Reference	Ortiz-Catalan M, Guðmundsdóttir R, Kristoffersen M, Zepeda-Echavarria A, Caine- Winterberger K, Kulbacka-Ortiz K, Widehammar C, Eriksson K, Stockselius A, Ragnö C, Pihlar Z, Burger H, Hermansson L.					
	Department of Signals and Systems, Chalmers University of Technology, Gothen- burg, Sweden.					
	Phantom motor execution facilitated by machin	le				
	learning and augmented reality as treatment for phantom limb pain: a single group, clinical trial					
	in patients with chronic intractable phantom limb pain					
	Lancet 2016; 388: 2885–94.					
Products	Machine learning, augmented reality and gaming vs. traditional treatment phantom limb pain	for				
Major Findings	With machine learning, augmented reality and gaming compared to traditional treatment for phantom limb pain: → Pain intensity was decreased by 51%. → Pain duration was reduced by 47%. → All patients experienced reduction in quality of pain					
	 → Pain sleep and activities of daily living intrusions were reduced on average by 61% and 43%, respectively. → Pain sensations, such as stabbing and tiring–exhausting, were significantly less prevalent after treatment. → Improvements remained 6 months after treatment. 					
	n after 1st v 12 − − − − − − − − − − − − − − − − − −	ł nt				
	10 session	າຣ				
	6 definition of the second sec	ərapy				
	4					
	Pain rating index Pain duration Pain sleep Pain ADL					

On the graph, the perception of phantom limb pain intensity, weight distribution, activities of daily living (ADL) and sleep pain intrusion are compared after the 1st treatment session and 6 months after therapy. The pain intensity (measured by pain rating index) was decreased by 51%, weight pain distribution by 47%, while pain sleep and activities of daily living intrusions were reduced on average by 61% and 43% respectively.

intrusions

intrusions

Population Subjects: 14 (7 transhumeral, 2 of them bilateral; 7 transradial) patients with upper limb amputation afflicted by refractory chronic phantom limb pain Previous prosthesis: n.a. 12 trauma, 1 infection, 1 tumor Amputation causes: 50.3 years (± 10.3 years) Mean age: Mean time since amputation: 10.4 years (± 11.1 years)

Study Design

Interventional pre- to post-test design:



All patients received an intervention twice per week except for one who had it daily. Each session lasted 2 h and consisted of (1) pain evaluation, (2) placement of the electrodes and marker, (3) practice motor execution in augmented reality, (4) gaming by racing car using phantom movements, and (5) matching random target postures of a virtual arm in virtual reality.

Results								
Body Function		Activity			Participation	Others		
	Pain	Grip patterns / force	Manual dexterity	Activities of daily living (ADL)	Satisfaction and Quality of life (QoL)	Training	Technical aspect	

Category	Outcomes	Results for machine learning, augmented reality and gaming vs. traditional treatment for phantom limb pain	Sig.*
Pain	Pain rating index	Significant reduction of pain intensity by 51%.	++
		All patients experienced reduction in quali- ty of pain. Pain sensations, such as stab- bing and tiring–exhausting, were signifi- cantly less prevalent after treatment.	++
		Reduction in pain intensity was maintained at all of follow-up visits. The average im- provement measured at the last treatment session decreased by 2%, 6%, and 24% at 1, 3, and 6 month follow-ups, respectively.	++
	Numeric rating scale of phantom limb pain	Significant reduction of pain intensity by 32%.	++
		9 patients (64%) experienced reduction of pain intensity.	++
	Weighted pain distribu-	Pain sleep and activities of daily living intrusions were reduced on average by 61 and 43%, respectively.	++
	tion	Significant reduction of pain duration by	++

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Machine learning, augmented reality and gaming vs. traditional treatment for phantom limb pain

Category	Outcomes	Results for machine learning, augmented Si reality and gaming vs. traditional treatment for phantom limb pain		
		47%.		
		12 patients (86%) experienced reduction of pain weight distribution.	++	
	Pain medication	Intake of pain medication was reduced at last treatment in 2 of 4 patients.	+	
		Intake of pain medication was reduced at last treatment in 2 of 4 patients.	+	
*no difference (0), positive	e trend (+), negative trend	(-), significant (++/), not applicable (n.a.)		
Author's Conclusion	"We introduce a novel plasticity-based, non-invasive treatment for phantom limb pain, in which phantom motor execution is decoded via machine learning, while			

pain, in which phantom motor execution is decoded via machine learning, while visualisation of the phantom is accomplished via augmented and virtual reality. These technological features overcome previous limitations of plasticity-based treatments, such as mirror therapy, while enhancing patient engagement via serious gaming. Reversal of cortical reorganisation and competitive plasticity are hypothesised to be the mechanisms of action of the approach presented here." (*Ortiz-Catalan et al. 2016*)

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