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Interpreting Pain as 'Catastrophic' Makes It Worse: The Neurological Basis

The work of Lin and colleagues in the current issue of the *Journal of Dental Research* demonstrates the ability of cross-cutting, multidisciplinary research to explore how psychological processes influence biological processes. By combining the methods of applied behavior analysis (Cooper *et al*., 2004) and neuroimaging, the authors have demonstrated the impact of coping mechanisms on the neural processing of pain, in the absence of behavioral change. The authors were able to structure the experience of pain to be either predictable or unpredictable by using an associative learning technique similar to that described by Pavlov, where dogs salivated when they heard a bell associated with food. Fifteen participants learned the pairing between a visual cue and the intensity of a painful stimulus delivered at the right upper incisor. Once this was learned, the authors were able to deliver a stimulus of either predictable intensity (by giving a visual 'cue' to the intensity level) or of unpredictable intensity (no cue). We know from previous research that unpredictable pain is generally rated as more distressing than the same physical stimulus given in a predictable manner. By recording the level of brain activation associated with pain using functional magnetic resonance imaging (fMRI), the authors were able to delineate the neural basis of the increased pain experience found for unpredictable stimuli. Furthermore, they were also able to demonstrate how a psychological mechanism (pain catastrophizing) influenced this biological phenomenon. Psychologists have long understood that our interpretation of events can make our experience of pain better or worse. 'Pain catastrophizing' refers to a pattern of thinking in response to pain, where the individual makes highly negative interpretations of the pain, such as "I have a serious problem", "I will be in pain for a long time", "There is nothing I can do about the pain", etc. Each participant's score on the Pain Catastrophizing Scale

was correlated with brain activation at the right posterior hippocampus, a region critically related to associative learning of aversive stimuli and context. The discussion draws together research from neuroscience, behavioral science, and cognitive theories of anxiety, offering a truly integrated understanding of oral health and disease. This research suggests a paradigm shift in the study of social and behavioral factors in the determinants of health.

As a dental researcher, I believe it is my duty and my great pleasure to seek to understand the manner in which an individual becomes healthy or ill, able or disabled. While I would strongly argue that to seek such understanding is a sufficient goal in itself, it also serves the purpose of helping us to develop safe, effective, and acceptable methods for improving the health of people and populations. The determinants of health are multidimensional and operate at 3 levels: the biological, the psychological, and the social (Marmot and Wilkinson, 1999; Marmot, 2005). Newton and Bower (2005) have argued that our ability to develop a 'grand unified theory' combining these determinants is held back by the absence of a theoretical framework of the causal pathways between and among social structure, social life, behavior, biology, and oral health and disease. This theoretical void has an impact on the ability of oral epidemiology to explain the social and behavioral causes of oral disease and to understand the biological pathways through which the social and psychological determinants are manifest. In addition, our ability to explore such determinants simultaneously across all levels has been further limited by a lack of appropriate methods by which to determine the interplay among the 3 groups of factors and the complexity of the analytical approaches required (Newton and Bower, 2005). The barriers to a unified model have been both theoretical and methodological; however, there is a suggestion that such barriers are possibly being addressed by the application of scientific principles in a new and rigorous manner (Amaro and Barker, 2006).

Our understanding of the basic biological mechanisms of health and disease has been dramatically expanded through the in-depth study of animal models, the exploration of the human genome, and the analysis of the biologic and health-promoting

impact of drugs, as well as the development of novel techniques (for example, Wade, 2011). *In vivo*, the development of increasingly sophisticated imaging techniques, allowing for the near-real-time analysis of brain activity or physiological responses, has facilitated the exploration of the impact of pain on brain functioning (see, for example, Howard *et al.*, 2011; Brugger *et al.*, 2012). Thus, we are increasingly able to demonstrate the biological mechanisms of disease and disability.

In contrast, the social and psychological correlates of health have largely been explored through epidemiological methods. With the increasing sophistication of such methods and our ability to analyze the complex inter-relationships of factors through techniques such as Structural Equation Modeling and Multi-level Modeling, it has become possible to map networks of correlation between and among health status, social status, and psychological well-being. For example, oral health has been found to be related to distal social factors such as social class, income, education, housing, and ethnicity (see, for example, Sheiham and Nicolau, 2005) and to more proximal social variables such as close social support and the size of an individual's social network (Sabbah *et al.*, 2011) and psychological factors such as sense of coherence, depression, and coping style (Locker *et al.*, 2000; Freire *et al.*, 2001; Bernabe *et al.*, 2012).

Advancing the agenda of developing and testing a Grand Unified Theory of the determinants of oral health will require consideration of a broad research agenda involving multi-disciplinary teams working across disciplines for mutual development, as well as the availability of time and for researchers across disciplinary boundaries to meet, discuss, and develop programs of research. Further, there will be a need for a plurality of research methods, including large-scale epidemiological studies combining the measurement of biological factors as well as the social and psychological, complemented by studies such as those described by Lin *et al.* (2013), exploring the biological manifestations of social and psychological processes, and qualitative research. This will of course be impossible without the recognition by research funders of the importance of understanding the determinants of health as the foundation for the development of healthcare and the consequent commitment to developing large-scale programs of research in this area which cross traditional disciplinary boundaries.

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