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Cognition based bTBI mechanistic criteria; an in silico tool for preventive and therapeutic innovations

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It is now well established that neurodegenerative and neuropsychiatric disorders are a direct outcome of blast-induced traumatic brain injury (bTBI). However, the link between the blast loading and the subsequent tissue damage remains largely elusive. To this end, this work aims to provide new insights into the mechanics of brain damage under blast loading by focussing on early-time events of primary blast and their correlation to functional impairments. In this work, we first conduct blast experiments on rats and compile the damaged regions of the brain by directly correlating cognitive deficits and oxidative stress. A computational model of the rat head is developed from imaging data, incorporates the geometrical information of the different head tissues as well as the axonal information within the white matter from diffusion MRI, and is validated with *in vivo* brain displacement measurements. The same blast conditions as in the experiments are then simulated in the *in silico* rat model allowing for the identification of a mechanistic criterion that correlates the damage within the brain tissue to a corresponding behavioural deficit. After identification of the mechanical injury criteria, this approach is applied to an *in silico* human head model addressing realistic blast conditions in a military context. A good correlation between the predicted brain damaged region and cognitive deficits reported in the literature within this context is found. Furthermore, the mechanistic insights from this work are used to propose future innovations in combat head protection from blast and further exploring links between physical injury phenomena and downstream biological processes [1].

[1] Patent Application No. GB1716849.3 entitled “Protective Device” filed on 13 October 2017 in the name of Oxford University Innovation Ltd.