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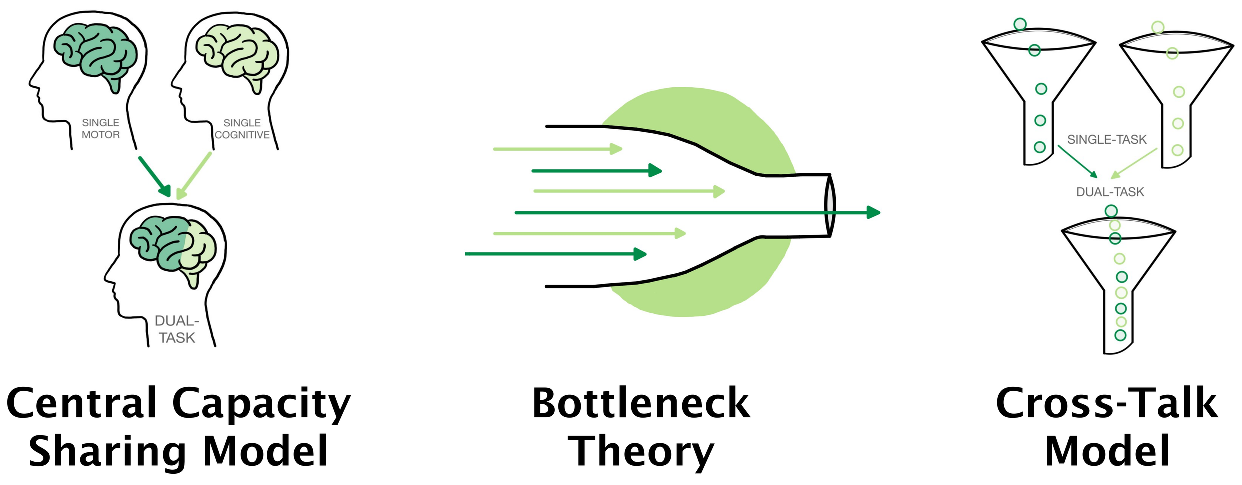
QR-Code for more detailed information and references

Investigation of Cognitive-Motor Interference in Dual Tasking

Background

When performing two tasks simultaneously, interference can occur, which means that the performance or outcome of each task could be affected. The study project investigated these possible interferences in Dual Tasking. The Motor Task consisted of maximal voluntary gripping, while the simultaneous Cognitive Task involved Serial-X-Subtraction. The research team assessed the occurrence of differences in forearm muscle electrical activity, grip strength and Serial-X-Subtraction success rate during Dual Tasking compared to Single Tasking. They aimed to test the hypothesis that Dual Tasking leads to changes in at least one of these factors.
Although the exact reasons for these interferences have not yet been confirmed, there are many theories that attempt to explain the underlying mechanism. The most popular ones are the **Central Capacity Sharing Model** [1], the **Bottleneck Theory** [2] and the **Crosstalk-Model** [3].



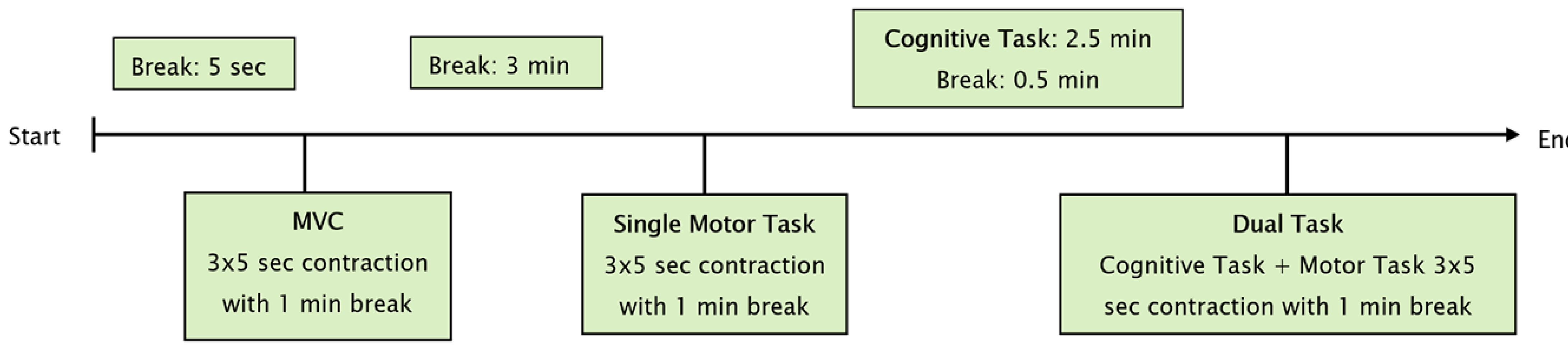
Method

The researchers recruited healthy adults aged 18 and older from their personal environment, excluding those with chronic illnesses, upper extremity issues in the last year, cardiovascular diseases, and electric implants. Twelve subjects were recruited for the study; however, one test was invalid due to technical issues.
Using the American Society of Hand Therapists guidelines [4], the test subjects sat with a neutral back in a chair, elbows at 90° flexion in a semipronated position. Their grip strength was assessed on both sides, and five sensors were attached to the stronger forearm.
The largest electrode was placed at 70% of the forearm length, measured from the distal end. Specifically, the sensors were put on the muscle bellies of M. flexor carpi radialis and ulnaris, M. palmaris longus, and M. extensor carpi radialis longus and brevis - determined through palpation - as shown in Figure 1.
In the Motor Task, participants were instructed to perform maximum voluntary contraction (MVC). For the Cognitive Task, participants subtracted from various numbers between 50 and 100 for two and a half minutes (Serial-X-Subtraction).The exact timing of the tasks and breaks is shown in Figure 2.

The signal was then processed using EMG Analysis from Delsys employing following functions:
Power Spectral Density analysis with window length of 0.3 and window overlap of 0.15, Filter IIR with Butterworth of fourth order, Simple Math, Root Mean Square with window length of 0.3 and window overlap of 0.15 and Scale-Offset. A paired t-test, as well as a Wilcoxontest
For non-normally distributed data were used for statistical analysis. More detailed information can be found in the appendix via scanning the QR-code.

Figure 1
Positioning of sensors

Figure 2
Timeline of the measurement process



Results

The participants had an average age of 32.4 years (SD = 13.45), with nine of the eleven subjects being female (82%) and two male (18%).
Compared to the Motor Task (M = 83.50 µV; SD = 58.52; 95% CI [44.18, 122.81]) the participants achieved significantly lower ($p < .006$) electrical activity in the forearm muscles during the Dual Task (M = 60.70 µV, SD = 46.78; 95% CI [29.28, 92.13]). The strength values were also significantly lower ($p = .0045$) in the Dual Task (M = 211.60 N, SD = 53.77; 95% CI [197.83, 274.92]) compared to the Single Motor Task (M = 236.38 N, SD = 57.37; 95% CI [175.48, 247.72]). The effect sizes, as indicated by Cohen's d = 1.04 for electrical activity and d = 0.69 for strength values, suggest moderate to large effects.
The Cognitive Task performance, which was evaluated using the calculated success rate, did not significantly differ ($p = .24$; $r = .35$) between the Cognitive Task (M = 0.90, SD = 0.11; 95% CI [0.82, 0.97]) and the Dual Task (M = 0.93, SD = 0.09; CI [0.87, 0.99]). A clearer representation of the values can be found in **Table 1,** as well as in the boxplots of **Figure 3, 4 and 5** below.

Table 1
Comparison of Electrical Activity, Grip Strength and Success Rate in Single- and Dual Tasking

		mean	test statistics	CI 95 %	df	p-values	effect size
Electrical Activity (µV)[1]	Single Task	83.50 [58.52]	t = 3.46	[44.18, 122.81]	10	.006**	d = 1.042
	Dual Task	60.70 [46.78]		[29.28, 92.13]			
Grip Strength (N)[1]	Single Task	236.38 [57.37]	t = 2.28	[197.83, 274.92]	10	.045*	d = 0.689
	Dual Task	211.60 [53.77]		[175.48, 247.72]			
Success Rate (%)[2]	Single Task	89.79 [11.31]	z = -1.17	[0.82, 0.97]		.241	r = 0.25
	Dual Task	93.0 [0.09]		[0.87, 0.99]			

[1] calculated using t-test [2] calculated using Wilcoxon-test *significant p < .05 ** highly significant p < .0

Figure 3
Electrical Activity (µV)

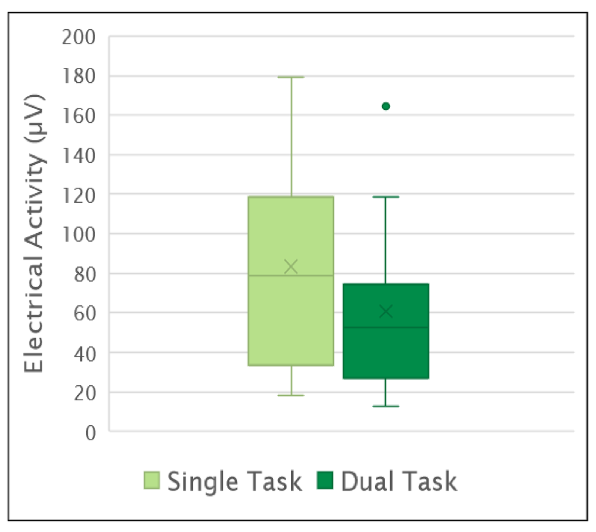


Figure 4
Grip Strength (N)

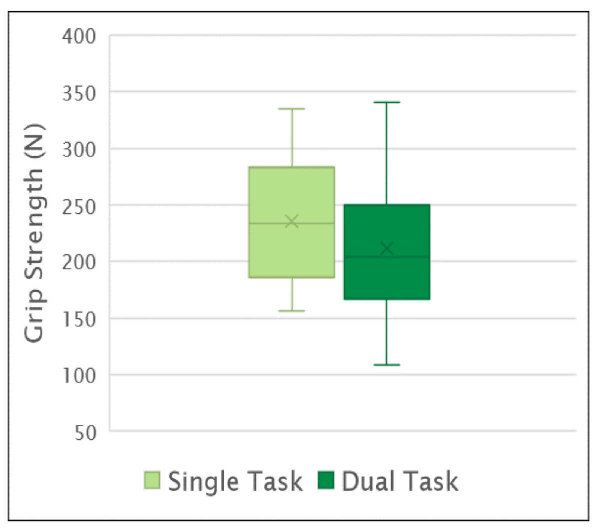
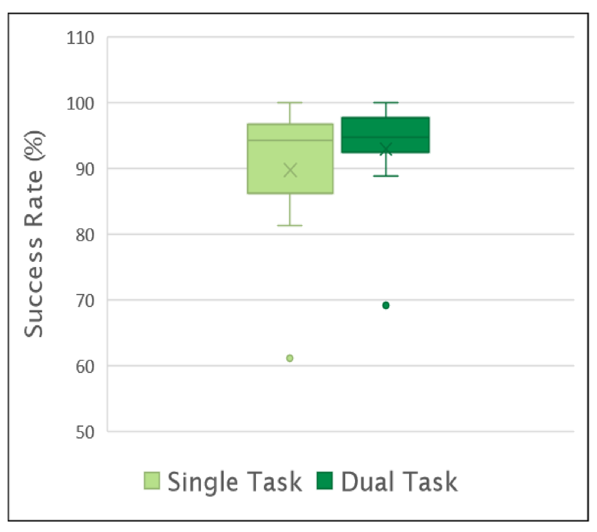


Figure 5
Cognitive Task Success Rate (%)



Discussion

The transferability of the results to the overall population is limited due to the small sample size, unequal gender distribution (nine women and two men), and a low average age of 32.2 years (SD = 13.47). The MCID for grip strength ranges from 49.05 to 63.77 N, indicating that the observed difference of 13.77 N is not clinically relevant [5]. For the success rate and muscle activity, the clinical relevance cannot be assessed.
The test setup may bias the results due to variations in electrode placements by different therapists and signal crosstalk from adjacent muscles.

Since the electrodes were placed on multiple muscles, the signal reflects general forearm activity rather than specific muscle activity. This approach was chosen due to the synergistic activation of wrist flexors and extensors during fist closure [6].
Additionally, individual excitement and learning effects due to repeated execution of tasks and use of the hand dynamometer may have influenced the results. The researchers suspect a subconscious prioritisation of the Cognitive Task during Dual Tasking through a division of limited attention resources of the central nervous system.

In general, the findings of the project are closely aligned with the key points of the Bottleneck Theory and the Central Capacity Sharing Model. Both of them indicate decreased performance for Dual Task activities in comparison to Single Task, as seen for the strength values and muscle activity.
For future research, it is essential to consider a larger sample size, a more balanced gender distribution, and the inclusion of diverse age groups in order to achieve more reliable results.

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