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An opinion on how a qualitative lens can advance translational and rehabilitation practices: The example of Environmental Enrichment

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ABBREVIATIONS
EE Environmental Enrichment

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ABSTRACT
Using the example of Environmental Enrichment (EE), we argue in this opinion piece that a qualitative interrogation of animal-based experimental paradigms can provide a substantial contribution to advance translational and rehabilitation practices. EE, a well-established paradigm in animal-based experimental biology, has been translated to human rehabilitation using a mechanistic approach, providing limited results. To advance current understanding of the paradigm, we have interrogated EE through a qualitative lens and have identified six principles—complexity, novelty, variety, individualization, integration, and scaffolding—that define EE in animals and can inform more effective, tailored rehabilitation strategies. This approach can be used in future research to create novel resources and teaching didactical methods that can help translate the impact of experimental paradigms, such as EE, seen in animals to human populations.

KEYWORDS: Pedagogical | Environment | Qualitative | Quantitative | Didactics | Teaching

Basic, animal-based research has for decades informed clinical practice. Understanding what is done in animals and their mechanisms of response represent key steps for a successful translation of experimental paradigms from animal to clinical settings. The quantitative, mechanistic approach leads the way in this translational endeavour. We argue in this opinion piece that a qualitative interrogation of animal-based paradigms can significantly contribute to advance translational efforts and improve clinical practice. Such qualitative approach has previously proven to be successful in advancing knowledge on the contentious relationship between exercise and cognition [1]. We use the example of Environmental Enrichment to illustrate the process.

Environmental Enrichment (EE) is a pivotal paradigm in experimental biology and neuroscience, and there is growing interest in its application to rehabilitation practices. EE involves the creation of an environment (both physical and social) rich in stimuli for enhancing motor, cognitive, sensory, and exploratory activities. Developed by chance in the 1960s by the biologist Donald Hebb, who observed the rodents raised in his home (rich in stimuli) displaying superior problem-solving ability relative to rodents raised in cages, EE was initially employed to investigate the relationship between genes and environment. Being largely employed in animal models of diseases (e.g., stroke and cerebral palsy), EE has then generated interest in the rehabilitation sciences. In fact, the large body of existing evidence indicates that animal models exposed to EE conditions consistently show increased physical activity, use of the body parts affected by the disease, and exploratory behaviour, which generate a cascade of effects leading to large improvement in motor, cognitive, and learning abilities, ultimately benefitting the rehabilitation process [2]. For instance, models of stroke had a large increase in neurobehavioral scores relative to animals recovering in standard conditions [3], and, curiously, EE facilitated the learning of driving skills in rodents [4]. In sum, the use of EE in animal models is well established but the translation of the paradigm to rehabilitation in humans is an open challenge.

A key issue in adopting EE in rehabilitation is understanding what is done in animals and adapt it to humans. In the quest for answers, research has primarily examined mechanistic aspects of the paradigm, including the timing of EE exposure, dose-response curves, and the underlying mechanisms of change. In short, the quantitative aspects have been prioritized. This approach has provided insightful knowledge on *how* the paradigm works but not on *what* the paradigm is. This quantitative approach has led to a linear translation of the paradigm, primarily towards structural and technological solutions: interventions in animals typically create a larger cage, interventions in humans have built new, large rooms for patients in hospital [5]; strategies in animals generally include the provision of toys and objects for manipulation, research in humans has focused on developing technological "toys" (e.g., virtual and augmented reality devices) [6]. This linear translation however has provided limited results [7] and misses an important point: if we don't know what is

done qualitatively in animals, we can't effectively adopt EE in rehabilitation.

A shift is needed. A shift that considers the translation of qualitative aspects of EE from animal to rehabilitation settings. To do so, we have conducted a scoping review, which highlighted that EE is integrated within the animals' daily life, and it is not something additional like virtual reality would be [8]. Further, we have identified 6 principles that underpin EE in rodents: complexity, novelty, variety, targeting individuals' needs, integration of rehabilitation aspects, and scaffolding. While a superficial look at EE would give the impression that the paradigm is simply about adding toys and structures to an environment, these principles provide a much more nuanced and informative perspective. EE is about modifying the environment with the aim of building complexity, through ongoing novelty and variety of behavioural activities; modifications that are relevant to individuals' daily life and their needs; modifications that are scaffolded and tailored to the current individuals' capacity; modifications that integrate rehabilitation aspects. These principles contribute to defining *what* EE is and *what* is done to enrich an environment, aiming to guide rehabilitation specialists in developing individualized strategies tailored to their patients. It is only through a qualitative inspection of the principles underpinning the paradigm that we start to build the foundation for advancing current translational efforts.

In this opinion piece, we used the example of EE to show the benefit of interrogating an experimental paradigm through a qualitative lens. Not only this approach can shed new lights on a paradigm, but it can importantly set the basis for developing an overarching pedagogical framework that can guide translation to clinical settings. Pedagogical frameworks coherently and meaningfully tie together a series of principles to inform practice design. Such pedagogical frameworks have largely contributed, in the motor behaviour field, to shaping the way movement educators design their tasks in physical education and sport [9]. In our EE example, the 6 identified principles will inform a novel conceptualization of the paradigm and will guide the creation of novel resources and teaching didactical methods. This will advance the translation of the impact of EE seen in animals to human populations and meaningfully provide a substantial contribution to advancing rehabilitation practices.

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