

# Lightweight Task/Application Performance using Single vs. Multiple Monitors: A Comparative Study

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# Motivation

- The growing use of multiple monitors
- Has research on their utility and potential benefits kept pace with actual use?
- Most research has focused on the development of new window management operations



# Motivation

Our intuition suggests

*Having more space to work should benefit productivity and better satisfy users*

Is our intuition correct?

*The increased screen area may require more window operations and space management*



# Hypotheses

- Multiple monitors will lead to faster task completion and reduced cognitive workload
- Prior experience with multiple monitors will be beneficial



# Experiment Design

- 28 participants
  - Moderate MS Windows and Office Suite competency
  - Experience with online travel agencies (e.g., Travelocity, Expedia)
  - 12 were regular users of a multiple monitor computer
- A within-subjects experiment with two settings
  - a single monitor computer (Singlemon) setting
  - a two-monitor computer (Multimon) setting
- Participants were randomly assigned to one of two groups





# Experiment Design

- Two sets of isomorphic tasks
  - One set involved a trip to Boston
  - The other used San Francisco
- Alternated the task sets within the same setting
  - The difference caused by the two task sets was negligible



# Procedure

- A pre-study training session
- A pre-study questionnaire
- Task completion with one setting
- An interim questionnaire asking time estimation (*perceived task time*) and a NASA TLX survey
- Task completion with the other setting
- An interim questionnaire
- A post-study questionnaire
- Semi-structured interview





# Tasks

- Typical computing tasks
  - MS Office applications
  - email reader
  - instant messaging (IM)
  - web browser
- Scenario-based tasks to replicate task switching and multitasking in the real world
  - An administrative assistant planning a business trip including air travel, hotel stay, and dinner



# Examples of Tasks

- Searching for the lowest roundtrip flight airfare and logging the information including departure/arrival time, airline, flight number, and total price to a MS Word file
- Estimating the total expenses using MS Excel
- Copying directions from the hotel to the restaurant from Internet Explorer to the MS Word file



# Intervention Tasks

- Side Task 1: check email and follow the instructions in a new message
  - Copy information (upcoming talk, book order) to a web form
- Side Task 2: reply to two instant messages
  - Browse desktop to find information requested (password, phone number)
  - Check on the web to find information requested (currency rate, weather forecast)



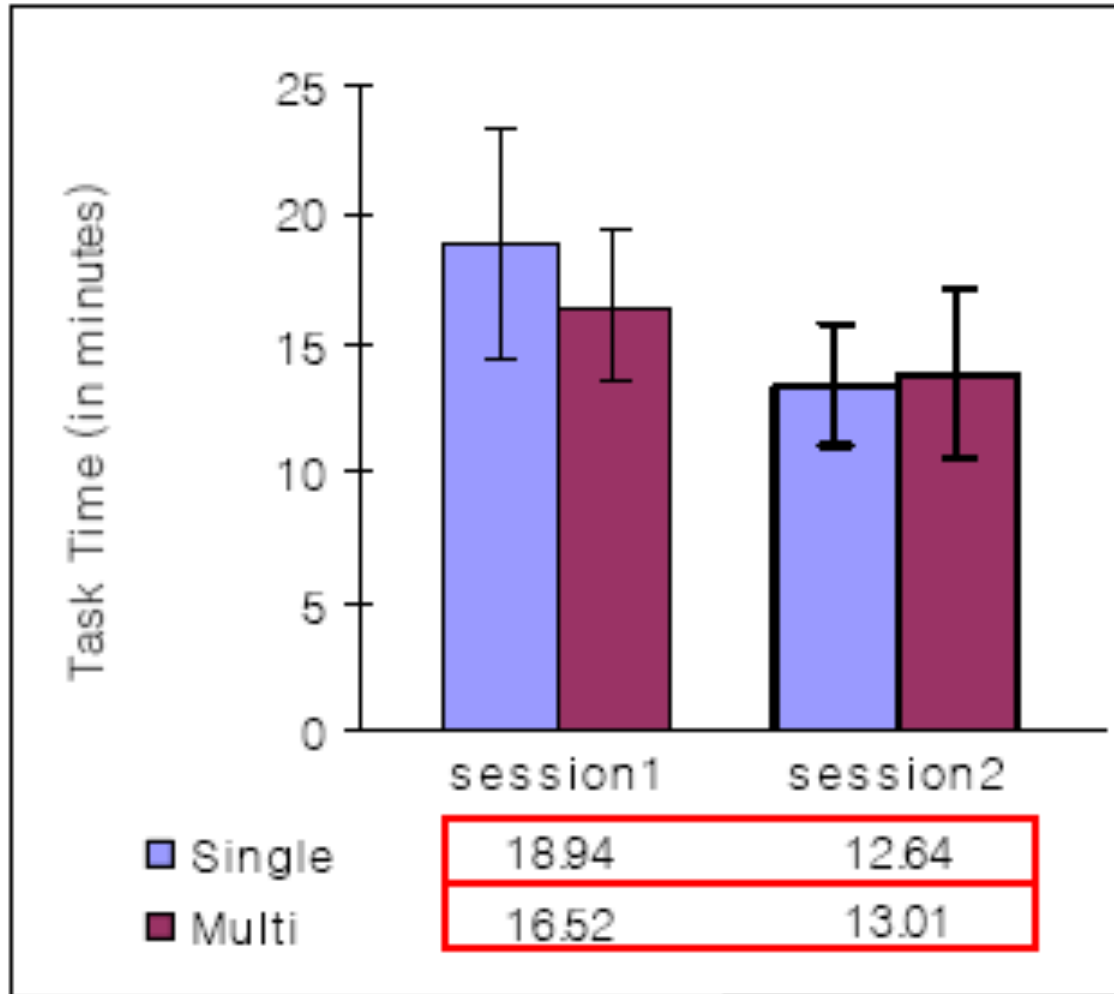
# Results 1: Multimon vs. Singlemon

## Task Completion Time

- Repeated Measures Two-way ANOVA
- A significant main effect of Setting ( $F=5.00$ ,  $p=.035$ ) and Order ( $F=114.53$ ,  $p=.000$ )
  - *Setting* indicates whether they interacted with Singlemon or Multimon
  - *Order* indicates which setting they used first



# Singlemon vs. Multimom in Task Time



- Multimom setting outperformed Singlemon setting in the 1<sup>st</sup> session
- Learning effect – better performance in the 2<sup>nd</sup> session regardless of settings

Boxes indicate significant differences ( $p < .05$ )

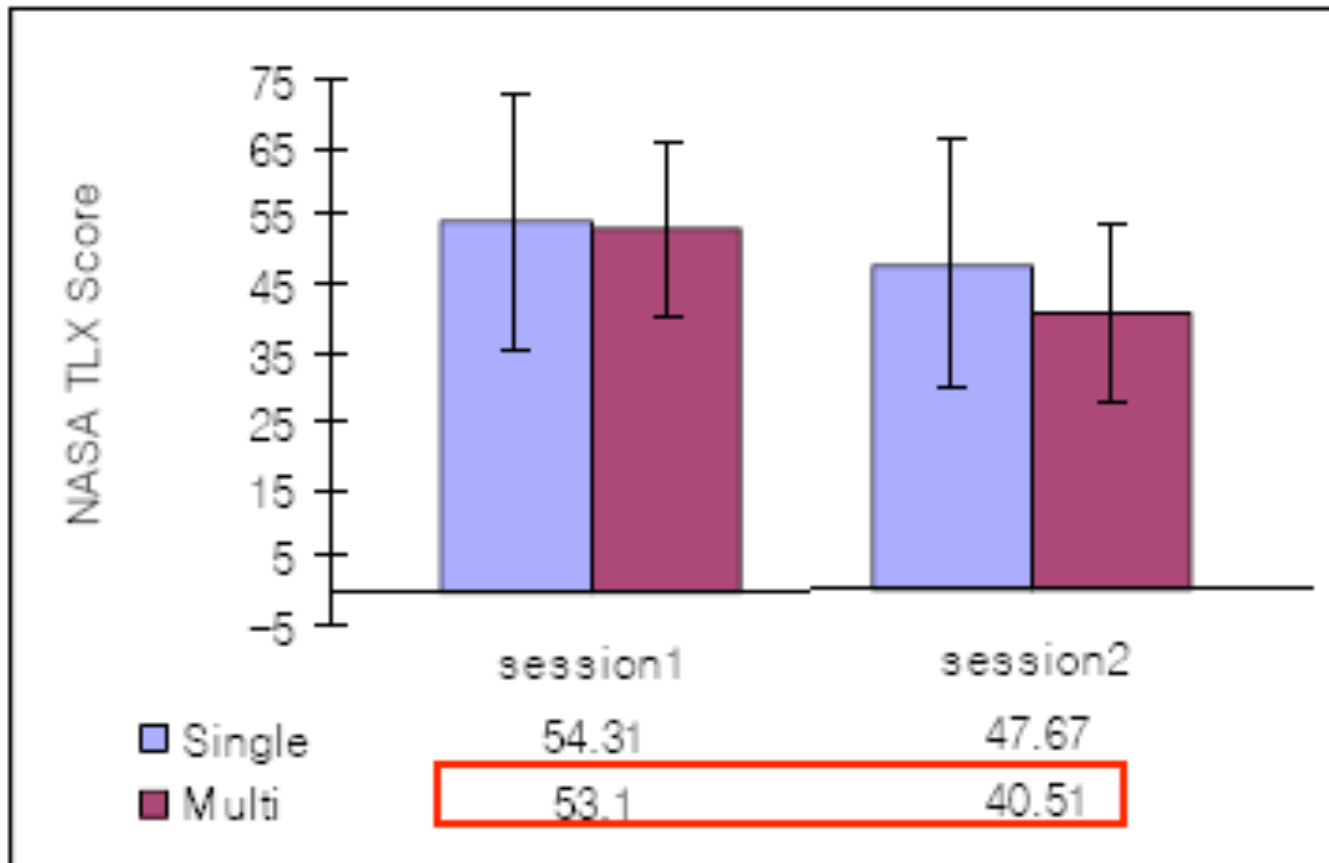
# Results 1: Multimon vs. Singlemon

## NASA TLX Score

- The main effect of Order ( $F=16.796$ ,  $p=.000$ ) and a trend of Setting ( $F=3.181$ ,  $p=.087$ )



# Singlemon vs. Multimon in NASA TLX Score



# Results 1: Multimon vs. Singlemon

## User Rating

- Usefulness, being easy to use, timesaving, and overall impression
- Strong favor for the multiple monitor setting

		Useful	Easy to use	Timesaving	Overall impression
Single	Mean	8.38	7.69	7.62	8.23
	N	13	13	13	13
Multi	Mean	7.64	7.21	5.50	7.36
	N	14	14	14	14
Total	Mean	8.00	7.44	6.52	7.78
	N	27	27	27	27

1: Singlemon is better 9:Multimon is better

5 indicates even



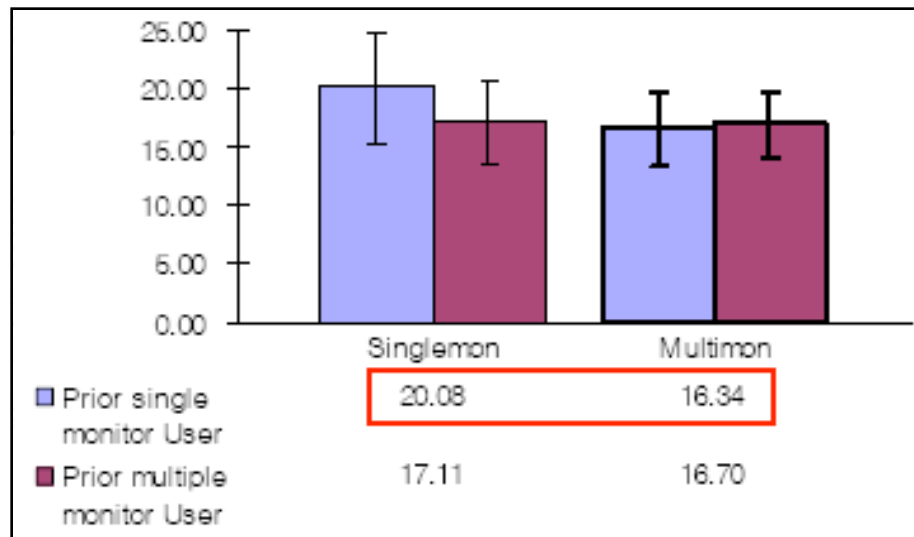
# Results 2: Multiple Monitor Experience

- Participants classified into two groups
  - those who are regular multiple monitor users
  - those who are not (single monitor users)
- Task completion time and NASA TLX score were analyzed using Repeated Measures three-way ANOVA
- Only found the main effects of Setting and Order



# Results 2: Multiple Monitor Experience

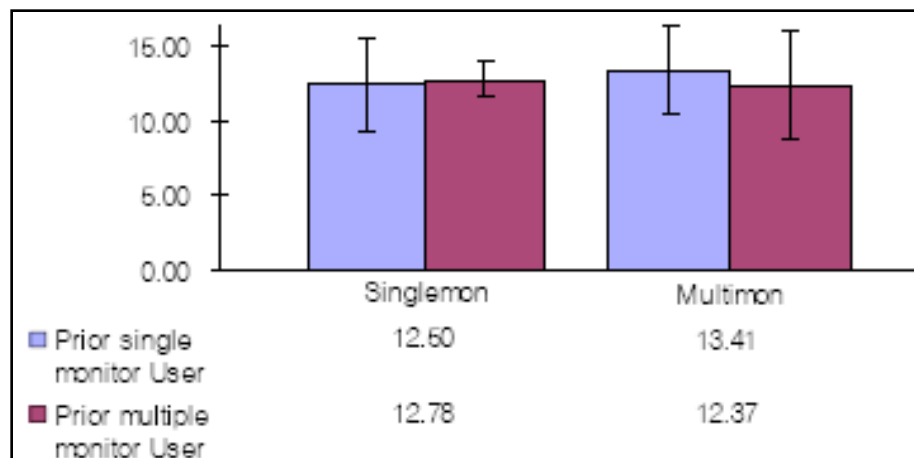
Session 1



Task Time

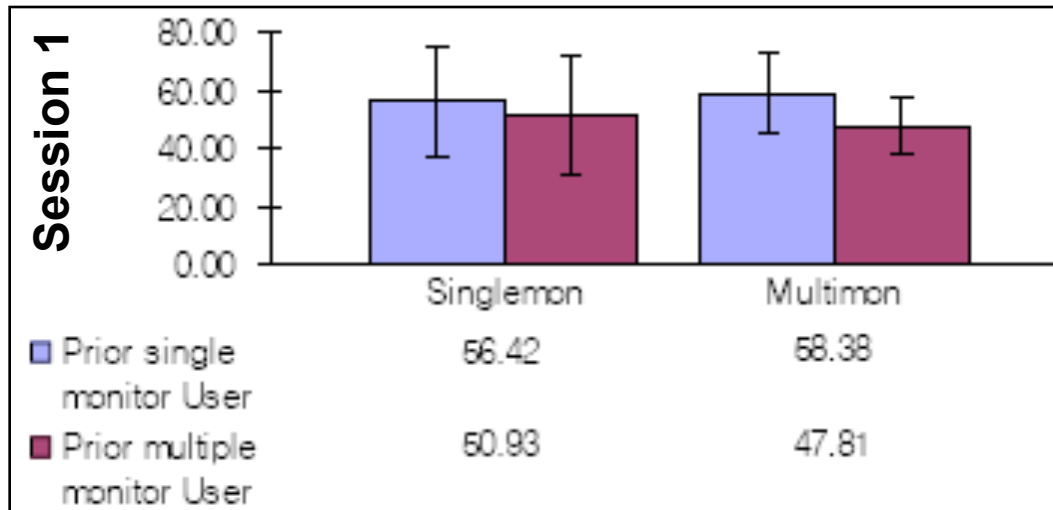
- In the 1<sup>st</sup> session, prior single monitor users performed better with Multimon than with Singlemon

Session 2

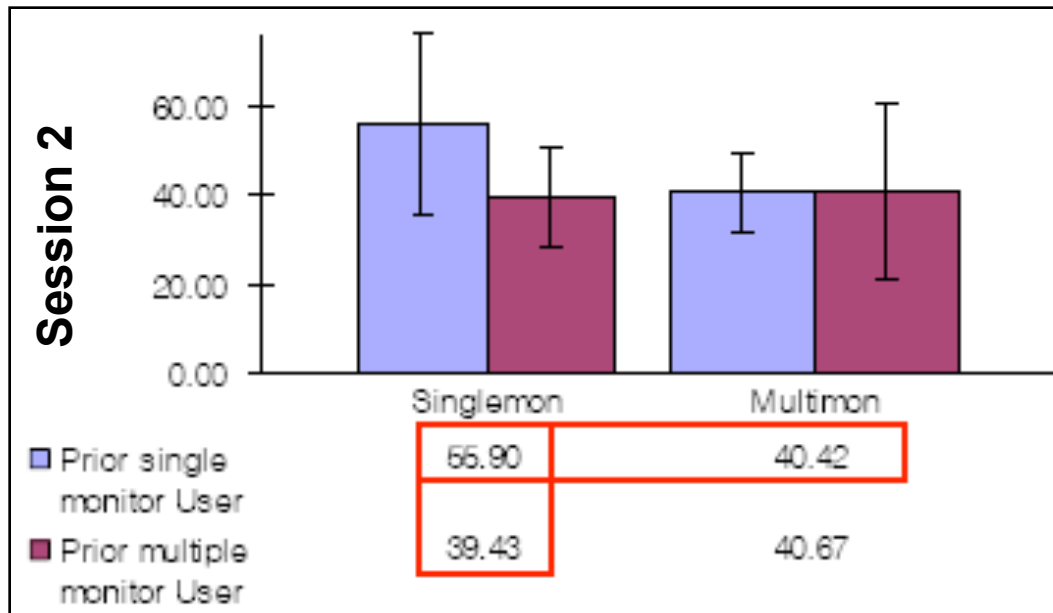


- Small differences between two groups and settings (learning effect in the 2<sup>nd</sup> session)

# Results 2: Multiple Monitor Experience



NASA TLX Score



- In the 2<sup>nd</sup> session, single monitor users had more workload with Singlemon
- Multimon helped single monitor users but did not affect multiple monitor users

# Results 3: Window Management Style

- Two explicit patterns of window management
  - Alt+tab users
  - Move/resizers
- Only found the main effects of Setting and Order



# Discussion – Multi vs. Single

- The Multimodal setting benefited productivity
  - Lower task completion time, workload, subjective ratings
- An order effect on the task time and workload
- *“I would have found a greater advantage for Multimodal if the tasks had been much more complex!”*



# Discussion – Multiple Monitor Experience

## Initial hypothesis

*Multiple monitors might benefit participants differently depending on their prior experience with multiple monitors*

1. Regular multiple monitor users would perform more quickly and feel less work load with the Multimon setting than with the Singlemon setting
2. Single monitor users, without prior Multimon computer experience, may show less improvement



# Discussion – Multiple Monitor Experience

## Actual Findings

1. Regular single monitor users performed better and felt less workload with Multimon than with Singlemon  
=> Low initial barrier of using Multimon
3. Multiple monitors users did not benefit more  
=> They performed well with Singlemon as well as Multimon  
=> The two user groups are not mutually exclusive



# Thanks, Questions?

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