

## **Childhood exposure to violence and neuropsychological deficit outcomes**

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### **PART 1: The evidence base**

#### **The psychobiological outcome: Neuropsychological test performance.**

Neuropsychological tests are indicators of integrity of the brain and its mental functions. The tests gather behavioral samples of language and verbal skills, visual-spatial skills, abstract reasoning and problem-solving, motor capacities, attention, mental processing speed, working memory, and the executive self-control functions of planning, initiating monitoring, inhibiting and re-directing one's own behavior toward a goal (Lezak, 1995 book). Typically a patient is administered a battery of many short tests over a period of one or more hours, with different tests selected to cover a range of different abilities. Often an intelligence test is included within the test battery.

**Neuropsychological functions are important predictors of physical health and quality of life.** Childhood mental abilities are strong predictors of life-long health, all-cause morbidity, frailty, and early mortality (Deary et al 2004; Gottfredson, 2004). An aggregate of an individual's neuropsychological abilities (the IQ) is the best predictor of his/her life success in education, occupational attainment, and job performance (Schmidt & Hunter, 2004). In modern history labor-force participation and every-day life are growing increasingly complex and demanding, and as a result healthy neuropsychological abilities have become more essential than ever for life success of future generations (Gottfredson, 1997).

**Despite the clear relevance of potential neuropsychological sequelae of juvenile violence exposure, there are few published studies.** This dearth arises from the unfortunate coincidence of two trends in behavioural science: The discovery of childhood maltreatment as a viable topic for research in the 1980's coincided with behavioral scientists' fascination with exciting new neuro-imaging technologies for assessing the status of the brain. In this historical context, neuropsychological testing was deemed a relatively less „sexy“ way to study trauma victims, as compared to neuroimaging.

As a result of this neglect by contemporary trauma researchers, neuropsychological assessment of violence-exposed humans is an almost-missing chapter in the story of how stress affects the brain. An over-simplified bird's-eye view of the theoretical story linking childhood stress to brain health includes a sequential chain of three outcomes: Early-life chronic stress disrupts (1) the homeostasis of stress hormone systems, which in turn disrupts (2) normal development of brain structures, which in turn produces (3) observable deficits in stress-exposed individuals' tested learning, memory, and attention capacities (Sapolsky et al 1996). All of these theoretical steps in the causal chain have been well worked out in animal stress research, particularly in rodent models (Millan et al 2012; Shors 2006; Teicher, Tomoda & Andersen, 2006). In contrast, research into stress-exposed humans has primarily focused on the two mediating steps: stress hormones and brain imaging. There is relatively less evidence about the final chapter in the theoretical account:

neuropsychological deficits in tested learning, memory, and attention capacities in stress-exposed humans.

**Neuropsychological testing is a natural complement to structural and functional brain imaging.** Neuropsychological testing serves the important purpose of validating neuro-imaging findings, by testing whether or not abnormalities revealed through imaging have in fact affected externally observable mental abilities and behaviors (Hanson et al 2010; Wilson, Hansen, & Li, 2011). Furthermore, neuropsychological assessment offers the advantage over imaging data of a long-established, excellent standard of psychometric measurement, as well as standardized norms for comparing patients to the distribution of test performance in the general population of the same age (Meyer et al. 2001). Neuropsychological assessment has a long history of use in clinical settings. It is used to ascertain patients' patterns of strengths and weaknesses to inform treatment planning, and to trace patients' recovery over time through repeated testing (Sattler, 2008). For these reasons, neuropsychological test data form a natural bridge from basic science to clinical application.

### **What does the research literature show?**

**Two hypotheses of violence effects on neuropsychological function have received support: a specific memory deficit, versus pan-cognitive deficits.** The initial expectation that violence exposure should harm functions of memory while leaving other neuropsychological functions intact arose from rodent research indicating that chronic elevations in stress hormones wreaked damage in one particular brain structure, the hippocampus, which plays a key role in memory (Sapolsky et al 1996, Stress). Hippocampal abnormalities have been confirmed in adult humans who reported childhood maltreatment (Teicher, Anderson, and Polcari, 2012). As such, childhood violence exposure is expected to produce deficits in tested memory. In general, this hypothesis has been supported. Studies that have included memory tests have reported memory deficits.

In contrast, additional evidence from animal models and neuro-imaging studies has broadened the neuroanatomical list of stress targets beyond the hippocampus, to include the brain's amygdala, corpus callosum, prefrontal cortex, and cerebellum, as well as connections amongst them (McCrory, DeBrito, and Viding, 2010). This more inclusive anatomical list suggests that childhood violence exposure should produce deficits in a broad array of mental functions, as well as low scores on the intelligence quotient that summarizes them (IQ). This prediction is consistent with longstanding evidence that seemingly disparate cognitive functions are not actually independent, but are inter-dependent, highly correlated, and represent whole-brain integrity (Millan et al 2012, Nature Reviews Drug Discovery). In general studies this hypothesis too has been supported. Studies that have included broad test batteries have reported a broad pattern of non-specific deficits, and studies that have included IQ testing have reported the expected IQ deficit.

**Neuropsychological studies of violence-exposed children.** A handful of small studies comparing maltreated children versus comparison children have detected

deficits in IQ, and tests of memory, executive functions, attention, and concentration (see review in Wilson, Hansen & Li, 2011; Mezzacappa, Kindlon & Earls, 2001). To highlight key findings we feature a subset of studies that have used the strongest designs.

One of the earliest and oft-cited reports in the literature is remarkable for the breadth of mental functions tested (Beers & deBellis, 2002). Unfortunately, the sample included only 14 maltreated children with PTSD and 15 control children. This small sample severely limited the statistical sensitivity of the study, and as a result, group differences of moderate effect size in language, visuo-spatial skills, and memory skills failed to attain statistical significance. Nevertheless, the maltreated PTSD patients showed marked and significant deficits on tests of attention and executive functions.

A larger clinical study documented that maltreatment of longer duration is associated with more neuropsychological deficit (Jaffee & Maikovich-Fong, 2011). This study examined a sample of 1,777 children who were registered cases with Child Protective Services and who represented such cases nationwide. The main finding was that children victimised chronically across multiple years had lower IQ than children who were situationally maltreated. This finding remained significant after controlling for a host of associated family and individual risk factors.

Representative cohort studies have documented that neuropsychological deficits in maltreated children are not an artifact of biased official or clinical samples. This is illustrated by three cohort studies described in the paragraphs below. In the Child Development Project, physical maltreatment before age 5 years was prospectively ascertained in a community-representative birth cohort of 585 children (Lansford et al. 2002). Maltreatment was assessed through maternal interviews, irrespective of official detection or clinical treatment for post-traumatic symptoms. Maltreated five-year olds scored significantly lower than their peers on standardized tests of academic abilities 12 years later. Findings remained after statistical controls for a host of risk factors.

Another cohort study has documented that neuropsychological outcomes for child maltreatment also extend to other forms of violence exposure. In the E-Risk Longitudinal Twin Study, physical maltreatment, bullying victimization, and maternal domestic violence were prospectively ascertained in a nationally representative 1994-95 UK birth cohort of 2232 children (Jaffee et al. 2007). These forms of violence exposure were assessed through four repeated maternal interviews across the first decade of life, irrespective of official detection or clinical status. Maltreated children scored 8 IQ points lower than their peers at the age-12 follow-up, and children who had been victims of frequent ongoing bullying scored 4 IQ points below their peers. These findings remained significant after statistical controls for parental IQ and social class. In this same E-Risk cohort, children exposed to domestic violence between their mother and her partner also scored 8 IQ points lower than peer children, even after controlling statistically for any child maltreatment history (Koenen et al. 2003). Thus, in this cohort child maltreatment, frequent bullying victimisation, and domestic violence exposure were independently associated with a general neuropsychological deficit.

A four-decade cohort study has shown that childhood maltreatment can be followed by a decline in abilities well into adulthood. Neuro-imaging studies have consistently shown nil effects of maltreatment on brain structure and function in samples of children, but much larger effects in samples of adults who were child victims of

maltreatment. This apparent age difference implies a long-term process of neurological degeneration, and it has attracted many attempts at explanation (McCrary, DeBrito, and Viding, 2010; Wilson, Hansen & Li, 2011). However, until now no study had assessed the same maltreated children in childhood and adulthood. In the Dunedin Longitudinal Study, maltreatment in the first decade of life was prospectively ascertained in a population-representative 1972-73 birth cohort of 1000 children (Caspi et al. 2002). Maltreatment was assessed through repeated maternal interviews, staff observations, official records, and retrospective recall by the study members when they reached adulthood; thus maltreatment was defined irrespective of official detection or clinical status. Maltreated children scored on average 5 IQ points lower than cohort peers when tested at ages 7 to 13 years, and this finding remained significant after statistical controls for parental IQ and social class. In 2010-2012 the cohort was re-tested at age 38. The IQ deficit evident in maltreated Dunedin Study children had grown worse; when the same children were re-tested 25 years later they scored 8 points lower than their peers. This decline in their mental abilities since age 13 years was statistically significant. Neuropsychological testing at age 38 documented that the formerly maltreated children had deficits in working memory, visual-spatial perceptual reasoning, and verbal comprehension, but not processing speed.

Typically, neuro-imaging and neuropsychological studies fail to provide evidence that research measures represent deficits severe enough to cause impairment in daily life (Millan et al 2012). However, in the aforementioned Dunedin cohort, low test scores for the adults with a history of childhood maltreatment translated into impaired function in everyday life. Impairment was evidenced by cohort members' self-reports of difficulties with attention, word-finding, planning and organizing, and memory. Informants' reports confirmed that the cohort members with a childhood maltreatment history were viewed by others as distractable, disorganized, and forgetful.

### **Neuropsychological studies of adults who report a childhood abuse history.**

Studies of adults who report a history of child abuse have variously reported deficits, on tests of memory, attention, executive functions, and overall lower IQ, relative to non-abused comparison adults (see review in Wilson, Hansen & Li, 2011; Gould et al 2012). Unfortunately, group differences on tests of specific functions have not consistently replicated within or across adult samples, and there are many reports of no group differences, including one report of no memory deficits in childhood sexual abuse victims recruited from the community (e.g., Navalta et al. 2006). How much this weak pattern of findings results from small and biased samples is unknown, but it is fair to say that the adult studies have in general lacked the methodological strengths of childhood studies.

### **The question of causation: Does the empirical evidence support the inference that juvenile victimization actually 'causes' the psychobiological outcomes?**

Experimental research has documented that stress causes deficits in attention, learning, and memory in non-human animals. In contrast, the requisite evidence for causation in human children is weaker. The studies reviewed here each made an attempt to support causal inference by statistically controlling for other maltreatment-correlated risk factors that might have generated the low neuropsychological test

scores, such as low SES, low parental IQ, or parental psychopathology. However, children exposed to maltreatment and violence are statistically likely to experience a whole host of additional adversities that could diminish their neuropsychological abilities (Cicchetti & Toth, 2005). Because it is difficult to control properly for all these alternative causes, the statistical control approach cannot provide compelling evidence for causation.

Several study designs can assist with causal inference. For example, the hypothesized causal effect of violence exposure on neuropsychological deficits could be confirmed by experimental designs exposing children to violence (which are unethical) or by longitudinal designs giving neuropsychological tests before and after violence exposure to assess within-individual change in test scores (which are impractical). This causal hypothesis could also be tested using the design comparing the test scores of twin children who are discordant for the experience of violence exposure (though in most twin pairs studied as young children, when one twin is maltreated, so is the other). As a result of lacking research, we cannot yet rule out that the possibility that neuropsychological deficits observed in violence-exposed children were caused by some other adversity. The current evidence base also fails to rule out the possibility that some children's neuropsychological deficits were present before their violence exposure, and may have increased their risk of victimisation (Gilbertson et al 2006; Koenen et al. 2007; Parslow & Jorm 2007).

**Effect moderation or mediation?** Why do some children who are victimized develop neuropsychological deficits whilst others do not? What processes account for the influence of victimization on neuropsychological function? We found no research into neuropsychological outcomes of violence that empirically addressed either of these key questions.

## **PART 2: Implications for prevention and intervention.**

**Implications of awareness for prevention.** A barrier to recognition and reporting of child maltreatment is adults' concern that the eventual benefits of intervening may not outweigh potential immediate harms (Gilbert et al, 2009). It has been proven that healthy neuropsychological skills such as the executive self-control functions, learning, and problem-solving are prerequisites for success in modern life. If children who experience violence develop permanent neuropsychological deficits and lack these essential mental skills, the eventual benefits of maltreatment prevention would extend to preventing lifelong educational and economic disadvantage. Greater public awareness of this contingency could thus add impetus to the prevention of childhood violence exposure.

**Implications for detection and support of violence-exposed children in schools.** Neuropsychological deficits are first and foremost detectable as real-life difficulties with attention, self-control, and learning. As such, if children who experience violence develop such difficulties, these will manifest at school, where teachers are well-placed to notice them (Cook-Cottone, 2004). Salient physical injury is rare, and as a result one of the commonest signs of maltreatment is a sudden decline in a child's

neuropsychological status. It has been reported that of all professionals, schools contribute the most reports to child protection services, but at the same time only about one-third of child-maltreatment cases known to school personnel are formally reported (Gilbert et al, 2009, Lancet). Schools are important, because the continuity of contact they provide offers opportunities for support of violence-exposed children, and for many children school may be the least restrictive care setting.

**Is there any evidence that interventions can normalize neuropsychological development among victimized children?** There are at least two reports of successful small-scale clinical trials of interventions for maltreated preschool children in foster care (Dozier et al. 2008; Fisher et al. 2000). Neither has examined neuropsychological outcomes. However, both reported that treatment normalized levels of the stress hormone cortisol. Disrupted homeostasis of stress hormone systems alters the brain development necessary for healthy neuropsychological functions, suggesting the hypothesis that treatments like these may enhance mental abilities.

**Neuropsychological management of adult patients who were childhood violence victims.** Although neuropsychological studies of adult former maltreatment victims have generated inconsistent findings, there is some indication that clinicians may expect such patients to suffer difficulties with executive self-control, attention, memory, and new problem solving. These kinds of mental difficulties can retard progress in psychotherapy, and may help to explain the known treatment resistance of former maltreatment victims (Nanni, Uher and Danese, 2011).

**Is there potential for reversing the effects of juvenile violence victimization on neuropsychological outcome?** Working memory performance is impaired by subjecting young rats to early-life stress in the maternal separation paradigm. In an initial report, this stress-induced working memory deficit was prevented by prophylactic administration of nonsteroidal anti-inflammatory medication in rats who experienced maternal separation (Brenhouse & Andersen, 2011 Biol Psychiat).

**Research recommendation.** When neuro-imaging studies of violence-exposed samples are undertaken, researchers should extend the data collection to include tests of relevant neuropsychological functions and assessments of impaired mental functions in every-day life. We also recommend that neuropsychological outcomes be assessed in randomised trials of treatments for child and adult violence victims.

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