) (Sonnby-Borgstrom, Jonsson, & Svensson, 2008). At longer exposure times, however, women reported a greater degree of emotional contagion whereas men did not. Thus, electrophysiological data suggest that men, compared to women, may process some stimuli more rapidly, but in a coarse manner that does not lend itself well to the sophisticated analysis that emotional perception requires.

In summary, there are sex-linked differences in the intensity, latency, and location of neuroanatomical responses to emotion-provoking stimuli. However, the manner in which neuroanatomical divergence in emotional expression and emotional perception develops is unknown. Do societal influences lead to sexual dimorphisms in brain functioning? The social adjustment of girls but not boys is related to their emotional recognition accuracy, suggesting this property is more valued in girls (Leppanen & Hietanen, 2001). However, hormonal differences may also contribute to these sexual dimorphisms. When faced with threat-related stimuli, both behavioral responses and responses of the amygdala are correlated with testosterone level in men (Derntl et al., 2009). Thus, societal influences, biological factors, and, potentially, genetic factors, may all interact to facilitate these sex-linked differences in emotional processes in a way that is not yet fully understood. The fact that these sexual dimorphisms are relative and not absolute complicates interpretation of the findings, as there is no definitive evidence suggestive of a social brain that is uniquely and completely male or female.

Neuropsychological Implications for Psychotherapy with Men

Relative to women, men show weaknesses in social cognition, show less interest in social stimuli, and tend to view themselves as less socially interrelated to others. This pattern has implications for psychopathology variables, and perhaps psychotherapeutic treatment variables. For instance, it has been well reported that men do not utilize psychological services to the extent that women do (Gilbert & Scher, 1999), and are less motivated to do so (Kessler, Agines, & Bowen, 2015) for reasons generally having little to do with the extent to which such services are truly needed. Additionally, the same factors that serve to prevent men from accepting and undergoing treatment may serve as impediments to positive treatment outcomes. Some men simply lack understanding of basic mental health constructs related to pathology, such as *depression* (Kaneko & Motohashi, 2007), and thus, their corresponding understanding of the need for psychological services may be limited. However, data demonstrating a less expansive range of emotional experience and expression in men relative to women suggests that there are cognitive and neurobiological forces conspiring to limit men's utilization of psychological services (Addis & Mahalik, 2003). Compounding these cognitive and neurobiological factors are sociocultural influences, such as gender role socialization. Men who rigidly adhere to culturally prescribed gender roles that emphasize their masculinity are less likely to seek psychological help (Addis & Mahalik, 2003), and may develop psychopathology as a result of such rigidly prescribed roles (Heifner, 1997). Gender roles that emphasize traditional cultural concepts of masculinity discourage emotional expression and disclosure, particularly of dysphoric emotions that may be perceived as signs of weakness. Indeed, the frequency with which men experience limitations in emotional experience and expression led Levant (1998) to coin the term *normative male alexithymia*. In this context, Levant is referring to men, who, while lacking obvious frank psychopathology, have nonetheless been socialized against describing and expressing emotions. Thus, there are potentially cognitive, biological, and sociocultural factors contributing to men's relative lack of emotional breadth and depth.

On the other end of this spectrum of emotional experience and expression is the concept of *psychological mindedness*. Psychological mindedness has been defined in part as the ability to see the relationship between thoughts, feelings, and actions, and the causes of each (Appelbaum, 1973). Men tend to have lower levels of psychological mindedness than women (Shill & Lumley, 2002). This is relevant for psychological service utilization since lower levels of psychological mindedness are associated with somatization and self-medication tendencies (Krystal, 1998), behaviors which themselves are associated with emotional constriction. Given findings suggesting higher levels of alexithymia and lower levels of psychological mindedness, it is perhaps not surprising that higher levels of masculinity are associated with greater use of externalization as a defense mechanism (Brems, 1990), and in fact men who are dysthymic are seen as more outwardly aggressive than dysthymic women (Gjerde, Block, & Block, 1988). Furthermore, even when able to express emotions, men are likely to experience anger (Tangney, 1995) and shame following such emotional expression and disclosure (Osherson & Krugman, 1990).

Thus, men may not understand or readily accept the need for psychological services, particularly those men who adhere to traditional gender roles (Good & Wood, 1995) and/or possess the type of normative alexithymia described by Levant. The attitude and experience of a psychological service provider are, therefore, crucial. Men can struggle when placed in an environment in which emotional disclosure and admission of weakness are expected, simply because these actions may fall outside of their possible behavioral repertoire. Psychological service providers who are not aware of the struggles men may face in such environments may erroneously interpret men's difficulties in emotional disclosure as resistance or even conscious defiance. Unfortunately, even psychological service providers may be subject to a traditional gender role bias, as men who openly discuss feelings of vulnerability or weakness run the risk of being viewed negatively by these very same treatment professionals (Lee, Park, & Park, 2004).

One area that has received little attention is the extent to which male-typical levels of psychological mindedness and alexithymia affect the treatment of diagnosed psychopathology. There are gender-by-outcome interactions in several forms of psychopathology as women generally fare better than men after treatment. This has been observed when individuals with obsessive-compulsive disorders (Raffin, Guimaraes Fachel, Ferrao, Pasquoto de Souza, & Cordioli, 2009) and schizophrenia (Brabban, Tai, & Turkington, 2009) are treated with cognitive-behavioral therapy. In samples of individuals with schizophrenia, women displayed significantly greater reduction in the total number of overall symptoms and also exhibited increased insight compared to men, even after controlling for symptom severity (Brabban et al., 2009). Some of the poorer outcomes in men likely also reflect their propensity to self-medicate, leading to frequent comorbidities with substance abuse (Frye et al., 2003). As a result, it is not clear if men suffer from a more intractable form of certain types of psychopathology, or if aspects of male-typical behavior compromise the effects of treatment.

Another aspect of psychological functioning in men receiving relatively little attention is the way in which the ageing process affects men's understanding and use of psychological services. The ageing process in men can either amplify the effects of preexisting psychological stressors or bring new stressors to the forefront. While there is relatively little data on the psychology of aging in men (Canham, 2009), men face unique challenges as they age. On the one hand, men are less likely than women to have pessimistic and overtly negative views of the influence of aging on cognition (Schafer & Shippee, 2010). On the other hand, however, social isolation is not uncommon, particularly in long-term care facilities where men may be far outnumbered by women, both among fellow residents and even among staff. In such institutions they are often treated as *de-gendered* (Silver, 2003). Thus, when faced with ageing-associated stressors, such as the loss of a spouse, men's premorbid lack of a social bias, once functional, may now become dysfunctional, and may serve to limit their independence. Gender-specific treatments in the elderly aimed at facilitating social relationships among men have proven to be beneficial (Gleibs et al., 2011).

Men also experience biological changes with age, including a loss of physical strength (Hurd, 1999). Hormonal changes are common, specifically a lowering of testosterone levels. In some elderly men, testosterone levels fall in a range that is considered abnormal (i.e., low) in young adults. However, the extent of this decrease varies considerably across individuals (Gooren, 2006). Thus, whether there is a male version of menopause associated with androgen deficiency is not clear (Morales & Lunenfeld, 2002). While testosterone supplementation can improve bone mass and sexual functioning, and possibly, mood, these results have not been confirmed in men over the age of 65. As a result, testosterone supplementation is not currently recommended as a standard of care in elderly men (Krause, Mueller, & Mazur, 2005).

Implications for the Neuropsychological Assessment and Treatment of Men

The unique pattern of psychological strengths and weaknesses that men possess calls for a unique approach to neuropsychological and psychological assessment. As part of this process, standardized assessment measures can supplement structured/unstructured psychiatric interviews. Areas of assessment in men undergoing psychological treatment should probably include gender role identity, alexithymia and/or psychological mindedness, and interpersonal functioning.

Assessment of gender role identity is compromised by the trend toward weakening of concepts of masculinity and femininity (Holt & Ellis, 1998). At present, commonly used scales such as the Bem Sex Role Inventory (Bem, 1974) utilize data that is likely outdated. While this area is nonetheless ripe for greater exploration, there are no such measures that can be unequivocally recommended. More options are available in the assessment of alexithymia and psychological mindedness. The Toronto Alexithymia Scale – 20 (Taylor, Bagby, & Parker, 1992) is a relatively concise 20-item measure with each individual item rated on a 5-point Likert scale. There are three subscales, two of which measure the ability to identify and describe feelings. A third subscale measures the degree of externally oriented thinking, which reflects the tendency to focus attention externally instead of internally on constructs like emotions. The resulting score is measured against cut-offs that label a respondent with *alexithymia*, *possible alexithymia*, or *no alexithymia*. The scale has good internal consistency (Cronbach's alpha = 0.81) and test-retest reliability (0.77). Scores on the Toronto Alexithymia Scale – 20 positively correlate with specific psychiatric diagnoses that are common in males, such as disruptive behavior in adolescents (Manninen et al., 2011) and more intractable forms of alcohol abuse in adulthood (Thorberg et al., 2011). The assessment of alexithymia can also be strengthened with an assessment of psychological mindedness. The Psychological Mindedness Scale (Conte & Ratto, 1997) is a 45-item self-report measure used to determine readiness for psychodynamic therapy. Subsequent research derived two factors, a *Belief in the benefits of discussing one's problems* factor and an, *Access to feelings* factor (Shill & Lumley, 2002). The scale has high internal consistency (Coefficient alpha = 0.86; Conte et al., 1990). The scale also has good convergent validity given its negative correlation with the Toronto Alexithymia Scale-20 (Shill & Lumley, 2002), and in its original form demonstrated predictive validity in determining psychotherapy outcomes (Conte & Ratto, 1997).

As part of the psychotherapy process, it has been recommended that men undergo assessment of their interpersonal relationship patterns (Mahalik, 2001). The 64-item version of the Inventory of Interpersonal Problems (Horowitz, Alden, Wiggins, & Pincus, 2000) requires respondents to rate how distressed they have been by each problem on a 0 to 4 point Likert scale. The measure has been shown to possess adequate internal consistency, test-retest reliability, and predictive validity in clinical settings. The original was a commonly used measure in both research and clinical settings, and the overall mean score correlates with general interpersonal distress (Tracey, Rounds, & Gurtman, 1993).

Summary and Future Directions

Men and women differ in their emotional and social capabilities. There is increasing evidence that cognitive and behavioral differences across the sexes in emotion and socialization have biological bases, or at the very least, biological correlates. These differences may contribute to the relative susceptibilities and resiliencies to various forms of psychopathology. Thus, an argument is made herein for a dimensional model of psychopathology in which normative sex-linked traits and behaviors in exaggerated forms may be expressed as psychopathology. The dimensional model is gaining further acceptance in the field of psychiatry, as evident by the most recent edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM) (American Psychiatric Association, 2013), which incorporates a method of dimensional assessment. Additional suggestions call for incorporation of a *cross-cutting* assessment in which it is possible to obtain a quantitative measurement of clinical areas pertaining to aspects of a disorder but which are not necessarily diagnostic criteria (e.g., sleep difficulties, substance abuse). These behaviors *cut across* numerous clinical diagnoses, and have validity in aspects of treatment formulation. Utilization of cross-cutting assessment would likely rely heavily upon self-report measures. Recommendations for sex-specific psychological assessment measures in the treatment formulation of men are consistent with the recommendations being made as part of the formulation of the latest revision of the DSM.

More research is needed to determine the effects that male-specific patterns of cognition and behavior have upon susceptibility to psychopathology and the resulting clinical manifestations of such. In particular, a research base emphasizing the ways in which gender role identification, normative male alexithymia, and interpersonal competence affect functional and clinical outcomes in psychopathology is needed. Neuropsychological assessment is a crucial component of this process in allowing the measurement of underlying and/or associated cognitive/behavioral patterns that precipitate such male-specific forms of psychopathology.

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