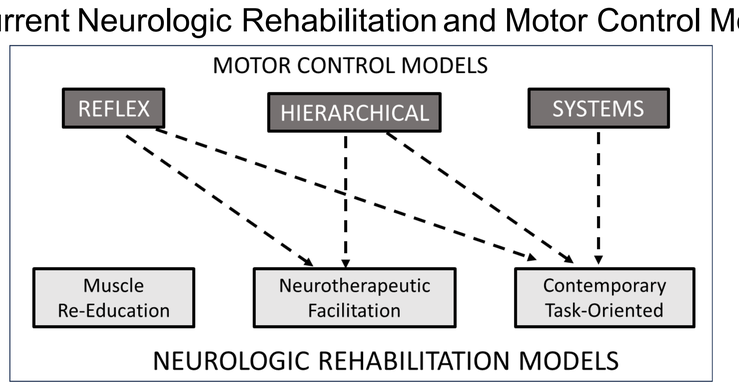
A Neuroplasticity Based Approach: Updating Traditional Neurorehabilitation Models to Include Evidence Based Neuroplasticity Principles

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Introduction

- Assessment and intervention principles used in neurorehabilitation have developed as new evidence has been revealed.
- Previous models described as muscle-reeducation, neurotherapeutic facilitation and task-oriented have been proposed with their underlying assumptions aligned with the reflex, hierarchical and systems models of motor control and recovery, but with no specific relationship to neuroplasticity (Figure 1).

Figure 1. Current Neurologic Rehabilitation and Motor Control Models



Note: American Physical Therapy Association (APTA),1992. Reproduction of this figure was authorized by the APTA.

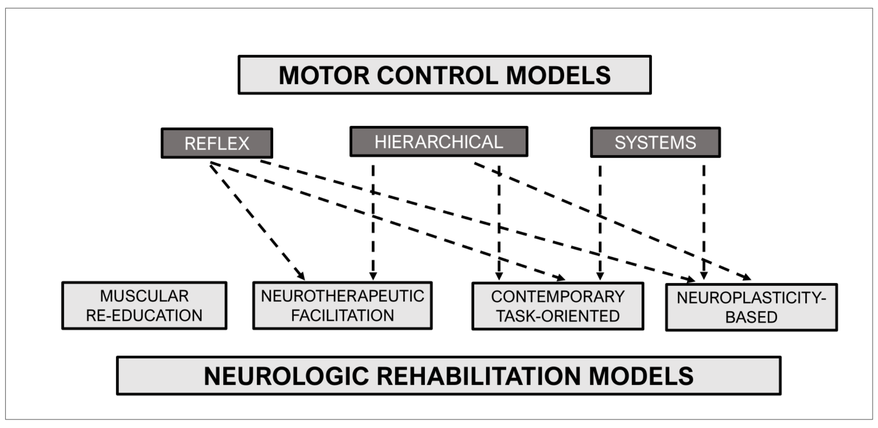
- Over the last 20 years, scientific advances in understanding neuroplasticity mechanisms applied to neurorehabilitation can be included in new neurorehabilitation models to guide evaluation and treatment of individuals with neurologic dysfunctions.

Purpose: Propose and describe a fourth model of neurologic rehabilitation, the Neuroplasticity-Based Approach (NBA)

The Neuroplasticity -Based Approach (NBA)

- The NBA includes five therapeutic aims that guide the elements to be included in therapeutic interventions and, when shaped by individual factors such as age and genetics, lead to a tailored neurorehabilitation program that promotes long-lasting neuroplastic changes. Thus, a forth model could be included in the previous models largely used in the clinical settings (Figure 2).

Figure 2. Proposed addition of the Neuroplasticity-Based Approach (NBA)



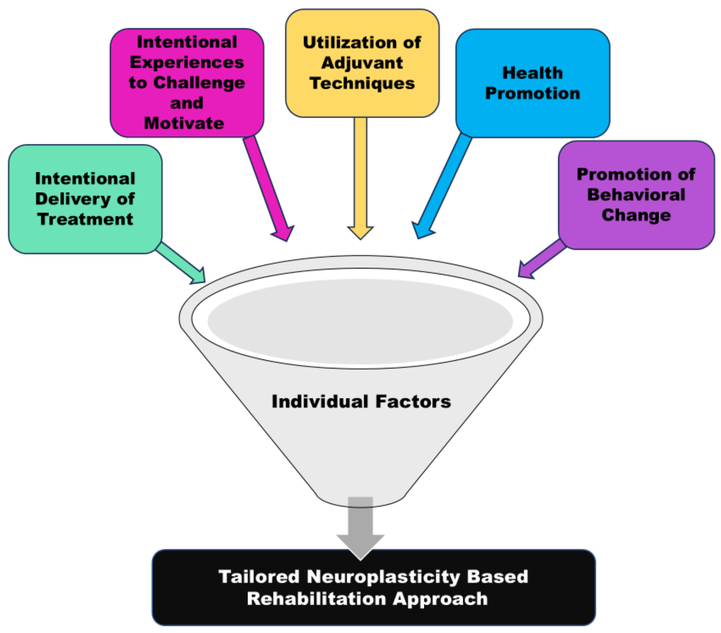
- In comparison to previous neurorehabilitation approaches, the NBA includes unique aspects such as techniques to enhance the central nervous system (CNS)response to training, as well as intensity and hormesis (Table 1).

Table 1. Underlying Therapeutic Aims for Current Neurorehabilitation Approaches

Muscle re-education	Neurotherapeutic facilitation	Contemporary task-oriented	Neuroplasticity-based approach
• Isolate muscle actions by focusing on individual muscles • Maximize strength and use of motor units remaining • Avoid secondary complications and compensatory patterns • Teach functional activities • Provide orthopedic support	• Facilitate normal movement patterns with proprioceptive inputs • Modify CNS from the experience of normal movement patterns • Fractionalize movements by breaking up abnormal synergies • Inhibit abnormal tone and primitive reflexes • Prevent the CNS from learning abnormal movement patterns	• Practice ability to achieve task goals • Teach motor problem-solving (i.e., adaptability to context) • Learn strategies to coordinate efficient, effective behaviors • Develop effective compensations • Use musculoskeletal and environmental constraints	• Optimal delivery of treatment sufficient to induce long-lasting neuroplastic adaptations • Intentional experiences to challenge and motivate • Utilization of adjuvant techniques to enhance CNS responsiveness • Health Promotion • Promotion of behavioral change to increase adherence and facilitate transfer from capacity to performance

- The NBA includes five therapeutic aims (TAs), including: 1) intentional dosing of experiences, 2) intentional design of experiences to challenge and motivate, 3) use of adjuvant interventions to enhance the central nervous system responsiveness, 4) health promotion, and 5) interventions to induce behavioral change (Figure 3).
- Individual factors are a crucial aspect of the model since there are individual differences in neural mechanisms supporting adaptive (or maladaptive) response to intervention.
- This change requires a shift from the "one-size-fits-all" paradigm of previous rehabilitation models, which prioritized treatment regimen over treatment response.
- Three major sources of differential treatment response include to following: 1) demographics; 2) genetics, and 3) clinical factors.

Figure 3: The Neuroplasticity-Based Approach



- Kleim & Jones (2008) proposed principle of use-dependent neuroplasticity in neurorehabilitation. Since then, new scientific advances were discovered and can now be included in the clinical setting.
- The TAs of the NBA includes the principles previously described by Kleim & Jones, and can be applied based on recent studies (Table 2).

Table 2: The application of the NBA Therapeutic Aims of in Relation to Kleim and Jones (2008)

Therapeutic Aims of NBA	Strategies To Employ Aim	Related Kleim & Jones (2008) Use-dependent Principles of Neuroplasticity	Examples of application of the Therapeutic Aims
#1: Optimal delivery of treatment sufficient to induce long term neuroplastic adaptations	• Repetitions should be delivered in massed and blocked practice schedules. Specific tasks should be practiced to improve performance of those tasks before moving onto another task. • Carryover must be seen in functional tasks outside of rehabilitation setting • Acute to subacute phase of recovery is ideal timing for administering rehabilitation.	• Use it or lose it • Use it and improve it • Specificity • Repetition • Intensity • Transference • Interference • Timing matters	CIMT: Kwakkel et al. (2015),[21] Morris et al. (2006),[78] Gauthier et al. (2008),[80] Könönen et al. (2012),[85] Rickards et al. (2014),[86] Sterling et al. (2013),[91] Taub et al. (2013),[79] Barghi et al. (2018),[92] Mark et al. (2018),[93] Demers et al. (2023),[84] Abdullahi et al. (2023)[83] SENSe: Carey et al. (2011)[98] CPASS: Dromerick et al. (2021)[23] LSVT-LOUD: Fox et al. (2012),[99] Liotti et al. (2003),[96] Narayana et al. (2010)[97]
#2: Intentional experiences to challenge and motivate	• Exercise regimens that carefully balance the challenge's level with the individual's capacity for adaptation • Rehabilitation interventions should be designed to include elements of physical exertion/aerobic intensity as determined by heart rate response and RPE, which should ideally reach moderate to high intensity on any measure.	• Intensity • Salience • Specificity	HIGT: Hornby et al. (2022),[100] Hornby et al. (2020),[101] Leech et al. (2016).[102] HIIT: Mang et al. (2013),[33] Calabrese, Mattson (2017)[27]
#3: Utilization of adjuvant techniques to enhance CNS responsiveness	• Explore emerging techniques such as neuromodulation, BFR, and HBOT as adjuvant interventions. • Employ neuromodulation for priming (e.g., TMS, tDCS, VNS) or reinforcement of motor behaviors during task-specific training. • Apply BFR to promote neuroplasticity through metabolic stress, growth factor expression, and cortical excitability. • Utilize aerobic exercise before task practice to optimize CNS responsiveness.	• Specificity • Timing matters • Transference • Interference	Neuromodulation: Polania, Nitsche, Ruff (2018),[38] Evancho, Tyler, McGregor (2023),[39] Stoykov, Madhavan (2015),[40] Dawson et al. (2021)[41] BFR: Li et al. (2022),[42] Yinghao et al. (2022),[43] Brandner, Warmington, Kidgell (2015),[44] Dalsgaard et al. (2003),[45] Tsukamoto et al. (2016),[46] Sugimoto et al. (2021)[47] HBOT: Burtscher et al. (2022),[48] Efrati, Ben-Jacob (2014)[49] Aerobic exercise: Ogoh, Ainslie (2009),[50] Mu et al. (2022),[51] Van Praag et al. (1999),[52] Holschneider et al. (2007),[53] Ben-Zeev et al. (2022),[54] Moriarty et al. (2019)[55]
#4: Health Promotion	• Address modifiable lifestyle factors (i.e, sleep, diet, physical activity) to enhance neuroplasticity. • Assess and monitor sleep quality and duration; recommend interventions and referrals for improving sleep. • Educate clients on a nutrient-rich diet; refer to nutrition specialists as needed. • Promote increased physical activity to enhance motor cortical excitability and neuroplasticity.	• Use it or lose it • Use it and improve it • Transference • Interference	Sleep: Medic et al. (2017),[58] Watson et al. (2015),[59] Mensen et al. (2019),[60] Pearce et al. (2016),[64] Glozier et al. (2017),[65] Yang et al. (2014),[61] Li et al. (2017),[62] Fleming et al. (2020)[63] Diet: Phillips (2022),[56] Poulos et al. (2017)[66] Physical activity: Smith et al. (2021),[67] Falck, Davis, Liu-Ambrose (2017),[68] González, Fuentes, Márquez (2017)[69]
#5: Promotion of behavioral change to increase adherence and facilitate transfer from capacity to performance	• Interventions should include behavioral change techniques • Health behavior theory may be used as a framework for the intervention • Interventions should promote autonomy and self-efficacy. • Interventions should be designed to target optimal cognitive drive to promote engagement.	• Use it or lose it • Use it and improve it • Specificity • Repetition • Intensity • Transference • Interference • Salience	LSVT-LOUD: Fox et al. (2012),[99] Liotti et al. (2003),[96] Narayana et al. (2010)[97] CIMT: Kwakkel et al. (2015),[21] Morris et al. (2006),[78] Gauthier et al. (2008),[80] Könönen et al. (2012),[85] Rickards et al. (2014),[86] Sterling et al. (2013),[91] Taub et al. (2013),[79] Barghi et al. (2018),[92] Mark et al. (2018),[93] Demers et al. (2023),[84] Abdullahi et al. (2023)[83] CIAT: Nenert et al. (2017)[94]

Conclusion

A 4th model of neurologic rehabilitation will assist neurorehabilitation therapists to incorporate current and emerging concepts of neuroplasticity into neurorehabilitation.

References: Scan the QR code to access the list of references

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