*Cover letter instructions (from eNeuro on registered reports)*

* *A brief scientific case for consideration. Authors are encouraged to refer to the likely replication value of the research. High-value replication studies are welcome in addition to novel studies.*
* *A statement confirming that all necessary support (e.g. funding, facilities) and approvals (e.g. ethics) are in place for the proposed research. Note that manuscripts will be generally considered only for studies that are able to commence immediately; however authors with alternative plans are encouraged to contact the central office for advice ([eNeuro@sfn.org](mailto:eNeuro@sfn.org)).*
* *An anticipated timeline for completing the study if the initial submission is accepted.*
* *A statement confirming that the authors agree to share their raw data, any digital study materials, and laboratory log for all published results.*
* *A statement confirming that, following IPA, the authors agree to register their approved protocol on the Open Science Framework or other recognized repository, either publicly or under private embargo until submission of the Stage 2 manuscript.*
* *A statement confirming that if the authors later withdraw their paper, they agree to the Journal publishing a short summary of the pre-registered study under a section Withdrawn Registrations*

Date

Dear Editor,

We are submitting the Registered Report, **“The role of movement consistency in locomotor use-dependent learning”**, to be considered for publication in *eNeuro*.

Repetition is an essential component of motor skill acquisition. Yet, even after skills are well-learned, repetition continues to impact movement patterns—by reducing movement preparation time, increasing movement speeds, and, most relevant to the current study, biasing future movements to be more similar to repeated ones ((Mawase et al. 20??, speed paper, Diedrichsen). This “use-dependent” learning is distinct from well-studied forms of error-based learning, such as sensorimotor adaptation, in that it occurs independent of an error signal and is purely repetition-based. Thus, use-dependent learning is linked to Hebbian learning and considered a basic form of motor memory (V & S, Classen et al. 1998).

To date, use-dependent learning has been almost exclusively studied in upper-extremity movements, and rarely looked at in lower-extremity activities. This is surprising given that walking is, by definition, a repetitive, cyclical movement that is repeated until a destination is reached; thus, walking also provides an excellent opportunity to study a repetition-based learning mechanism. Our recently published manuscript (Wood et al., 2020) represents an early attempt in this field to tackle use-dependent learning in walking from a mechanistic perspective. In the study, participants increased their stepping asymmetry in response to visual targets on a computer screen, causing them to walk with a limp. Of note, the visual feedback provided to participants was veridical, and therefore participants learned, and practiced, this asymmetry in the absence of sensory prediction error (i.e., difference between expected and actual sensory feedback). After several minutes of practice, when the participants were asked to return to normal walking without any visual feedback, the limp persisted for more than XX minutes, indicating use-dependent learning.

In the proposed study, we aim to extend prior work on use-dependent learning by examining constraints on this process during walking and providing a computational framework for understanding this basic form of learning. Through a combination of computational modeling, simulations, and a series of behavioral experiments, we directly tackle the question of how the consistency of movement patterns impacts use-dependent learning. We first provide two distinct computational accounts of how UDP may arise. In the Adaptive Bayesian model, adopted from a study of reaching (Verstynen and Sabes, 2011), UDP is framed as a process which combines quickly adapting prior probabilities of target (step) locations with current sensory estimates of where to step. Thus, the magnitude of use-dependent bias is directly related to the consistency of the environment, or target locations. Our second model involves two processes acting in parallel: a strategic learning process that is active when the goal is to match step lengths to visual targets, and in parallel, a slowly updating UDP process that biases movements in the direction of immediately preceding movements ( Diedrichsen et al., 2010). Critically, our two-process model is much less sensitive to the consistency of the environment than the Bayesian model. Thus, we have designed a set of walking experiments that systematically vary environmental consistency and assess the state of use-dependent biases during no-feedback trials in order to discriminate between these two competing theories on the underlying constraints of use-dependent learning.

We currently have approval from the University of Delaware Institutional Review Board to perform this work. We furthermore have the facilities and funding to complete the work. However, all labs have been shut down due to the COVID-19 pandemic. Data collections are ready to be initiated as soon as human research resumes at the university. Given uncertainty around when labs will be reopened, we offer a proposed resubmission window from November 15th, 2020 to May 15th, 2021.

All authors agree to share the raw data, any digital study materials, including experimental and analysis code, and laboratory log for all published results. We will also register the protocol on the Open Science Framework regardless of our acceptance here. We expect other labs and research groups will have a strong interest in trying to replicate the results of this work, as the topic should be of interest to neuroscientists engaged in motor learning, locomotion, and clinical research. Thus, our steps towards transparency in all aspects of this research project should facilitate others’ efforts in this direction. Lastly, if we later withdraw this paper, we agree to eNeuro publishing a short summary of the pre-registered study under the Withdrawn Registration section.

We look forward to your assessment.

Sincerely,

Jonathan Wood, Susanne Morton and Hyosub Kim