Printed e-textiles for wearable stroke rehabilitation

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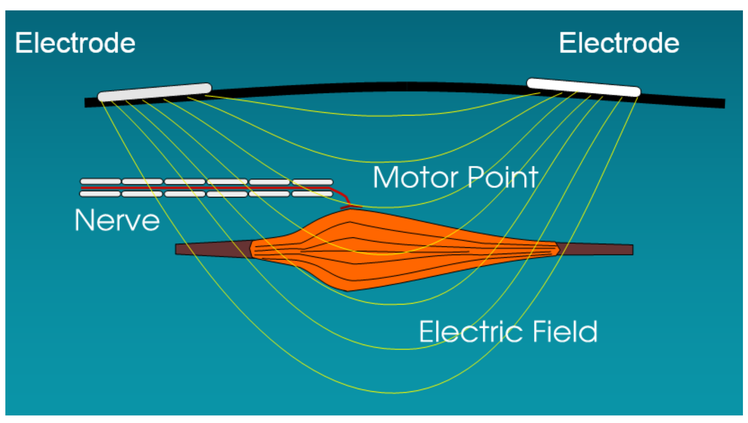
Need: Stroke is one of the largest causes of disability. Seveteen million strokes occur every year worldwide - one stroke every two seconds. Half of all stroke survivors lose the ability to perform everyday tasks with their upper limb, affecting their independence. The UK societal cost is nine billion pounds per year.

Solution: Intensive movement practice can restore upper limb function lost following stroke. However, stroke patients often have little or no movement, so are unable to practise. Function electrical stimulation (FES) activates muscles artificially to facilitate task practise and improve patients' movement.



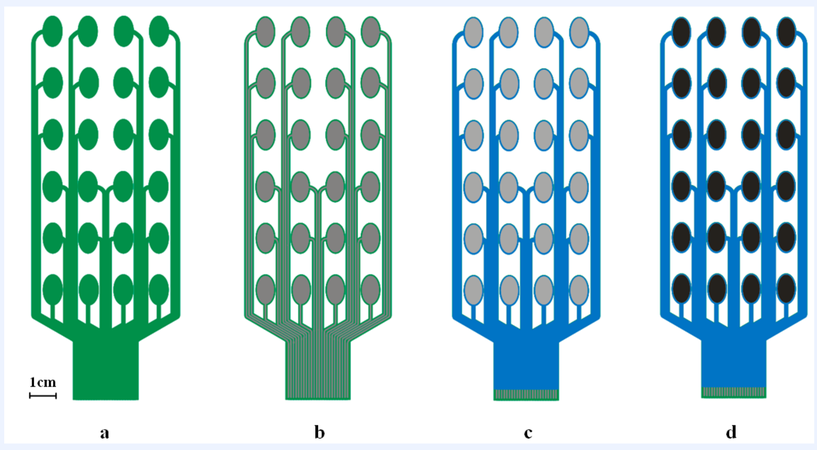
Electrical stimulation

Novelty: Current commercial FES devices use large electrodes which only stimulate a limited number of muscles, resulting in simple, imprecise movements. Our work demonstrates the use of bespoke screen printable pastes to print electrode arrays directly on everyday clothing fabric. The resulting garments will be integrated with cutting-edge sensor technologies and advanced control algorithms that adjust the stimuation based on past experience. Successful operation has been demonstrated by stimulating an optimised selection of electrodes in order to achieve different postures and assist performance of daily activities.

Competitive advantages: Comfortable to wear; Easy to use; Unobtrusive.

Fabrication and testing results

Fabrication processing



Top views of the FES processing after the printing of each layer in sequence of: interface layer (a), conductive silver layer (b), encapsulation layer (c) and carbon loaded silicone rubber layer(d).

e-textile FES array sample

Biocompatibility test

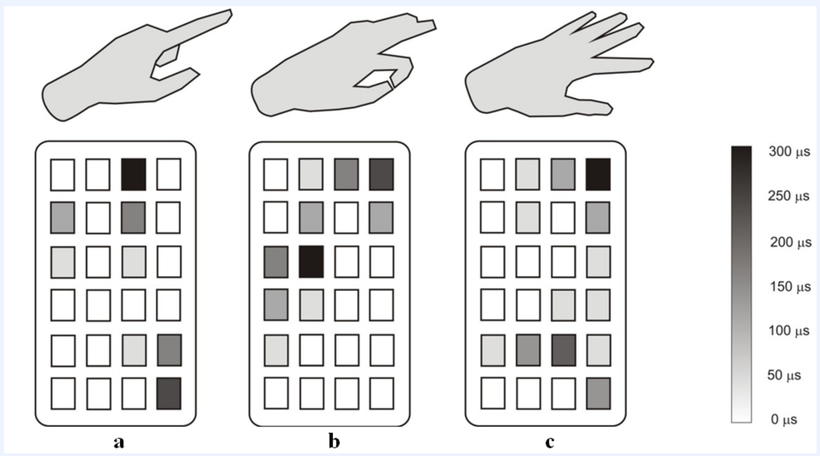
Materials	Scores	Results
Encapsulation	0	pass
Carbon/Rubber	1	pass

*Tested by Nelson Laboratories in US

ISO 10993-5: Agar overlay of L929 cells,

24 hours incubation.

Muscle stimulation results



Stimulation patterns for pointing (a), pinching (b) and open hand (c) gestures (shading indicates the pulsewidth levels).

e-textile assisting daily activities

Repositioning object

Closing drawer

Next Step: We have be awarded a £1 million, 2.5 year UK Medical Rearch Council (MRC) grant to bring this technology from the stage of a feasibility study to a functional prototype. This project will deliver a practical, comfortable, high performance solution for cost effective rehabilitation.

Conclusion

- **The feasibility of manufacturing e-textile electrode arrays using screen printing has been demonstrated.**
- **The materials used have confirmed biocompatibility using ISO 10993-5 cytotoxicity test results.**
- **Tests have shown that the electrode arrays can provide effective assistance of movement.**

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