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. Multimon in Task Time

- Multimon setting outperformed Singlemon setting in the 1st session
- Learning effect – better performance in the 2nd 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 ($F=3.181$, $p=.087$)
Singleomon vs. Multimon in NASA TLX Score

![Bar chart showing NASA TLX scores for Singleomon and Multimon in two sessions. The scores are as follows:

- Session 1: Singleomon 54.31, Multimon 53.1
- Session 2: Singleomon 47.67, Multimon 40.51]
Results 1: Multimon vs. Singlemon

User Rating

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

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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

Task Time
- In the 1\textsuperscript{st} session, prior single monitor users performed better with Multimon than with Singlemon
- Small differences between two groups and settings (learning effect in the 2\textsuperscript{nd} session)
Results 2: Multiple Monitor Experience

- In the 2\textsuperscript{nd} 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 Multimon 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 Multimon 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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