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Structural brain abnormalities in aggression and violent behavior

Sarah M. Bannon *, Katie Lee Salis, K. Daniel O'Leary

Stony Brook University, United States

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ABSTRACT

The purpose of this review is to synthesize the existing research on the structural brain abnormalities among perpetrators of violence. While previous work has documented the functional brain correlates of aggressive behavior, insufficient attention has been paid to structural brain damage and abnormalities associated with violence perpetration. Thus, the present review consists of three domains that have been examined in the context of violence perpetration, namely, head injury, lesion, and structural neuroimaging studies. Findings from head-injury studies suggest that brain damage is associated with difficulties in decision making and affect regulation. Lesion studies suggest that lesions in the prefrontal, temporal and associated limbic structures are particularly important, while imaging studies emphasize the orbitofrontal cortex as an area of influence. Overall conclusions include strong evidence from all three domains that damage or reductions in frontal areas of the brain and connected regions are associated with violence and aggression. Discussion of the clinical implications of existing findings, and suggestions for future studies is included.

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1. Introduction

The extant literature suggests that there is an association between brain damage (such as traumatic brain injury or lesions) and interpersonal violence and aggression (Farrer, Frost, & Hedges, 2012; Pinto et al., 2010). For example, as many as 70% of patients with traumatic brain injury (TBI: defined as a resulting injury that results from a violent blow or jolt to the head or body or from an object penetrating the skull; Mayo Clinic, 2014) display considerable irritability and aggression post-injury and cause significant distress to their families (McKinlay, Brooks, Bond, Martinage, & Marshall, 1981). As a number of researchers have outlined the functional neurological correlates and risk factors for interpersonal violence (e.g. Ali & Naylor, 2013; Howard, 2012; Pinto et al., 2010), our review attempts to provide the first comprehensive detailing of structural disruptions (i.e. brain injury), which are often accidental and incidentally-obtained in nature. Existing research from head injury and lesion studies will be discussed with the hope of elucidating structural changes that may predispose individuals to violence and aggression. With this aim, we will subsequently suggest areas that warrant further study with combined structural and functional imaging methods.

Before proceeding, it is important to note the inconsistencies surrounding the assessment (Norlander & Eckhardt, 2005) and conceptual overlap in the terms *aggression* and *violence* that can contribute to

* Corresponding author at: Department of Psychology, Stony Brook University, Stony Brook, NY, 11794-2500, United States.
E-mail address: sarah.bannon@stonybrook.edu (S.M. Bannon).

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confusion in interpreting results. While violence is often conceptualized as an aggressive act, many aggressive acts are not violent (e.g., do not cause harm; Anderson & Bushman, 2002). Further, an act of violence may not be aggressive, in that the harm was accidental or an act of defense. In collecting articles for the present review, we found that definitions of aggression and violence often implied that the constructs were indistinguishable. Herein, violence refers to behaviors that inflict physical harm. Conversely, aggression can refer to both affect/personality and violent behavior (e.g., irritability or frustration versus infliction of physical harm). Thus, our review proceeds with the knowledge that trait aggressiveness and violent behavior are correlated but not identical (see O'Leary, Smith Slep, & O'leary, 2007), and that violence perpetration can occur without trait aggression, and vice-versa.

Included articles were focused on scientific works containing male adult (18 or older) samples of perpetrators of intimate partner violence (IPV; any physical, sexual, or psychological harm occurring between current or former intimate partners) as well as general violence and aggression. Studies containing clinical populations, such as those selected exclusively containing a comorbid psychiatric diagnosis or medical conditions were excluded from the present review. As alcohol use is frequently associated with both partner and general violence, studies containing populations with comorbid alcohol problems were included. Literature searches were conducted on PsychINFO, Google Scholar, and PubMed for relevant articles. The search terms for head injury and lesion studies were *head injury*, *traumatic brain injury*, *intracranial injury*, *lesion*, *brain damage*, and *frontal lobe injury* combined with the terms *partner violence*, *partner abuse*, and *domestic violence*. For the review on imaging techniques, we limited our discussion to studies not included in the above sections, and used the terms *structural imaging*, *neuroimaging*, *MRI*, and *brain abnormality*. Search terms from each section were also combined with the terms *general violence*, *violence*, *violent crime*, and *aggression* for the integrated discussion.

1.1. Head injury

The occurrence of head injury was first linked to partner violence nearly three decades ago when Rosenbaum and Hoge (1989) found that closed head injury was present in 61.3% of partner violence perpetrators (closed head injury refers to cases of injury in which there is no open wound or gash). With a larger sample, Rosenbaum et al. (1994) later replicated the findings with similar prevalence rates of head injury among male spouse abusers (51%). This rate was elevated when compared to the rates of head injury in non-violent maritally-discordant (25%) and maritally-satisfied (16%) men, all of whom were matched on demographic variables. Further, head injury was a unique predictor of IPV perpetration. The findings of elevated rates of head injury among male abusers compared to healthy controls have since been widely replicated (Cohen, Rosenbaum, Kane, Warnken, & Benjamin, 1999; Cohen et al., 2003; Marsh & Martinovich, 2006). However, one study comparing a head-injured group with a group of orthopedically (spine, joint, and muscle) injured men on the occurrence of IPV found no differences in rates of IPV between groups based on injury type (Warnken, Rosenbaum, Fletcher, Hoge, & Adelman, 1994). Though there were no differences in perpetration of IPV, head-injured men reported more factors that may predispose them to physical violence than did the orthopedically injured group (Warnken et al., 1994). For example, head-injured men reported increased loss of temper and control, more difficulty communicating verbally, arguing with others, and more verbal abuse when compared to the orthopedically injured men.

Prevalence, as well as severity of head injury and abuse has been examined across studies. Farrer et al. (2012) conducted a meta-analysis to examine the association between traumatic brain injury and violence perpetration using six studies and over 222 perpetrators of IPV. The authors found that the weighted average of TBI among IPV perpetrators (53.6%) was significantly higher than that of the general population-based prevalence of TBI in men (38.5% of men by age 25; McKinlay et al., 2008). Additionally, Turkstra, Jones, and Toler (2003) compared 20 African American men convicted of domestic violence to men without criminal convictions matched for age, race, and socioeconomic status and found that while more than half of the participants in both groups had experienced TBI, the IPV perpetrator group had significantly more *severe* damage (as determined by a health history questionnaire).

In clinical populations, patients have demonstrated changes in both behavior and temperament. One study conducted with TBI patients found that 11% had increases in aggression and agitation following injury that were not explained by pre-injury characteristics (Brooke, Questad, Patterson, & Bashak, 1992). Importantly, agitation and frustration place stress on both caregivers and workers; these symptoms are often inappropriately treated with physical or chemical restraints that paradoxically increase frustration for patients (Alderman, 2003). Brooke et al. (1992) also observed restlessness (behavior interfering with staff or requiring staff action but less severe than aggression or agitation) in 35% of the patients, and suggested that for some, restlessness may be a normative experience of recovery. However, one study found that 31% of caregivers (mostly spouses) for individuals who sustained TBI reported moderate or severe "aggressiveness" toward themselves by 2 years post-injury (Hall et al., 1994). Further, caregivers reported more complaints with head-injured persons' behaviors over time; specifically, they noted fatigue, slowness, and forgetfulness, as well as increasingly severe temper outbursts, anxiety, and self-centeredness over time. A similar study found that head injured patients as a group had higher reported anger and extreme violence scores than normal controls, and relatives of the patients reported considerable distress with patient behavior (Grafman et al., 1996). Thus, in the immediate time following head injury roughly 1/3 of head-injured individuals display changes in temperament that produce disruptions for caregivers and attending staff. For both clinical and nonclinical populations, suboptimal treatment of TBI-related changes in function (e.g., personality, cognition, impulse-control, and behavior) may present a substantial obstacle to recovery (Kim, 2002).

Changes in aggression and violence perpetration have also been studied multiple years after the occurrence of head injury. A study of 300 inpatients at a brain injury center found that at any given period postdischarge (6, 24, and 60 months post-injury), 25% of individuals with moderate to severe TBI exhibited aggressive behavior (Baguley, Cooper, & Felmingham, 2006). In one study conducted with a large cohort of 520 head-injured patients from the Vietnam Head Injury Study, over one-fifth of veterans reported increases in violent behavior nearly 15 years after the initial trauma (Schwab, Grafman, Salazar, & Kraft, 1993). Proximal changes have also been explored by Tateno, Jorge, and Robinson (2003) who found elevated rates (33.7%) of aggression 6 months after injury among trauma patients. Aggressive behavior was also associated with the presence of major depression, poor premorbid[1] social functioning, history of substance abuse, and damage to the frontal lobes. Elevated rates of aggression were found in several additional studies (Alderman, 2003; Baguley et al., 2006; Kim, 2002), and the deficits in self-regulation of anger may reflect broader difficulties associated with post-concussion syndrome (Stevens, 1982).

Head injury is also associated with broad risk for criminal behavior among both violent and nonviolent individuals. One such study conducted by Diamond, Harzke, Magaletta, Cummins, and Frankowski (2007) screened 107 male and 118 female offenders from 6 federal prison sites across 3 prison security levels for traumatic brain injury and found that 88% of prisoners experienced at least one head injury incident. Another study conducted with a cohort of prisoners in New Zealand found that 86.4% of all offenders, both violent and nonviolent, had experienced at least one significant head injury, and 56.7% reported experiencing multiple significant head injuries (Barnfield & Leathem,

[1] Pre-injury.