Task-specific training: evidence for and translation to clinical practice

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ABSTRACT: There is mounting evidence of the value of task-specific training as a neuromotor intervention in neurological rehabilitation. The evidence is founded in the psychology of motor skill learning and in the neuroscience of experience-dependent and learning-dependent neural plastic changes in the brain in animals and humans. Further, there is growing empirical evidence for the effectiveness of task-specific training in rehabilitation and for neural plastic changes following task-oriented training. In this paper, we position the evidence for task-specific training in the context of rehabilitation; review its relevance for occupation-based neurological rehabilitation, particularly in relation to upper limb function and everyday activities; and recommend evidence-driven strategies for its application. We recommend that task-specific training be routinely applied by occupational therapists as a component of their neuromotor interventions, particularly in management related to post-stroke upper limb recovery. Specifically, we propose five implementation strategies based on review of the evidence. These are: task-specific training should be relevant to the patient/client and to the context; be randomly assigned; be repetitive and involve massed practice; aim towards reconstruction of the whole task; and be reinforced with positive and timely feedback. Copyright © 2009 John Wiley & Sons, Ltd.

Key words: motor rehabilitation, stroke, task specific training

Introduction: task-specific training

There is mounting evidence that therapists treating people affected by a neurological disorder should be prescribing task-specific training in their therapy (National Stroke Foundation, 2005; Winstein et al., 2006; French et al., 2008).
Task-specific training is a term that has evolved from the movement science and motor skill learning literature (Schmidt and Lee, 2005) and is defined as training or therapy where patients ‘practice context-specific motor tasks and receive some form of feedback’ (Teasell et al., 2008, p. 576). In the field of skill learning, it may be associated with different practice conditions, feedback and conditions of transfer (Schmidt and Lee, 2005; Winstein et al., 2006). Task-specific training in rehabilitation focuses on improvement of performance in functional tasks through goal-directed practice and repetition. The focus is on training of functional tasks rather than impairment, such as with muscle strengthening. Other terms used that reflect these elements are ‘repetitive functional task practice’, ‘repetitive task practice’ (French et al., 2008), ‘task-related training’ (Carr and Shepherd, 1982) and ‘task-orientated therapy’ (Bayona et al., 2005).

A strength of the task-specific training approach is in its scientific origins. The evidence informing task-specific training is based on animal (basic science) research (Knapp et al., 1963; Nudo and Milliken, 1996; Nudo et al., 1996), has been developed within the psychology literature of motor control and learning (Schmidt and Lee, 2005), and has since been applied in human studies with ‘healthy’ participants (Schmidt and Lee, 2005) and following injury (Nelson et al., 1996; Winstein et al., 2004; Michaelsen et al., 2006). Further, there is increasing evidence of neural plastic changes associated with training (Richards et al., 2008). Learning is reported to be maximal for the specific task trained (Schmidt, 1991; Goldstone, 1998). Important, repetitive use alone may not be sufficient to effect changes in cortical representation. Rather, changes are associated with specific skill learning, consistent with a learning-dependent model of neural plasticity (Karni et al., 1995; Plautz et al., 2000). Neurophysiological evidence also supports the value of the object used or task undertaken in the organization of movement (Lemon et al., 1991; Turton et al., 1993). The evidence indicates that cortico-motor neuron pools are organized relative to specific tasks rather than specific muscles. Importantly, evidence suggests that motor skill learning capability may be retained in stroke survivors under similar conditions to healthy volunteers (Platz, 2004; Winstein et al., 2006).

Neural plasticity and task-specific training

A major contributor to the theoretical framework informing neuromotor rehabilitation is the evidence concerning brain plasticity. Neuroplasticity refers to the brain’s ability to reorganize itself in response to changes in behavioural demands (Rossini et al., 2003). It is important to remember that this is a capacity of both the healthy and injured brain, and is therefore always active. Non-invasive technology, such as functional magnetic resonance imaging, provides an opportunity to better understand how the brain’s circuits interact with one another, and to explore the reorganization that occurs when one or more areas
of the brain are either partially or completely ‘shut down’ following injury. Researchers have suggested that in time, therapists should be able to decide on the most optimal intervention for an individual based on evidence of residual brain circuits (Guadagno et al., 2003; Dobkin and Carmichael, 2005; Johansson, 2005; Teasell et al., 2005; Duffau, 2006; Carey, 2007; Carey and Seitz, 2007; Stinear et al., 2007).

Animal studies have demonstrated that task-specific training (e.g. skilled reaching task) can restore function by using spared (non-affected) parts of the brain which are generally adjacent to the lesion (Nudo et al., 1996) and/or recruiting supplementary parts of the brain (Nudo et al., 2000). Many authors, including Rossi et al. (2007), have detailed the neurobiological changes underlying the brain’s reorganization in response to task-specific training, concluding:

Regardless of concomitant interventions, the extent of functional improvement is strongly dependent on the specific external stimulation that the rewiring circuits experience. Adaptive cortical reorganization in both intact and injured CNS is not induced by generic use or activation, but requires the application of task-specific training protocols. (Rossi et al., 2007, p. 19)

Neural plastic changes have also been demonstrated in the human brain (Calautti et al., 2001; Carey and Seitz, 2007; Richards et al., 2008) following an ischaemic stroke and neuromotor interventions. For example, the effect of task-oriented arm training on motor function and brain reorganization has been investigated in randomized controlled trials with a small number of patients (Nelles et al., 2001; Carey et al., 2002). Using a task-oriented training regime of intensive finger movement tracking, improvement in finger control was found in association with evidence of brain reorganization in chronic stroke patients (Carey et al., 2002). There are now an increasing number of such studies measuring changes in brain activation patterns following task-specific training which, although still relatively small in participant numbers, provided enough data for meta-analysis (Richards et al., 2008). Findings from this analysis suggest that task-specific training can influence functional outcomes and brain activation patterns.

As summarized by Bayona et al. (2005):

Task-oriented therapy is important. It makes intuitive sense that the best way to relearn a given task is to train specifically for that task. In animals, functional reorganization is greater for tasks that are meaningful to the animal. Repetition alone, without usefulness or meaning in terms of function, is not enough to produce increased motor cortical representations. In humans, less intense but task-specific training regimens with the more affected limb can produce cortical reorganization and associated, meaningful functional improvements. (p. 58)
Evidence for task-specific training in rehabilitation

Evidence indicates that task-specific training could have relevance for people affected by a traumatic brain injury (Canning et al., 2003; Chua et al., 2007), Parkinson’s disease (Mak and Hui-Chan, 2008), a total hip replacement (Drabsch et al., 1998), a work-related injury (McCannon et al., 2005) and/or a spinal cord injury (Betker et al., 2007; Kubasak et al., 2008). However, most of the task-specific training evidence relates to post-stroke recovery. It has been found to be effective in cognitive neurorehabilitation (Calvanio et al., 1993), sensory retraining (Carey et al., 1993), gait retraining (Hesse, 1999; Peurala et al., 2004; Sullivan et al., 2007), sit-to-stand retraining (Canning et al., 2003) and motor training of the upper limb (Feys et al., 1998; Byl et al., 2003; Blennerhassett and Dite, 2004; Page et al., 2004, 2005; Hakkennes and Keating, 2005; Wood-Dauphinee and Kwakkel, 2005; Michaelsen et al., 2006; Wolf et al., 2006).

Task-specific training is a core element of a number of interventions, as discussed below. It may be augmented by strategies to enhance learning, as used in the motor relearning/movement sciences approaches, or to force use of the limb in daily activities, as in the constraint-induced movement therapy (CIMT) approaches (Winstein et al., 2006). Equipment or virtual environments may also be used to facilitate the movement or learning environment. A recent systematic review of repetitive functional task practice in stroke rehabilitation included 31 trials with 1078 participants (French et al., 2008). Overall, it was found that some form of task-specific training resulted in improvement in global motor function, and in both arm and lower limb function, although the evidence for upper limb interventions was less clear because of insufficient good-quality evidence. Nineteen trials, with 634 participants, measured arm or hand function. The pooled effects for the impact of repetitive functional task training across all trials showed small effect sizes, which were statistically significant for arm function and marginally non-significant for the hand. There was little or no evidence for modification of treatment effects because of time post-stroke or dosage of task practice. However, for the upper limb, the type of intervention did impact on treatment effects, with findings from the CIMT studies showing a large, statistically significant effect. Improvement in activities of daily living was also reported, and it was recommended that adverse effects should be monitored with this therapy. Retention effects persisted for up to 6 months, with retention beyond this time unclear. Economic modelling suggested that task-specific training was cost-effective.

Post-stroke, there is evidence that task-specific, upper limb training not only impacts functional recovery, but also brain activation patterns. This evidence includes a meta-analysis by Richards et al. (2008) and a review by Carey and Seitz (2007). Examples of upper limb, task-specific training used included: task-oriented motor training (Nelles et al., 2001); CIMT and household tasks such as ‘eating, opening and closing jars and spring-loaded clothespins’ (Hamzei et al., 2006, p. 712); CIMT and ‘gross and fine motor skills, such as grasping and
using a spoon and picking up an object with a specified grasp' (Schaechter et al., 2002, p. 328); and CIMT and ‘gross motor activities such as throwing a ball and simulating hockey, and fine motor activities using pegs and putty, and general activities related to daily living (ADL)’ (Kim et al., 2004, p. 242). It is worth noting that much of this task-specific training was supervised by physiotherapists, and the rationale for this is not discussed.

Task-specific training: how does it relate to current interventions?

It will be increasingly obvious to the reader that firstly, the term ‘task-specific training’ is part of a broad range of interventions, and secondly, it is difficult to differentiate it from routinely used neuromotor interventions in current occupational therapy practice. For occupational therapists, neuromotor interventions have been historically driven by three primary approaches: neurodevelopmental, sensorimotor and motor relearning approaches (Trombly, 1995; Umphred, 1995). The Bobath (1980) approach, sometimes referred to as neurodevelopmental therapy (NDT), is based on the concept of abnormal patterns of movement and stresses the importance of ‘breaking down’ the abnormal or maladaptive patterns with the use of limb and trunk positioning and/or weight bearing, and is still very much in use today (Langhammer and Stanghelle, 2000). Walker et al. (2000) surveyed therapists in the United Kingdom and found that most reported that they used the Bobath approach when treating stroke patients. While the approach focuses on patterns of movement, it also includes incorporation of these movement strategies in daily activities, once improvements in patterns of movement have been achieved (Davies, 1994), and thus has an element of task-specific practice. It does not, however, recognize that movement is organized according to the object used or the environment.

The sensorimotor approach, originating from the research of Ayres (1965) and further developed by others [e.g. Case-Smith (2005)] is based on theories of a child’s healthy development through a series of motor skill ‘milestones’. Ayres’s approach, although primarily aimed at paediatric neurorehabilitation, has also been used in adult neurorehabilitation (Moulton, 1997). In the sensorimotor approach, therapists selected tasks and activities which enabled them to modulate the amount of stimulation and were ‘of interest’. The sensorimotor approach has some similarities, therefore, with task-specific training in that it is task orientated, uses tasks which are meaningful to the patient and involves repetition and practice. It does not, however, incorporate motor learning principles.

The motor relearning approach, as described by Carr and Shepherd (1982, 2000), is derived from the movement science literature and incorporates principles closely aligned with task-specific training. It includes isolated training practice of impaired essential movements, and then immediate practice within the relevant, specific functional task. As such, it emphasizes specific training of
motor control in everyday activities and represents a shift away from facilitation of movement and exercise therapy. This approach formally identifies the task as integral to effective motor relearning. The repetitive task training is combined with techniques to enhance cognitive involvement (e.g. through functional relevance of tasks used and knowledge of performance). Task-specific training is most closely related to the motor relearning approach, but the two are not synonymous.

An approach that has gained interest more recently and is supported by evidence from animal studies (Knapp et al., 1958, 1963; Taub et al., 1993; Nudo et al., 1996) and systematic review (Hakkennes and Keating, 2005) is CIMT. CIMT is primarily designed to reverse the conditioning that leads to ‘learned non-use’ and aims to promote spontaneous use of the hand through using of ‘shaping’ procedures (Taub et al., 1993, 2002). The approach involves a constraint applied to the less affected limb and intensive upper limb training of the more affected limb. The ‘shaping’ procedure is based on operant conditioning, with the aim of eliciting a behaviour (task goal) and reinforcing it (positive feedback). This involves intensive periods of task practice using shaping and progressive increments in task difficulty, feedback and encouragement (Wolf et al., 2002). Although the approach is task based and involves practice of graded activities, the focus is not on the acquisition of a voluntary skill nor the optimization of motor skill learning (Winstein et al., 2006).

**Task-specific training and use of everyday activities**

It is recognized that ‘movement emerges from an interaction between the individual, the task, and the environment in which the task is being carried out’ (Shumway-Cook and Woollacott, 1995). This model is consistent with the task-oriented, occupation focus of occupational therapy. It has been suggested that the organization of movement of the upper limb for reaching is positively influenced by the conditions in which it is undertaken (Trombly and Wu, 1999). Further, movement kinematics of the upper limb are different under different conditions, from real-life action to simulated conditions, in healthy volunteers (Ross and Nelson, 2000). Similarly, van Vliet et al. (1995) found that there was a difference in movement kinematics of the upper limb when undertaking a more functional goal of drinking from a glass compared to only moving a glass of water, further highlighting the goal of the task. Wu et al. (2000) concluded that the use of real and functional objects might be an effective way of facilitating efficient, smooth and coordinated movement with the impaired arm after stroke.

Task-specific training often uses ‘real-world’ or everyday tasks as the therapeutic medium in functional recovery. In combination with high levels of massed practice, it aims to achieve optimal function, which in turn allows the patient/client to adequately undertake everyday activities (Dobkin and
Carmichael, 2005). To review the importance of tasks and everyday activities in neurorehabilitation, and further, to report this to occupational therapists could well be ‘preaching to the converted’. However, the authors would suggest that this body of evidence serves to validate the focus of occupations, tasks and activities in neuromotor interventions. Suffice to say that researchers and opinion leaders are in agreement that there is ample evidence to support neuromotor interventions, which are task specific and based in and around everyday activities (Blennerhassett and Dite, 2004; Mathiowetz, 2004; Bayona et al., 2005; Dobkin and Carmichael, 2005; Teasell et al., 2005; Kelly et al., 2006). In this context, we may define task-specific training as: training or intervention which utilizes, as its principal therapeutic medium, ordinary everyday activities which are intrinsically and/or extrinsically meaningful to the patient or client.

Recommendations for application of task-specific training in clinical practice

Taking into consideration the limitations and strengths of the evidence available, the authors recommend that: task-specific training be routinely applied by occupational therapists as a component of their neuromotor interventions, particularly in post-stroke upper limb management. Further, authors/researchers should consider using ‘task-specific’ terminology if reporting on outcomes relating to neuromotor interventions, particularly those based in and around everyday tasks, occupations and/or activities.

Following a review of the task-specific evidence, it is also possible to recommend five strategies to guide application of task-specific training in clinical practice. These are consistent with guidelines put forward by others (e.g. Byl et al., 2003; Mathiowetz, 2004; Bayona et al., 2005; Dobkin and Carmichael, 2005; Carey, 2006; Davis, 2006; Krakauer, 2006). The strategies are presented in ‘practice-ready’ dialogue with the aim of assisting therapists in translating them into clinical practice. To facilitate recall, they have been formulated as the five ‘Rs’: (i.e. task-specific training should be relevant, randomly ordered, repetitive, aim towards reconstruction of the whole task and positively reinforced).

Strategy 1: task-specific training should be relevant to the patient and to the context

Firstly, it should involve activities which are intrinsically and/or extrinsically meaningful to the patient (Byl et al., 2003; Bayona et al., 2005; Davis, 2006). A patient-generated index such as the Canadian Occupational Performance Measure (Law et al., 2005) can be used to formally identify these tasks, and this, in turn, can serve as an outcome measure for later reassessment. The evidence infers that to spend large amounts of time and effort on tasks and
activities which, although appearing important to the therapist and/or institution, have no such value for the patient, could be counterproductive.

Secondly, evidence indicates that where possible, the task trained should be ‘real world’ or context specific (Shumway-Cook and Woollacott, 1995). For example, if a patient/client is relearning to use a knife and fork, then they should be doing this in sitting and if possible, with ‘real’ food and using ordinary cutlery and crockery. This evidence supports the move in many neurorehabilitation settings to set up the treatment environment to reflect the usual home and/or community environment. Some may also refer to this as enriching the environment (Johansson, 2005; Davis, 2006).

Strategy 2: task-specific training practice sequences should be randomly ordered

Task variability has been identified as important to increasing ‘generalisation of learning to new tasks’ (Krakauer, 2006, p. 85). Further, evidence indicates that utilizing randomly ordered practice facilitates retention and transfer, thus increasing the task’s generalizability (Schmidt and Lee, 2005). Task-specific therapy, therefore, should be random in its application using differing contexts and settings, and differing occupational demands and sequences (Bayona et al., 2005; Dobkin and Carmichael, 2005; Teasell et al., 2005; Davis, 2006). If task-specific training is too task or movement specific, and applied in only one context or sequence, then potentially the skills re-learned or learned are not as readily applied across similar tasks and alternate settings. Clearly, there are times when this is neither practical nor feasible (e.g. showering), but for the most part, where possible, therapists should randomly schedule therapy routines and task selection.

Strategy 3: task-specific training should be repetitive

Task-specific training should be repetitive and involve massed practice (Schmidt and Lee, 2005; Winstein et al., 2006). The old adage of ‘practice makes perfect’ applies in this context as it is practice which assists the healthy and injured brain alike to master skills and to reorganize to accommodate the new learning. Most researchers (Blennerhassett and Dite, 2004; Mathiowetz, 2004; Bayona et al., 2005) recommend that the more a task is practiced, the better the overall performance. However, Page (2003) suggested that task specificity is clinically more significant than intensity, and recommends that task-specific training is still worth considering even if patients are not able to manage high-intensity treatment regimes.

Bearing in mind that for much of the day, patients in hospital are frequently doing very little (Bernhardt et al., 2007; Hubbard and Parsons, 2007), therapists should assume that more is better and that most patients are not practicing enough. It is recommended that the maximum amount of repetition feasible should be prescribed in task-specific, neuromotor interventions and that the
task-specific environment should be as occupationally demanding as possible (Johansson, 2005), with every opportunity afforded to patients to practice real-world tasks (Teasell et al., 2005).

Strategy 4: task-specific training should aim towards reconstruction of the whole task

When formulating a treatment plan, a therapist will:

- deconstruct a task into its component parts
- assess the patient’s performance of the whole task and of its component parts
- identify which skills and/or component parts are adversely affected and why
- formulate a treatment plan targeted at the mismatch between ‘can do’ and ‘need/want to do’.

Task-specific training should start with skill acquisition and massed practice of the individual component parts (shaping) (Page et al., 2005), moving towards the regrouping and normal sequencing of some, most and, if feasible, eventually all of the component parts. However, in the midst of all the planning, prescribing, goal setting, documenting and discharge planning, the achieving of whole tasks may become lost in the day-to-day activity of the neurorehabilitation setting. Nevertheless, the overriding goal should be the reconstruction of the whole task to maintain focus and motivation.

The evidence suggests that it is unwise to simply prescribe a series of self-directed upper limb exercises, with an increasing dose of practice which, although seemingly advantageous, bears no relationship to the mastering of a task that is important to the patient. If the patient’s interest and motivation are to be maintained, task-specific interventions should be in the context of eventual mastery of a whole task that has been identified as relevant. Further, interventions should include complex tasks as a means of involving more regions of the brain in the reorganization response (Mathiowetz, 2004; Davis, 2006; Kelly et al., 2006; Krakauer, 2006).

Strategy 5: task-specific training should be positively reinforced

The evidence indicates that task-specific therapy should include timely and positive feedback, but that all rewards should fade over time to prevent unnecessary dependency (Mathiowetz, 2004; Dobkin and Carmichael, 2005; Seitz, 2005; Davis, 2006). Therapists can enhance the feedback environment by using commentary and positive encouragement; however, this augmented reinforcement or artificial feedback should ‘fade’ over the duration of a task, session and admission as it is potentially maladaptive. Dobkin and Carmichael (2005) recommend that this feedback is always positive.
The five strategies arise out of the task-specific evidence and expert commentary. Again, much of this may not be new to readers, but may provide evidence to support practices already applied. However, there is some evidence that the inpatient setting particularly can raise competing agendas for therapists (Daniëls et al., 2002), and these strategies may serve to refocus the efforts of therapists in their prescription of neuromotor interventions.

**Implications of task-specific training for occupational therapists and future practice**

The evidence relating to task-specific training has direct application to occupational therapy practice and resonates with the theory and ideology associated with occupational science (Christiansen and Townsend, 2004) and occupational therapy. The strategies are steeped in long-held, professional values concerning client-centred practice and the importance of involving the patient/client in goal setting and rehabilitation agendas (Armstrong, 2008). However, while the premise of occupation and our approach to learning new motor skills are highly consistent with task-specific training, it is not a term that is commonly used by us. Further, despite the growing evidence for task-specific training, rehabilitation is commonly based instead on accepted practice or custom. The theoretical and empirical foundations for task-specific training, derived from research on brain plasticity and motor learning, provide a strong, evidence-based platform for occupational therapists to confidently select neuromotor interventions which involve task-specific training and everyday tasks and activities.

**References**


Copyright © 2009 John Wiley & Sons, Ltd DOI: 10.1002/oti


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