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New Clear Fusion – Harnessing the Energies of Psychology, Neuroscience and Exercise Physiology in Neurorehabilitation

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Abstract
In this paper, the authors introduce a novel framework for rehabilitation. This framework is intended to be one that feels intuitive, is grounded in evidence, supports clinical decision making, and serves multiple professions. This approach intended to bring together, to fuse, knowledge from psychology, neuroscience, neurorehabilitation and exercise physiology in an adaptable fashion that provides space for patient preferences. This approach, known as High Intensity Unloaded-Loaded-Unloaded (HULU) is a framework that can be leveraged in efforts to promote skill acquisition, as well as skill re-acquisition (rehabilitation after loss). HULU is intended to provide structure for treatment planning and afford therapist-patient (or therapist-athlete) dyads to create engaging, precise and person-specific dosage when the goal is learning to capture or recapture skills for athletics, occupation, mobility, activities of daily living, or instrumental activities of daily living. While this framework is not intended to serve all people, it will provide clinicians with an easy and logical tool to implement the principles of exercise physiology, neuroplasticity and psychology while leveraging approaches from the OPTIMAL Theory of Motor Learning, Motivational Interviewing and occupation-centered care via engagement pathways influencing intensity, attention and awareness.

Introduction

In physical therapy (PT), occupational therapy (OT), and speech-language pathology (SLP), we should have some unifying principles. Beyond an appreciation for the importance of patient engagement, the skilled nature of clinical decision-making, and the changeable nature of the brain (neuroplasticity), we have very few commonalities in what each field reads, writes about, or practices. Instead, each profession has remained relatively encapsulated within their silos, without endorsing any unified approaches or positions (white papers or otherwise), that strengthen our collective.

Instead of collaborating for unified empowerment, the allied professions tend-to divide-up the body, assign functional activities and develop our own silos of nomenclature. We come back together as a multidisciplinary team in the conference rooms of inpatient rehabilitation centers for team meetings and family education.

While it is unlikely that the fields of coaching and rehabilitation need more jargon and terminology, it is likely that these professions would benefit from a common approach that includes the people that we serve. As a group, we lack a collectivism that either unifies our professions or aligns us in scientific discovery. Our professions have untapped potential to align forces for a 1 + 1 + 1 = 5 outcome.

In an age where the patient is recognized and included as a team member, we are compelled to ask, what do these three professions have in common with the people that we serve? We all place value in science that informs our care, interventions that both embody science and feel translatable, and experiences that feel challenging, intense (where appropriate), salient and engaging.

The novel framework introduced here, High intensity Unloaded – Loaded – Unloaded (HULU) therapy is intended to be a new, clear fusion of these values, serving therapists and patients alike in hospitals, clinics, classrooms, facilities, athletic settings, workplaces and homes.

Historical Background Providing Context for a Unifying Approach

Neurologic rehabilitation has been evolving and improving over the last 100 years. Along the way, the practice and professions have experienced a series of pendular swings and identity crises on topics regarding developmental sequencing, allowing patients to error, the utility of therapeutic exercise vs. task specific practice, the definition and application of intensity, practitioners' hierarchical responsibility for care planning versus patient autonomy, the use of therapeutic touch and manual cues, as well as the need for randomized controlled trials with clinical practice guides vs. personalized care. While some of these crises should leave room for growth and middle-ground, there is often a sense of absolutism (most notably in PT) that results in professions defeating themselves from within, leaving payers and other practitioners laughing and benefiting from the infighting. These pendular swings and pedagogical camps make it challenging to develop curriculum, make it difficult for students to feel confident in clinical decision-making, and make it challenging for both referral sources and payors to take rehabilitation professionals seriously as scientists.

Readers may be best prepared to read this paper introducing such a unifying approach if they have a foundational knowledge of motor learning and an understanding of the principles of neuroplasticity. We suggest Kleim and Jones (2008) on the principles of neuroplasticity and more exemplary papers cited here that include authors from PT, OT, and SLP as exceptional starting points for the concepts of motor learning (Fisher et al., 2014; Leech et al., 2022; Sohlberg & Mateer, 2001; Shumway-Cook et al., 2023; Winstein et al., 2014; Wulf & Lewthwaite, 2016).

The authors propose a common ground across all practitioners in neurologic rehabilitation, to serve as a basis for this paper. This common ground includes considerations that rehabilitation requires a sufficient stimulus to promote neuroplasticity, that precision care is improved through person-specific care, and that rehabilitation can be strengthened through patient engagement.

Regarding the first point, neuroplasticity, as a rehabilitation community we recognize that the human brain is changeable in most situations and conditions. These changes occur through structural, chemical and electrical processes that result in changed behavior (learning) that is underpinned by neuroplasticity. While in some diagnoses a patient will experience spontaneous recovery, neuroplasticity requires a stimulus.

The neuroplastic stimulus must be sufficient to promote neuroplasticity may come in the form of practice that includes errors, intensity, a challenge, or the need to avoid a potential consequence (imbalance, frustration, missed goal/target). The dosage in terms of intensity and repetitions of the stimulus will be condition, acuity, and person-specific. Even people with the same diagnosis and severity (presentation) respond differently to most any rehabilitation variable that could be considered. Therapists should make clinical decisions with consideration for feedback, instruction, practice, error frequency, intensity, novelty, divided attention, and autonomy. We need a means to grade such variables with patient input.

Ultimately, a higher level of engagement is beneficial, yet not mandatory, to optimize learning and promote neuroplasticity. There are many ways to engage a person in rehabilitation. We can engage people with play, salience, gamification, music, autonomy, agency/inclusion, intensity, sensory preferences, as well as a person-specific approach built with therapist-patient collaboration. Patients that can see their improvement may be more likely to remain engaged. As such, some rehabilitation approaches provide patients with an opportunity to observe and reflect on their past and present function.

Finally, before we introduce the underlying assumptions and basis for HULU, it is important to clarify the word choices readers will see in this article. The authors frequently use the term "person" to indicate an appreciation for the biopsychosocial attributes that may precede a condition, including their lived experiences, preferences and biases. We will use the term "patient" which might indicate a known diagnosis or heath care relationship. However, we recognize that we could use terms such as client, customer, student, or athlete depending on the setting. In all cases they were before and will always remain, a person, beyond the diagnosis and setting.

Underlying Assumptions and Principles Defined

Readers are encouraged to review the terms listed here along with their operational definitions as a basis for understanding the assumptions made in developing HULU. This paper does not intend to explain the mechanisms of action or attempt to provide a comprehensive list of applications, but rather to introduce HULU to the rehabilitative and scientific communities for the framework to be fully vetted. As such, these learning-based definitions and this disclaimer may offer some clarity for what is included and what is left-out of the ensuing paragraphs.

Autonomy is the degree of gain realized when a learner is given agency and choice in deciding elements of instruction (assistance, cues) or dosage (intensity, time, type) (Iwatsuki et al., 2017; Li et al., 2024; Wulf & Lewthwaite, 2016). Therapists will recall that not all people prefer autonomy in their medical or rehabilitative relationships. Those that do not prefer autonomy or choice may benefit from therapists explaining why they chose a given element specifically for this task.

Constraint is an element introduced in training to restrict movement or cognitive solutions toward an assumed optimal or to elevate tolerance to challenging conditions (adaptability, reduced time, unfavorable weather, safe but undesirable consequences, instability, time under tension, or force) (Dehghansai et al., 2020; Hodapp & Rabovsky, 2024; Moy et al., 2024).

Predictive Processing (PP) is an interconnected operation concentrated in the brain that requires a dynamic interplay between semantic and procedural memories (facts learned and lived experiences) with real-time sensory information (resulting in the perception of current task-environment-context) in an effort to make sense, be prepared, be accurate, and be safe (Allen et al., 2021; Bracco et al., 2026; Karabüklü et al., 2025; Mouatt et al., 2023).

Predictive Code or Predictive Set describe expectations that are built from PP applying to this context-environment-task combination leading to an expectation of what the experience or result will be or what motor control is required (Barron et al., 2020; Fitch & Barnstaple, 2024; Grossberg, 2021; Köster et al., 2020). To be clear, PP is the dynamic operation or equation that is consistently updated; Predictive Code being the "opinion" for this task, this context, or this environment.

Post Activation Performance Enhancement (PAPE) is the net improvement in motor control and neuromuscular recruitment that is temporary yet follows from recent experience. Most typically PAPE refers to the benefit of order wherein an intense trial or repetition precedes a less-intense repetition (Biéchy et al., 2025; Rumeau et al., 2023; Rumeau et al., 2024).

The HULU framework embodies all of these principles. The benefits of this framework are optimized when a person is offered autonomy (deciding what type of load from options created by the therapist); endures a constraint (the load), and engages in a less-intense repetition after a more intense repetition (PAPE).

It would be expected and normal for a patient to establish a prediction about how well they will do on a given task once it is explained. Patients could be expected to adjust their prediction following their initial unloaded trial. This prediction based on prior knowledge and limited experience is known as a Predictive Code or Predictive Set. A patient would likely to eclipse their prior performance in the second unloaded trial. When the Predictive Code is exceeded by performance, a person can be said to experience a positive prediction error or what is known as a Reward Prediction Error. This is an overly-simplified and intentionally reductive explanation, sufficient for an overview.

HULU Defined

High intensity Unloaded – Loaded – Unloaded framework will indeed be intense, but what does intensity truly mean in the context of a neuroplastic stimulus?

Kleim and Jones (2008) introduced 10 essential principles to induce neuroplasticity. Principle 5 being referred to as, "Intensity Matters". The authors made their case for "intensity matters" by writing, "Induction of plasticity requires sufficient training intensity.". The authors further clarified that, "higher intensity stimulation will induce long term potentiation" and that intensity could include constraint induced movement (citing science in aphasia and animal studies). However, in the years since this seminal article, intensity has (in some circles) come to be synonymous with high exertion training, effectively leaving-behind intensity that can be delivered by potential consequence, accuracy, or the demands of pressure.

The expansion of intensity beyond exertion opens the door to a broader and arguably more clinically relevant conversation, especially for people where exertion-based intensity is contraindicated, poorly tolerated, or simply misaligned with the goal (skill to be developed or function to be recaptured). Consider the person recovering from post-concussion visual motion sensitivity, for whom a busy parking lot or a scrolling screen represents a profoundly intense stimulus, not by any cardiovascular measure, but by the degree to which it disrupts multisensory integration and provokes an increase in symptoms. As Allen, Trofimova, and Ahluwalia (2021) discussed, post concussive visual motion sensitivity is associated with measurable alterations in central vestibular network processing, with symptom intensity correlating with fMRI-identified disruptions in multisensory integration not with heart rate, or physical load. Similarly, a person with a Functional Neurological Disorder (FND) may not benefit from exertion-based intensity. The act of performing a feared movement, for example, turning the head, crossing a busy intersection, or rising from a chair after months of avoidance, carry an intensity their own, calibrated not by RPE but possibly by the degree of threat or potential consequence – and tolerated best when under some degree of patient control. In these contexts, clinician-patient teams may use more familiar proxies to communicate about the intensity of that experience. This exchange might employ visual analog scales (VAS) or patient reported outcome measures (PROMs). Table 1 offers the reader some practical examples of tools that may convey intensity outside of physical exertion.

Table 1: Clinical Tools to Convey Intensity Beyond Exertion

Clinical Tool (patient reported)	Description
Rate of Perceived Stability (RPS) (Bae et al., 2024; Shenoy et al., 2022)	Most typically a 1 to 5 or 1 to 7 scale rating the degree of balance challenge, conveyed from patient to therapist.
Subjective Units of Distress Scale (SUDS) (Wolpe & Lazarus, 1966; Mattera & Zaboski, 2025)	Visual analog scale rating the degree of emotional or physical intensity perceived from a given stimulus. This might describe intensity from light, sound, cognitive load or other.
Rate of Perceived Challenge (RPC) (Hendricks et al., 2019)	A 1 to 7 scale rating the degree of cognitive intensity, conveyed from patient to therapist. Often used in dual task applications.
NASA Task Load Index (Bolton et al., 2023; Cao et al., 2009; Hart, 2006).	A scale representing an individual's perceived effort across six dimensions: mental, physical, performance, temporal, effort, frustration

Note: The Subjective Units of Distress Scale (SUDS; Wolpe and Lazarus, 1966), long used to sequence graded exposure hierarchies in anxiety, trauma, and fear-avoidance conditions. While recent psychometric scrutiny has raised valid concerns about its construct validity and precision as a stand-alone measure (Mattera & Zaboski, 2025), its clinical utility as a real-time, patient-generated indicator of perceived threat intensity, especially when supplemented by behavioral observation and subjective inquiry remains recognized in exposure-based practice.

A person with the FND subtype known as Persistent Postural Perceptual Dizziness (PPPD) may rate the experience of walking independently across a sidewalk with other pedestrian traffic as intense. A person recovering from a stroke with residual difficulties in expression may be invited to give a speech celebrating their daughter's wedding. An individual with Parkinson's Disease may be independently preparing their holiday-tradition meal for a large family gathering. These experiences may all feel intense.

To create a dosage or document improvement, we should rate the intensity experienced in these situations. The numbers generated from scales of intensity (see examples in Table 1) would provide a score representing intensity that is real, person-specific and person-generated. These scores are no-less a representation of intensity as a Rate of Perceived Exertion (RPE) would be, providing a clinically actionable score (Bae et al., 2024; Bolton et al., 2023; Cao et al., 2009; Hart, 2006; Shenoy et al., 2022).

While this final example on the point of intensity is oversimplified, it may be of service to convey the point of intensity, being essential for dosing a therapeutic stimulus. A challenging balance task practiced with a person's heart rate remaining low, at 62 beats per minute, can still be sufficiently intense to be neuroplastic via difficulty, accuracy or challenge. The level of balance challenge ascribed through difficulty (compliant surface, narrow base of support) can be engaging through the nature of being realized as a surprising success, or even a near-miss ("I almost made a personal-best amount of time with my eyes closed"). Either result (personal best or near-miss) can serve as a sufficient intensity to be a neuroplastic stimulus contributing to motor learning that is processed as a meaningful event that can be tagged for consolidation later that night. Neuroplasticity does not require full-time exertion or even intervals of high exertion. It is tempting to conflate exertion with intensity. It is additionally easy to misunderstand that exertion would be the only mode for delivering intensity. Having redefined intensity to include difficulty, to include challenge, or in some instances compelling accuracy, we come to the U-L-U, defining loaded and unloaded experiences, best introduced with Figure 1, HULU.

Unload (U1) → Load (L) → Unload (U2)

Figure 1: The HULU Method

The first unloaded trial (U1) establishes a baseline impression of what to expect of the task and of themselves (my score, tolerance, fear, comfort or familiarity). This may be as simple as a single repetition of supine to sit, reading one sentence, pulling on a sock, or threading a nut onto a bolt. Then, the loaded trial (L) introduces a carefully negotiated additional demand which as noted in most cases would include the patient in design. In the aforementioned examples the loaded trial might include supine to sit with a weight vest on, reading one sentence with a distraction in the background, pulling on a sock while sitting on an unstable surface, or threading a nut onto a bolt with 2# wrist weights on.

Now, at the second unloaded trial (U2), the patient performs the task again, without the load. This order affords a U1 to U2 comparison that patients with intact or emerging awareness might naturally conduct without prompting.

This reductive overview merely introduces the approach, yet glosses-over the opportunities for elevated awareness, patient engagement, therapeutic alliance, collaboration, and enhanced expectancies. There are many opportunities to enrich the learning environment in HULU.

The HULU framework invites the clinician and patient to co-construct the load. This may include a load that feels like a perfect amount of intensity to be experienced briefly. The modalities or modes of load are detailed more in Table 2, yet could include options such as exertion, accuracy, pressure (time or consequence), sensory (light, noise), or cognitive (e.g. responsibilities in divided attention, novelty, or recall responsibilities). The keys here being that a discussion will occur between patient and therapist about the particulars of the load. On a treadmill, this might include speed, incline, ankle weights, hands-on/off, or even targets on the treadmill belt. In a kitchen, this might include wrist weights, a time component or a functional reach excursion. In a classroom setting, this might involve auditory comprehension with degrees of distracting stimuli (sounds and motion that are heard and seen yet to be filtered).

Table 2: The Modes of Load

Load Mode	Description	Example
Physical	Any element that makes the task more physically challenging or would require more METS.	Incline, speed, resistance cord or cable, weight vest or cuffs, perturbations, surface height to arise from or compliant surface.
Complexity	Task complexity: Any feature intrinsic to the activity that requires more processing, filtering irrelevant stimuli, decision-making, or any other cognitive exertion for successful execution. Environmental complexity: Any element that draws attention or requires the learner to filter attention without participating in the distractions; contextual factors external to the task, including sensory environment, social demands, and physical space.	Task complexity: Multiple steps to a recipe, putting on a shirt with a disorienting pattern, cutting a smaller vegetable. Environmental complexity: Cooking in a loud kitchen, putting on a shirt in a dark room, more cars or pedestrians on the road, obstacles in gait, ambient noises or optokinetic stimuli
Cognitive	Elements of divided attention that require the simultaneous participation alongside the primary task. Must be measurable and discrete. May be graded with novelty or volume.	Walking and removing an item from a backpack. Dressing and singing along to a preferred song, or listening to a set of instructions that do not pertain to dressing. Chewing and swallowing while listening intently to conversations that one will participate-in.
Psychological	Environmental context: Observers Situational context: Importance of success Combined situational and environmental: Potential embarrassment or injury Elements of consequence, potentially triggering either symptoms (e.g. pain, nausea), or emotion (e.g. fear, embarrassment Exposure or risk of exposure to stressors related to co-occurring conditions (OCD, autism, etc.) Increased independence (physical or cueing-assistance)	Being observed by scouts at an important game. Overtly announced elements of pressure by time or accuracy, “Can you beat this score?” Hurrying to the restroom to avoid incontinence. Driver’s test or other examination. Elevated expectations in the form of social demands Engaging in a trial for the first time without contact-guard assistance; without real-time cues from a therapist; or without a memory notebook to recheck a complex sequence.

This discussion of load can foster therapeutic alliance and provide space for patient autonomy (perhaps even patient control). While the load is temporary, often only lasting one or two repetitions, this too can be a point for patients to state their preference (e.g. removing the load after 2 repetitions, 7 steps, 30 seconds). When learners have agency in the load, they may feel that the environment for learning is known and supportive, affording the best opportunity to mitigate fear.

Before leaving the discussion of load, it may be helpful to explain that the framework provides space to include “addition through subtraction”. As will be detailed later in the applications section, readers will be invited to see that removing assistance can be an effective means to add load, albeit only temporary and with provisions for both physical and psychological safety.

The second unloaded trial (U2) affords the person an opportunity to update their impression (score, tolerance, fear, comfort, familiarity) and to naturally compare the performances U1-U2. The comparison can be engaging, regardless of the outcome, a “win” or a “near miss” through the now well-established mechanisms of PP, the mind’s need to make sense and predict future interactions for purposes that we can only assume for now, and may never be able to ascribe a singular motive to demonstrate control, provide comfort or ensure protection.

In an effort to summarize what we have read about the HULU framework to this point, we reiterate the definitions.

U1 is simply performing a task in its natural form – context, speed, pressure, resistance. Loaded (L) is performing a task with an added degree of difficulty or the pressure of increased responsibility or increased independence. As depicted in Table 2, the options include physical (resistance, speed, perturbation, compliant surface); complexity; cognitive (novel challenge, or dual task); or psychological. Psychological load can be overt or subtle, coming in the forms of more complex cognitive demands, more complex or distracting environment, added pressure (time constraint), elevated independence, more potential risk/consequence (less-access to a stabilizing surface), or even an elevated and unwelcomed sensation (fear, anxiety, potential for embarrassment). The choice of which load category to apply and how long to apply it gives the therapist-patient team an opportunity to build their relationship and collaborate accordingly. To conclude the framework cycle, U2 includes returning to the original task without a load. Providing the learner/performer with an opportunity to face the task with the "load" removed.

In this framework the order of operations is critical. As will be detailed, the learner establishes a predictive set with the first "unloaded" trial. The second trial provides an opportunity to maintain their established level of performance under the duress of an additional load. The third trial affords the learner to benefit from the control generated to overcome the load (constraint), and perform without that constraint, yielding the likely outcome that they will naturally exceed their own predictive modeling, yielding an opportunity for enhanced expectations.

The Scientific Basis for Hulu

Load and Overload as Constraints in Training

In competitive weightlifting, the approach of training under additional constraint (heavy load) can be known as supramaximal loading, the "H" of HULU. Aune et al. (2026) write about overload in their paper on balance training, "The overload principle is a well-established concept in exercise physiology, emphasizing that to improve, a system must be challenged beyond its current capacity by imposing greater-than-normal demands on the body or motor system to induce physiological or neural adaptations…in line with research on neuroplasticity, which have shown that the plasticity (adaptation and adjustment ability) of the neuromuscular system is substantial and increases because of specific training with progressive overload." The authors cite the seminal Challenge Point Framework (CPF) article by Guadagnoli and Lee (2004) in their work, noting that overload is effective and consistent with the CPF in efforts to, "apply overload in a targeted manner strategically to find the optimal challenge point for the learner to promote skill acquisition." While some authors use the terms "progressive overload" and others use the term "overload", there is commonality to be found in manipulating a task to the level of difficulty that this learner can handle at this time (Aune et al., 2026; Guadagnoli & Lee, 2004; Plotkin et al., 2022).

Training that is targeted toward motor learning or re-learning requires a stimulus. Elevating difficulty can be that stimulus and can come in many different forms. Overloading a task by adding a physical load, cognitive load, or psychological load can be that stimulus. In the Dynamical Systems Theory, this may be referred to as a task constraint, encouraging a change toward a new state, or a novel movement pattern. In the Constraints Led Approach (CLA), loading the learner across any of these pathways can promote a use-dependent (or experience-dependent) neuroplastic effect that is vertically-beneficial throughout the nervous system from the premotor and motor cortices through to the motor unit, including vertically in the reverse direction (bottom-up) from the motor unit.

It should be reiterated that the science of load includes the full palette of intensity. Load is more than just resistance and near-maximal exertion. Practicing in a more complex environment has evidence to suggest that this element can stimulate neuroplasticity as well. This evidence can be found both in rehabilitation and in skill development where the reader may expect to see this referred to as the Constraints Led Approach in skill development and in athletics. This might be referred-to ask work hardening in occupational medicine. Equally representative of load could be a music teacher asking for an up-tempo repetition of a piece in practice, or an SLP-patient team agreeing that adding an irrelevant distractor, music to be filtered-out while undergoing reading comprehension training could be ultimately beneficial.

The Reversal Principle

While oversimplified, the A-B-A reversal (specifically referring to the U-L-U of HULU) provides for a physiologic enhancement of voluntary force production for a short period of time after near-maximal recruitment. This phenomenon is most widely cited in resistance-based loading and deemed to be more common in muscles with a high proportion of type II fibers and is in this context known as PAPE, (Blazevich & Babault, 2019; Calkins et al., 2025; Da Costa et al., 2023; Moriarty et al., 2022; Qu et al., 2026; Rumeau et al., 2023; Tseng et al., 2021). Recently, dynamic warm-ups have been suggested to be beneficial by leveraging the local (peripheral) mechanisms under the PAPE phenomenon (Blazevich & Babault, 2019).

Moriarty et al. (2022) studied the effects of exercise on the primary motor cortex activation. This group as well as others have cited the benefits of various combinations of motor imagery, single-bouts of aerobic exercise or near-maximal repetitions to potentiate performers using a priming-effect for both immediate performance, and learning. While beyond the scope of this paper, readers are directed to investigate the concept of Active Inference. Active Inference may be salient in the HULU design by leveraging the brain's predictive set (as defined previously), expectations built from experience applying to this context-environment-task combination) that are challenged across such a three-repetition design where the conditions change before returning to baseline (Moriarty et al., 2022).

Revisiting overload, Aune et al. (2026) wrote, "*(overtraining induces adaptations that) include strengthened neural representations of the practiced task within sensorimotor cortical areas, enhanced efficiency of task-relevant motor unit recruitment, or refined integration of sensory information that is uniquely engaged during specific training with overload.*

These changes probably result from experience-dependent plasticity, where repeated performance of a given motor task selectively reinforces the synaptic connections and neural pathways relevant to the specific task executed.". These findings (positive-rebound effects after training in a constrained or overloaded context) are supported by many works in neuroscience and neurorehabilitation, including forced-use, constraint-induced, and error-augmented approaches, wherein the learner and therapist expect a positive change after removing a load (Abdollahi et al., 2018; Frost et al., 2022; Marchal-Crespo et al., 2017; Menezes-Oliveira et al., 2024; Tedla et al., 2022).

Autonomy, Expectations and the Patient's Psychological Needs

Wulf and Lewthwaite introduced the OPTIMAL Theory of Motor Learning to the field in 2016. In this article, the authors outlined three primary principles of the model, including Autonomy (AS or Autonomous Support); Enhanced Expectancies (EE) and External Focus (EF). Readers are directed back to this seminal work for details, mechanisms and examples of each. As designed, the HULU approach provides the opportunity for autonomy when patients choose the "mode to load" as well as the extent or duration (a given amount of time or number of repetitions). HULU affords an opportunity to focus on the goal to be achieved (EF), as temptations for internal focus about performance could naturally be dismissed when practicing under load. Finally, HULU's U1-U2 comparison may provide EE, be that from a measurably better performance, or a near-miss. Either could promote hope (EE) that a future trial will be a personal best.

Some learners would be engaged by the natural gamification opportunities in the HULU framework. Deterding et al. (2011) defined gamification as, "the use of game design elements in nongame contexts.". HULU provides a natural opportunity to both compete and compare their own performance (as referenced and as seen in Figure 1, from U1 to U2), leveraging and inviting gamification through a natural human tendency to compete against a past performance. Gamifying U1 to U2 is particularly intuitive, given the limited time from one to the other, referred to as temporal proximity. For reasons of priming the brain (EE) it is expected that a learner would frequently improve their performance in trial three (U2), thereby experiencing a sense of reward. Whether by EE, gamification, or autonomy, there is ample scientific support to expect these experiences to promote the release of dopamine. There is additional scientific support for the benefits of an RPE or even a near-miss. A dopaminergic experience through EE, RPE or a near-miss could be suspected to neuromodulate the brain toward positive growth and reorganization in the form of optimized neuroplasticity.

Winstein and Kay (2015) wrote, "*…there is mounting evidence that when the individual's needs are considered in the context of instructions or expectations, the learning/rehabilitation process is accelerated.*". What are the individual's needs? Inherent in this question is that this is unanswerable for a population as a whole and can only be answered for one person at a time. Human psychological needs in rehabilitation can and likely will include the need to feel safe; the need to see improvement, the need to see that increased effort matters (self-efficacy); (for some) the need to experience agency (safe, believed, understood); to understand that others have succeeded in this same plight before them (vicarious experiences); and ultimately the notion that this care/time in rehabilitation will have a meaningful impact on quality of life. The HULU framework allows-for a person's psychological preferences and needs in two distinct ways. We include the individual's needs or a person's preferences first by providing autonomy through choice. This may come in the form of selecting a mode or dosage from a short list of options selected by the therapist. Second, we leverage familiarity and safety while priming the motor cortex with an activity that this person has both seen and chosen. This biases the third repetition (U2) to be more likely gainful.

While we may never be able to dissect the individual contributions from each of these factors, the effect of combining all the conditions may ultimately position learners to expect and realize more gains in recovery. Some learners cannot express their preferences or fears. In these circumstances, therapists are tasked with reading non-verbal signs and critically appraising gains in motor performance as well as learning, asking themselves, "Is this person tolerating this brief load?" and "Is this person trending-better in the reference task (the goal or function)?".

Providing the learner with the opportunity to be heard and listened-to, both in an initial construct of what load to use, and then a post-task reflection on their experience, heightens the opportunity for the learner to have the lived experience of autonomy. This reflection affords the patient-therapist team to determine to make changes in the load (weight, speed, environmental complexity, dual task novelty, and pressure or consequence-based expectations). Granted the "soft skills" (psychologically informed practice, motivational interviewing, building therapeutic alliance, participating in collaborative decision-making and goal setting, assessing readiness to change) are a collection of approaches built in hard science. These approaches can feel amorphous and challenging for some to apply. The HULU approach makes intentional efforts to fuse principles of therapeutic exercise and neuroplasticity with these hard skills by clearly indicating where autonomy and choice are leveraged to ensure that the learner has been heard and included. These applications, when fused, seamlessly, can prime the brain, elevate the learner's belief that the dosage is safe and therapeutic, engage the placebo effect and ultimately elevate the effectiveness of the intervention (Geers et al., 2013).

The HULU framework creates a natural structure for embedding Motivational Interviewing (MI) into the clinical encounter. First described by Rollnick and Miller (1995), MI is a collaborative, person-centered communication style designed to elicit and strengthen a person's own motivation for change by exploring ambivalence, affirming autonomy, and drawing out the person’s values and goals. Within the HULU sequence, MI is operationalized at two deliberate moments. First, at the outset, when the therapist and learner collaboratively select the mode of load. Second, we use MI following the loaded trial, when a structured reflection invites the learner to appraise their experience. This reflection provides the therapist-learner team with the information needed to make informed adjustments to the load, whether in terms of weight, speed, environmental complexity, dual-task novelty, or pressure-based expectation, grounded in the person’s experience, not just in what the therapist observed.

This exercise-neuroscience-behavioral economics-psychology fusion complement and support the endeavors of precision rehabilitation by considering the person, the timing, and the condition. It should be noted that each element of the fusion is based in hard sciences, not a more derogatory dismissal of “soft skills” with a “soft science” foundation. Through a synthesis of autonomy support from the OPTIMAL Theory of Motor Learning, choice architecture from behavioral economics, and the reflective listening techniques of MI, the HULU approach provides an opportunity to recognize and elevate patient beliefs that the dosage is both safe and therapeutic. This matters because perceived safety and therapeutic expectation are not merely psychological byproducts of good care; they are active mechanisms.

The degree to which choice enhances therapy is not universal, and HULU is designed with this in mind. As Geers et al. (2013) write, “*a growing body of research suggests that when individuals choose between treatment options, treatment effectiveness can increase.*” The group is careful to qualify this, noting that “*when individuals desire control, choice over treatment alternatives improves treatment effectiveness by enhancing personal control.” The operative phrase is “when individuals desire*.” Choice, when genuinely desired, becomes a therapeutic mechanism that activates personal control, strengthens engagement, and amplifies the perceived effectiveness of the intervention. When it is not preferred, however, choice can produce the opposite effect. Schwartz and Ward (2004) described this as the Paradox of Choice, a state in which an excess of options generates decision fatigue, anxiety, and diminished satisfaction rather than empowerment. In clinical practice, this is sometimes observed as Choice Burden, where a patient offered too many decisions disengages from the process rather than investing in it. The invitation to select the “mode of load” (Table 2) within HULU should therefore be offered with attunement extended to patients who signal a preference for agency and gracefully released for those who do not. Recognizing which patient is in front of you in any given session is itself an expression of skilled, person-centered care.

Principles of Neuroplasticity

The HULU framework is well supported by several key principles of experience-dependent neuroplasticity. Kleim and Jones (2008) described ten principles that guide recovery after brain injury, including intensity, use-dependent training, and specificity. HULU addresses each of these directly. The loaded trial brings intensity not only through exertion (Vints et al., 2022), cardiovascular effort, but also through challenge, complexity, and precise movements, factors shown to promote long-term potentiation and synaptic reinforcement (Vints et al., 2022; Kumar et al., 2023; Winstein et al., 2014; Zotey et al., 2023). HULU is also use-dependent by nature. It requires active, skilled involvement with a specific movement task during all three trials, reflecting the idea that the quality and type of experience, not just repetition, drive plasticity. Specificity is inherent using the HULU framework as both task specificity and salience are respected when load is applied atop a functional task. Prosperini and Di Filippo (2019) noted that task-oriented training—rather than more general or holistic methods—is most often linked to measurable structural and functional changes in the nervous system. By tying intensity and load to a meaningful goal, the HULU framework fits this principle and provides a practical way to deliver the kind of targeted, intense, and engaging experiences that research shows are most likely to lead to lasting recovery.

Applying Hulu

Clearly, therapists, athletic trainers and personal trainers alike routinely apply a constraint or a load to their patients or clients, only to remove that load soon after. This is not a novel concept. However, the framework of U-L-U, applied with intent to compare and intent to include the learner, is a novel application. Through this point in the article, it is likely already apparent to readers that this truly is a novel fusion of psychology, neuroscience and exercise physiology in rehabilitation.

Athletic and Mobility-Based Applications Using a “New Clear Fusion”

The athletic applications can be an insightful introduction to HULU, as many people are familiar with these applications under the terms overtraining, constraint, or load. A short list of specific applications aligned with HULU includes parachutes attached to sprinters (speed chute training), a cylinder reducing the opening of a basketball rim, a complex environment in team sports with additional on-field defenders in practice, divided attention or complex visual demands for hitters in baseball, and applications to increase drag for swimmers (drag suits). In each of these examples, to apply the HULU approach with fidelity, the athlete would need to experience the play, shot, lap or drill without the load, then with the load, and again without it to leverage the full psychological, cognitive, and neuromuscular benefits, optimizing the likelihood of performing better without the load and ultimately refining or learning the underlying skill.

In a Mobility Related Activities of Daily Living (MRADLs) application, a person may be recovering their ability to Move from sitting to standing, transfer from a bed to wheelchair, or walk. HULU Lends itself very nicely to these applications simply introducing and overtraining element During the middle repetition. For MRADLs, common examples of load may include an ankle weight or a pair of them, a weighted vest, an obstacle course, a distracting stimulus, a trial with less assistance (reduced body weight support), or even a trial with pressure (less time, no assistive device, or even no assistance).

Application of HULU in Occupation-Centered Care

Some readers will be familiar with the work of Trombly (1995) and Gray (1998) to establish the occupation as ends, occupation as means, framework. Those that are familiar may wonder how to bridge the gap between HULU and occupation-centered care.

For those unfamiliar with her seminal work, Gray argued against component-driven practices that attempt to improve occupational engagement by addressing only the individual performance components. This reductionist approach fails to capture the complexity of occupational engagement, which Gray describes as an "*output of a complex system interacting with the environment*". This may lead to people improving at the prescribed exercises but not in engagement in meaningful activities outside of the clinic.

The proposed solution is occupation as means and as an end, or the integration of purposeful, meaningful, and contextual activities as part of the therapeutic process, not just as the goal of treatment (Gray, 1998). This framework of occupation-centered care has since driven discussion in occupational science research (Fischer et al., 2023; Main et al., 2021; Valdes et al., 2023).

The HULU structure can be implemented by an occupation-centered therapists by focusing on nesting HULU within an occupation as well as addition through subtraction (removing assistance, assistive device, or adaptive equipment).

First, nesting HULU within an occupation. A therapist may initiate a session with a person-selected occupation (e.g. cooking), but within the session identify a specific task that will benefit from a HULU framework (e.g. challenge with chopping onions). In that moment, the therapist and patient may collaboratively determine the U-L-U conditions for targeted practice, then return to complete the occupation.

Nesting HULU within an occupation allows for both the complexity and meaningfulness of occupation to emerge in practice, and the person to benefit from the full range of neuroplasticity principles.

Second, addition through subtraction. This can be accomplished through loading by reducing assistance, assistive devices, or adaptive equipment. As described by Gray (1998), engagement in occupation is limited by a "*complex arrangement of any number of variables*," including the environment. It follows that the more occupation-centered an intervention becomes, the less control the therapist has over the conditions of the task.

Consider a person with visual motion hypersensitivity looking to return to shopping. The therapist will have more control over the loaded condition in a simulated shopping experiment in the clinic, as opposed to a session out in the community where the visual clutter of the aisles, crowd- and noise-level, or movement of other customers may overload the patient in unexpected ways. This creates a unique challenge for the person and the therapist, as this reduces autonomy and increases risk for overloading the patient may be unprepared for at this time. This is why the loaded condition in HULU framework may include an increase in difficulty through addition of a challenge or a variable. In contrast, the loaded condition may include an increase in independence, or a reduction in support provided by the therapist.

Returning to the example of shopping, a therapist may load the condition by reducing the number of verbal cues given to navigate the aisles or by standing behind the person, instead of next to them. These adjustments still increase the challenge of the task, while maintaining a naturalistic, occupation-centered approach.

Application of HULU in Rehabilitation in Reading and Communication

Patient-therapist teams working on reading fluency, reading comprehension, or communication (speaking and listening) can benefit from the HULU application. In the example of reading fluency, the Unloaded task may include measuring reading fluency (recording errors) and time (start to finish). Load could be introduced through complexity with a higher level of vocabulary or distracting music; add pressure to achieve the reading in either less time or with no errors; or divide attention by introducing a memory task before reading that must be recalled after.

Reading comprehension could be loaded in a similar fashion as described, testing fact-retention to demonstrate improved capacity after tolerating the chosen load. As for communication, additional demands of speed (time to convey a thought or rate of audio playback) may be considered.

Reducing the Burden of Care Planning

The demands of clinical documentation and care planning carry a well-recognized cognitive and administrative burden for therapists across settings. A framework that simultaneously structures the clinical encounter, generates measurable outcomes within a single session, and actively involves the learner in their own prescription stands to meaningfully reduce that burden. HULU provides exactly this structure. Rather than requiring a therapist to design a distinct clinical rationale for each component of treatment, the U-L-U sequence is itself the rationale offering a built-in, session-level arc that produces within-session change that is both documentable and defensible as skilled care. Both Zanca et al. (2019) and Hart et al. (2019) contend that demonstrating skilled care in rehabilitation requires clinicians to explicitly articulate treatment targets, active ingredients, and mechanisms of action in ways that both justify services and distinguish their clinical reasoning from what a less-trained provider could offer. The HULU framework operationalizes precisely those decisions embedding dosage selection, load progression, and patient-reported response into a sequence that is transparent and reproducible to payers, care teams, and the patients themselves.

Limitations and Contraindications

As stated in the introduction, the authors do not believe that the HULU approach should be considered an approach grounded in pedagogy. HULU should not become a ubiquitous approach that is suggested to work for everything and everyone. Our professions have fallen into these temptations in the past and should be advised against-such in the future.

While recent research is revealing that we have historically underdosed many patients recovering from stroke, those with Multiple Sclerosis, persons with Parkinson's Disease, persons with Cerebral Palsy and people with many other conditions, therapists may exercise caution in delivering repeated loaded trials until a patient's response can be assessed. Delivery must include clinical decision-making regarding acuity, diagnosis, preference, beliefs and objective data reflecting responsivity, not "just" diagnosis.

There are four exceptions that may give therapists appropriate pause in delivering HULU as described. The first consideration includes applying speed-based challenges with people that have exhibited limited impulse control, "Can you do it faster?". This particular load would likely be contraindicated as it would invite limited impulse control, yet is left for therapists to decide.
The second consideration surrounds therapists applying cognitive overload to persons with severe dementia, those with severely impaired awareness or patients that have exhibited agitation under stress. It may be clear that load should not be delivered to an intensity that would predictably trigger agitation.

The third consideration is in applying consistent and repeated physical load to persons with known or suspected neuromuscular junction disease, those with acute inflammatory demyelinating polyneuropathy, or those with Post Exertional Malaise. This list is not intended to be exhaustive and is left to therapist-discretion for matters of condition or acuity.

Finally, the authors advise caution in delivering the HULU framework to patients that have expressed a preference for more consistent repetitions under the same conditions.

By acting on prediction models and setting performance-based expectations, the HULU approach provides more than a warm-up. Priming may be accomplished through a practice effect, through the intense (central and peripheral recruitment needed in the "L" phase), and a person-specific psychological drive to gamify the third repetition (second "U" phase).

Outside of contraindications, the authors note that the framework is yet to be tested and ultimately will need to be refined. There are five distinct questions that the authors ask themselves and therapists may consider, regarding HULU.

First, therapists may ask if through HULU that we are training for motor performance or motor learning. According to the OPTIMAL Theory of Motor Learning, one feeds the other through enhanced performance that can elevate motor learning. The HULU approach can be delivered in a manner that provides AS, promotes EE and directs goal-directed attention (EF), for what is known as a "triple play", serving motor learning through improvements in motor performance. The authors recognize that the U-L-U is clearly priming performance, that the sense of a win may be priming by creating an ideal environment for neuroplasticity and learning of all forms (motor and otherwise).

Second, we may ask, "what to do" when a gait deviation or unwanted movement pattern emerges under the duress of the load. In many cases, an abnormal or less than efficient (aberrant) movement pattern should be expected under load. If the therapist-patient team value quality of movement such that, "doing the task in a specific way" has value, then we may focus on the movement pattern, and the challenge may include tolerating a load without incurring a loss in movement quality. However, if task participation/completion is the primary value, and the unwanted movement pattern disappears without load, then the stimulus may have served its purpose therapeutically.

Part of clinical decision making, part of precision rehabilitation includes deciding about this person and this intervention at this time. This is the essence of skilled care, which includes an assessment of whether the patient is thriving under this load or is not.

Related, we would expect that therapist-patient teams are most well positioned to determine if the load is tolerated without physical or psychological harm (injury, accumulated fatigue, agitation, or embarrassment that disrupts the therapeutic alliance).

As a point of application, the second unloaded trial (U2) should offer a great deal of insight into the person's capacities (neuromuscular fatigue as well as psychological response (affect)) to rebound after load, from which a therapist-learner team can decide next direction.

Third, it is appropriate to consider if this approach is indicated for persons with neuropathy, adult or pediatric cerebral palsy, subacute stages of Guillan-Barre', Amyotrophic Lateral Sclerosis, or an atypical Parkinson's or Parkinsons-plus condition like Multiple Systems Atrophy. We may discover that HULU serves as an interval-training approach of sorts, in keeping with recent studies on persons with Multiple Sclerosis. This may warrant investigation across other conditions with predominant concerns regarding peripheral fatigue in nerve conduction, at the motor unit, or anterior horn cell.

Related, HULU may serve as a framework for functional task practice that unifies an approach toward Mobility Related Activities of Daily Living (MRADLs), ADLs, most instrumental ADLs (IADLs) as well as high-level sport performance.

PT, OT, and SLPs alike may find that HULU serves as a function-specific interval training approach. Therapist-patient teams may elect to take most any task and, in consecutive sets, apply the U-L-U on repeat.

Finally, therapists should ask if HULU is contraindicated for persons with severe cognitive limitations. While there is no need to make a blanket statement of contraindication for any population, if the framework of HULU cannot be communicated (or perceived), that the framework would not be nearly as effective.

Future Insights, Potential Applications

From the very wise words of Taylor and Kerry (2017), "*We suggest that no approach, no matter how vocal and evangelistic its followers, would likely be any more certain than what preceded it.*". If the HULU framework feels intuitive to practitioners, it may help to increase adoption of new approaches and thereby shorten our evidence to practice gap. The recent implementation of High Intensity Gait Training (HIGT) could theoretically have been made easier through the HULU framework by providing therapist-learner teams with the U-L-U structure and uniquely causing the patient-therapist dyad to find enhanced expectancies as depicted in Figure 1 with the natural U1 to U2 comparison. The same could be said for emerging approaches such as Blood Flow Restriction (BFR) therapy service as the load. The HULU framework may expedite the knowledge translation and adoption for persons with central nervous system impairments. To be clear, the high-speed gait or BFR could be introduced in-sequence as the load (L); surrounded by self-selected gait or lifting the same weight without BFR, on either side (U1, U2) respectively. In this manner, HULU can be seen as a complement to task-specific interval training for movement-based applications, yet also by extension for executive function applications, as will be elaborated. It is worth repeating here that HULU is not meant to serve all patients and all interventions. For example, the application of Constraint Induced Movement Therapy (CIMT) may not be a good fit. Applying a mitten or arm sling may need a larger dosage (volume, in minutes and in hours), than would be suggested with HULU.

Although PAPE has received very little scientific treatment in rehabilitation, we may soon be in a position to determine if the HULU framework could promote a transient dopaminergic boost in learning through Reward Prediction Error, and through enhanced expectancies, ultimately leading to elevated self-efficacy.

Conclusion

HULU may permit more therapist-learner teams to feel safe psychologically, cognitively, and physically to explore more challenge than what the pair might have previously engaged in by offering a small-sized option (as small as one loaded repetition) with an immediate, observable and objective return. This challenge could come in the form of novelty, intensity, pressure, complexity or divided attention and most importantly could complement the growing body of knowledge around play in adult neurorehabilitation (Canepa & Ramenghi, 2026; Hodges & Lohse, 2022).

Clearly, any person-specific approach that can elevate engagement and expectations can, in a virtuous or circular fashion, influence the intensity and errors one would be willing to tolerate. HULU may give people an intuitive and friction-reduced opportunity to safely translate gains from the clinic to home, as they leverage the HULU framework across the very activities and context that they fear-most or are in which they are experiencing a plateau. All possibilities must be weighed-against the limitations previously stated and ultimately examined to ensure that the mechanisms of action become lived experiences.

High Intensity Unload-Load-Unload will never and should never be ubiquitous or mandatory. This approach can prime the nervous system, challenge suppressed predictions, and serve to optimize both implicit and explicit learning, as well as re-learning.

Readers are encouraged to consider and challenge the theoretical underpinnings, apply them in clinical settings and examine the rigor in laboratory settings. The authors welcome this discussion, as we will continue to do the same as well.

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