

The Role of Instant Messaging on Task Performance and Level of Arousal

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16.422 Human Supervisory Control
MAS.630 Affective Computing



Introduction

- Common project:
 - 16.422 Human Supervisory Control
 - Influence of IM on task performance
 - MAS.630 Affective Computing
 - Influence of IM on level of arousal
 - AC = “How computational systems can sense, recognize and understand human emotions and respond”

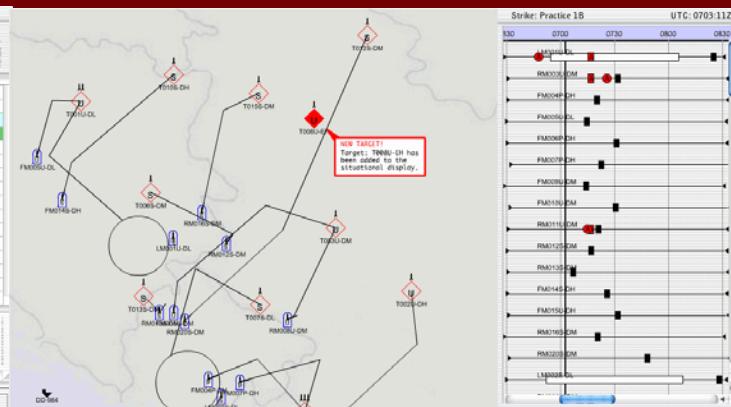
Motivation

- Instant Messaging (IM) is a collaborative communication tool
- IM enables an informal way to communicative
- IM builds bridges to other media
- BUT:
 - IM is a pervasive tool
 - IM does not provide info on people's situation
 - IM is intrusive and disruptive

Motivation

■ Tactical Tomahawk Dual Screen Human Supervisory Control Interface

Strike: BB				UTC: 0704-40Z					
Convoy	ZSU-23	Munitions Depot	Truck Park	Barracks	Electric Grid	Training Camp	SAM Site	Oil Storage	Fuel Depot
0708	0717	0711	0706	0729	0717	0722	0706	0718	0721
0709	0718	0712	0707	0730	0720	0725	0713	0725	0726
0710	0719	0713	0708	0731	0721	0726	0714	0726	0727
0711	0720	0714	0709	0732	0722	0727	0715	0727	0728
0712	0721	0715	0710	0733	0723	0728	0716	0728	0729
0713	0722	0716	0711	0734	0724	0729	0717	0729	0730
0714	0723	0717	0712	0735	0725	0730	0718	0730	0731
0715	0724	0718	0713	0736	0726	0731	0719	0731	0732
0716	0725	0719	0714	0737	0727	0732	0720	0732	0733
0717	0726	0720	0715	0738	0728	0733	0721	0733	0734
0718	0727	0721	0716	0739	0729	0734	0722	0734	0735
0719	0728	0722	0717	0740	0730	0735	0723	0735	0736
0720	0729	0723	0718	0741	0731	0736	0724	0736	0737
0721	0730	0724	0719	0742	0732	0737	0725	0737	0738
0722	0731	0725	0720	0743	0733	0738	0726	0738	0739
0723	0732	0726	0721	0744	0734	0739	0727	0739	0740
0724	0733	0727	0722	0745	0735	0740	0728	0740	0741
0725	0734	0728	0723	0746	0736	0741	0729	0741	0742
0726	0735	0729	0724	0747	0737	0742	0730	0742	0743
0727	0736	0730	0725	0748	0738	0743	0731	0743	0744
0728	0737	0731	0726	0749	0739	0744	0732	0744	0745
0729	0738	0732	0727	0750	0740	0745	0733	0745	0746
0730	0739	0733	0728	0751	0741	0746	0734	0746	0747
0731	0740	0734	0729	0752	0742	0747	0735	0747	0748
0732	0741	0735	0730	0753	0743	0748	0736	0748	0749
0733	0742	0736	0731	0754	0744	0749	0737	0749	0750
0734	0743	0737	0732	0755	0745	0750	0738	0750	0751
0735	0744	0738	0733	0756	0746	0751	0739	0751	0752
0736	0745	0739	0734	0757	0747	0752	0740	0752	0753
0737	0746	0740	0735	0758	0748	0753	0741	0753	0754
0738	0747	0741	0736	0759	0749	0754	0742	0754	0755
0739	0748	0742	0737	0760	0750	0755	0743	0755	0756
0740	0749	0743	0738	0761	0751	0756	0744	0756	0757
0741	0750	0744	0739	0762	0752	0757	0745	0757	0758
0742	0751	0745	0740	0763	0753	0758	0746	0758	0759
0743	0752	0746	0741	0764	0754	0759	0747	0759	0760
0744	0753	0747	0742	0765	0755	0759	0748	0759	0761
0745	0754	0748	0743	0766	0756	0759	0749	0760	0762
0746	0755	0749	0744	0767	0757	0759	0750	0761	0763
0747	0756	0750	0745	0768	0758	0759	0751	0762	0764
0748	0757	0751	0746	0769	0759	0759	0752	0763	0765
0749	0758	0752	0747	0770	0760	0759	0753	0764	0766
0750	0759	0753	0748	0771	0761	0759	0754	0765	0767
0751	0760	0754	0749	0772	0762	0759	0755	0766	0768
0752	0761	0755	0750	0773	0763	0759	0756	0767	0769
0753	0762	0756	0751	0774	0764	0759	0757	0768	0770
0754	0763	0757	0752	0775	0765	0759	0758	0769	0771
0755	0764	0758	0753	0776	0766	0759	0759	0770	0772
0756	0765	0759	0754	0777	0767	0759	0760	0771	0773
0757	0766	0760	0755	0778	0768	0759	0761	0772	0774
0758	0767	0761	0756	0779	0769	0759	0762	0773	0775
0759	0768	0762	0757	0780	0770	0759	0763	0774	0776
0750	0769	0763	0758	0781	0771	0759	0766	0775	0777
0751	0770	0764	0759	0782	0772	0759	0767	0776	0778
0752	0771	0765	0760	0783	0773	0759	0770	0777	0779
0753	0772	0766	0761	0784	0774	0759	0771	0778	0780
0754	0773	0767	0762	0785	0775	0759	0772	0779	0781
0755	0774	0768	0763	0786	0776	0759	0773	0780	0782
0756	0775	0770	0764	0787	0777	0759	0775	0781	0783
0757	0776	0771	0765	0788	0778	0759	0776	0782	0784
0758	0777	0772	0766	0789	0779	0759	0777	0783	0785
0759	0778	0773	0767	0790	0780	0759	0778	0784	0786
0750	0779	0774	0768	0791	0781	0759	0779	0785	0787
0751	0780	0775	0769	0792	0782	0759	0780	0786	0788
0752	0781	0776	0770	0793	0783	0759	0781	0787	0789
0753	0782	0777	0771	0794	0784	0759	0782	0788	0790
0754	0783	0778	0772	0795	0785	0759	0783	0789	0791
0755	0784	0779	0773	0796	0786	0759	0784	0790	0792
0756	0785	0780	0774	0797	0787	0759	0785	0791	0793
0757	0786	0781	0775	0798	0788	0759	0786	0792	0794
0758	0787	0782	0776	0799	0789	0759	0787	0793	0795
0759	0788	0783	0777	0800	0790	0759	0788	0794	0796
0750	0789	0784	0778	0801	0791	0759	0789	0795	0797
0751	0790	0785	0779	0802	0792	0759	0790	0796	0798
0752	0791	0786	0780	0803	0793	0759	0791	0797	0799
0753	0792	0787	0781	0804	0794	0759	0792	0798	0800
0754	0793	0788	0782	0805	0795	0759	0793	0799	0801
0755	0794	0789	0783	0806	0796	0759	0794	0800	0802
0756	0795	0790	0784	0807	0797	0759	0795	0801	0803
0757	0796	0791	0785	0808	0798	0759	0796	0802	0804
0758	0797	0792	0786	0809	0799	0759	0797	0803	0805
0759	0798	0793	0787	0810	0800	0759	0798	0804	0806
0750	0799	0794	0788	0811	0801	0759	0799	0805	0807
0751	0800	0795	0789	0812	0802	0759	0800	0806	0808
0752	0801	0796	0790	0813	0803	0759	0801	0807	0809
0753	0802	0797	0791	0814	0804	0759	0802	0808	0810
0754	0803	0798	0792	0815	0805	0759	0803	0809	0811
0755	0804	0799	0793	0816	0806	0759	0804	0810	0812
0756	0805	0800	0794	0817	0807	0759	0805	0811	0813
0757	0806	0801	0795	0818	0808	0759	0806	0812	0814
0758	0807	0802	0796	0819	0809	0759	0807	0813	0815
0759	0808	0803	0797	0820	0810	0759	0808	0814	0816
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0752	0811	0806	0801	0823	0813	0759	0811	0817	0819
0753	0812	0807	0802	0824	0814	0759	0812	0818	0820
0754	0813	0808	0803	0825	0815	0759	0813	0819	0821
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0757	0816	0811	0806	0828	0818	0759	0816	0822	0824
0758	0817	0812	0807	0829	0819	0759	0817	0823	0825
0759	0818	0813	0808	0830	0820	0759	0818	0824	0826
0750	0819	0814	0809	0831	0821	0759	0819	0825	0827
0751	0820	0815	0810	0832	0822	0759	0820	0826	0828
0752	0821	0816	0811	0833	0823	0759	0821	0827	0829
0753	0822	0817	0812	0834	0824	0759	0822	0828	0830
0754	0823	0818	0813	0835	0825	0759	0823	0829	0831
0755	0824	0819	0814	0836	0826	0759	0824	0830	0832
0756	0825	0820	0815	0837	0827	0759	0825	0831	0833
0757	0826	0821	0816	0838	0828	0759	0826	0832	0834
0758	0827	0822	0817	0839	0829	0759	0827	0833	0835
0759	0828	0823	0818	0840	0830	0759	0828	0834	0836
0750	0829	0824	0819	0841	0831	0759	0829	0835	0837
0751	0830	0825	0820	0842	0832	0759	0830	0836	0838
0752	0831	0826	0821	0843	0833	0759	0831	0837	0839
0753	0832	0827	0822	0844	0834	0759	0832	0838	0840
0754	0833	0828	0823	0845	0835	0759	0833	0839	0841
0755	0834	0829	0824	0846	0836	0759	0834	0840	0842
0756	0835	0830	0825	0847	0837	0759	0835	0841	0843
0757	0836	0831	0826	0848	0838	0759	0836	0842	0844
0758	0837	0832	0827	0849	0839	0759	0837	0843	0845
0759	0838	0833	0828	0850	0840	0759	0838	0844	0846
0750	0839	0834	0829	0851	0841	0759	0839	0845	0847
0751	0840	0835	0830	0852	0842	0759	0840	0846	0848
0752	0841	0836	0831	0853	0843	0759	0841	0847	0849
0753	0842	0837	0832	0854	0844	0759	0842	0848	0850
0754	0843	0							



○ Show: Action Messages Information Messages Health/Status Warnings

- (0702Z) Blue Ridge => EMERGENT TARGET IN THE SOUTH CENTRAL SECTOR
- (0702Z) Blue Ridge => How many missiles will hit their targets after 0730??
- (0702Z) TTIMR => Retargeting LM031S-DL to T051S-EH
- (0703Z) Blue Ridge => How much loiter time is remaining for LM029U?
- (0703Z) Blue Ridge => Intelligence reports a possible emerging target in the central sector.
- (0704Z) Blue Ridge => EMERGENT TARGET IN NORTH CENTRAL SECTOR
- (0704Z) Stump => Missile FM052P-DH impacted target

Last message received @ 0704Z

■ Tactical Tomahawk IM Interface

A research recently conducted by Pr. Missy Cummings on the Control Interface for the new retargetable Tomahawk missile involved instant messaging as a tool to measure situational awareness. During this study, most of the subjects tended to focus too much on the chat interface, instead of monitoring their primary task. Therefore, it is of interest to find out if the disruptiveness of IM is such that it impairs performance.

Motivation

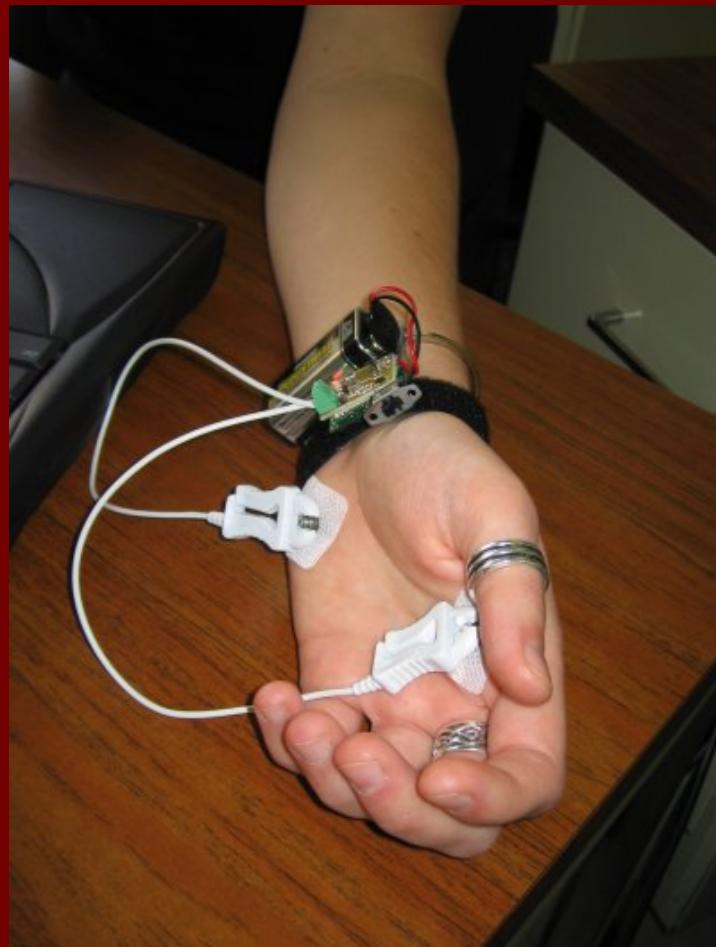
- IM = series of discrete events
- Repeated discrete interruptions modify alertness / level of arousal
- Level of arousal = “how awake I am in response to an emotional stimulus”
- Alertness = “how much I am prone to give a quick response”

Experimental Design

- 6 subjects
- Play ATC sim game
(primary task)
- Respond to IM
(secondary task)
- Protocol:
 - Basic rules
 - Live demo
 - Questions
 - Experiment



Experimental Design



- Experiment configuration
- Skin Conductivity Response (SCR) measurement device:
GSR (Galvanic Skin Response)

Skin conductivity was recorded using a galvanic skin response (GSR) measurement device disposed on the subject's left hand (if right-handed, right hand if left-handed), which was to remain motion less over the entire experiment. Here is a picture of the GSR .The skin conductivity signal was sent to the experimenter's computer using Bluetooth technology, and Python interpretation code.

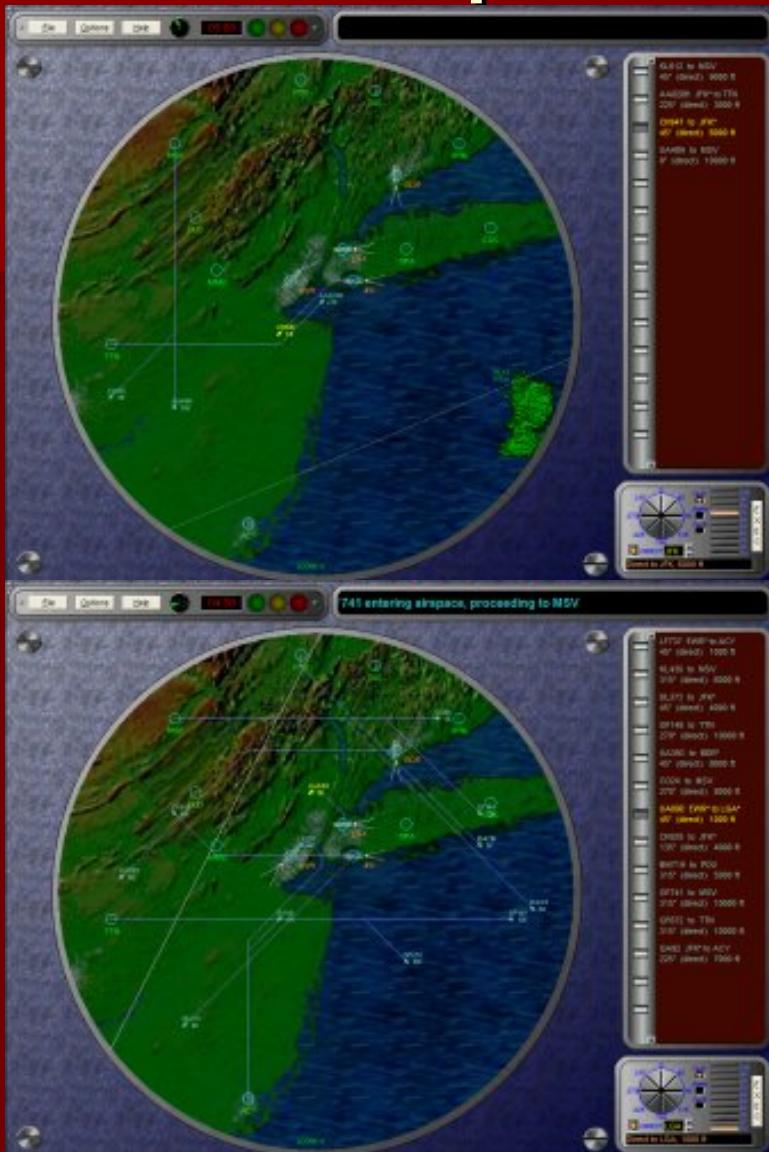
Experimental Design

- 3 independent variables:
 - Gender (M/F)
 - Workload (low/high) = #planes (4/12)
 - Flow of IM (none, low, high) = relevant questions
- 3 dependent variables: Score, Time delay, SCR
- 6 scenarii

	Low WL	High WL
No IM	1	4
Low IM	2	5
High IM	3	6

This specific order was determined by a pilot study: since the game automatically shuts down when a collision occurs, it was preferable to avoid collisions as much as possible, therefore increasing the difficulty progressively, which is the case with this protocol.

Experimental Design



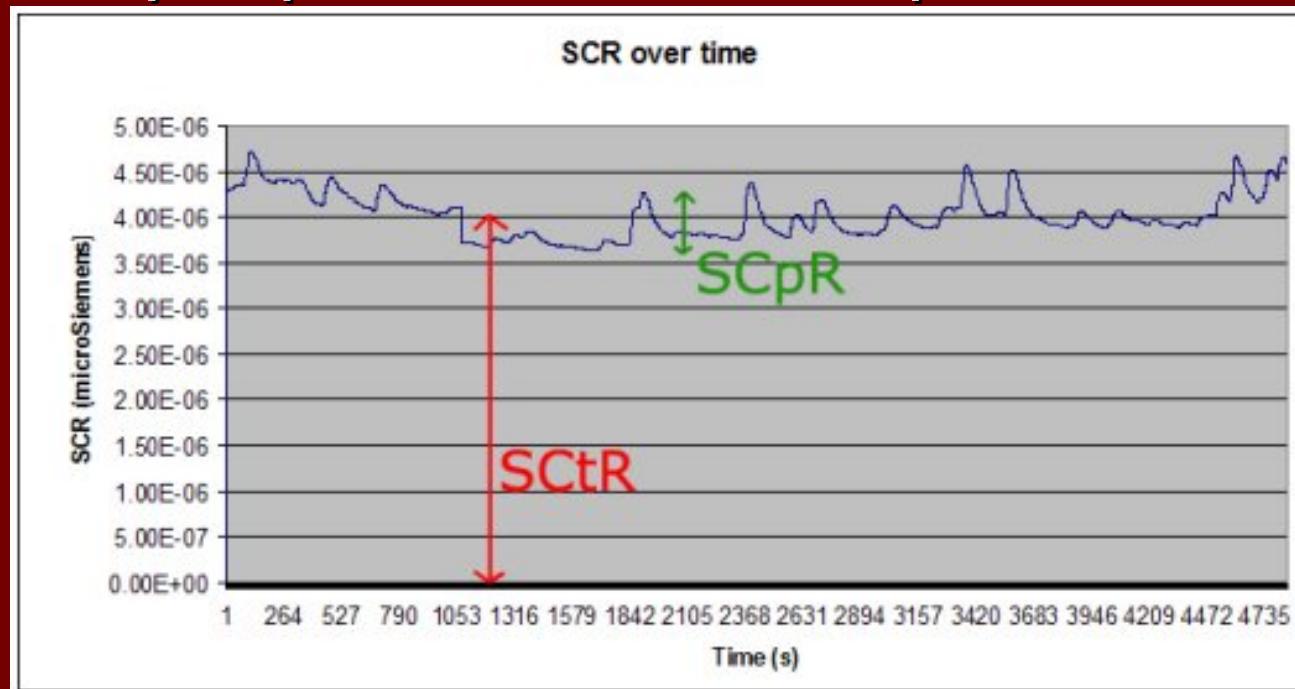
5/8/2004	2:36:33 PM	Sylvain	Subject	start now!
5/8/2004	2:36:48 PM	Sylvain	Subject	What time is it?
5/8/2004	2:36:56 PM	Subject	Sylvain	00:45
5/8/2004	2:37:01 PM	Sylvain	Subject	What flight is going to CCC?
5/8/2004	2:37:15 PM	Sylvain	Subject	What flight is taking off from JFK?
5/8/2004	2:37:24 PM	Subject	Sylvain	TW362H
5/8/2004	2:37:33 PM	Sylvain	Subject	qa916h
5/8/2004	2:37:44 PM	Subject	Sylvain	What is TW362H's heading?
5/8/2004	2:37:49 PM	Sylvain	Subject	ccc
5/8/2004	2:37:54 PM	Subject	Sylvain	What many planes are you responsible for?
5/8/2004	2:38:06 PM	Sylvain	Subject	4
5/8/2004	2:38:19 PM	Subject	Sylvain	What flight is going to HVN?
5/8/2004	2:38:35 PM	Sylvain	Subject	no one
5/8/2004	2:38:47 PM	Subject	Sylvain	What is flight QA810's altitude?
5/8/2004	2:39:06 PM	Sylvain	Subject	5k
5/8/2004	2:39:12 PM	Subject	Sylvain	How many VOR are there?
5/8/2004	2:39:19 PM	Sylvain	Subject	3
5/8/2004	2:39:28 PM	Subject	Sylvain	You sure?
5/8/2004	2:40:14 PM	Sylvain	Subject	yes
5/8/2004	2:41:06 PM	Sylvain	Subject	stop now!
5/8/2004	2:42:45 PM	Sylvain	Subject	start now!
5/8/2004	2:42:48 PM	Sylvain	Subject	collision
5/8/2004	2:43:23 PM	Sylvain	Subject	stop now
5/8/2004	2:55:02 PM	Sylvain	Subject	start now!
5/8/2004	2:55:26 PM	Sylvain	Subject	stop now!
5/8/2004	2:56:27 PM	Sylvain	Subject	start now!
5/8/2004	2:56:43 PM	Subject	Sylvain	Where is going CH69?
5/8/2004	2:57:11 PM	Sylvain	Subject	msv
5/8/2004	2:57:29 PM	Subject	Sylvain	Where is going NW286?
5/8/2004	2:57:34 PM	Sylvain	Subject	jk
5/8/2004	2:58:16 PM	Subject	Sylvain	What is flight US47's altitude?
5/8/2004	2:58:49 PM	Sylvain	Subject	3k
5/8/2004	2:58:56 PM	Subject	Sylvain	What is CS17's heading?
5/8/2004	2:59:01 PM	Subject	Sylvain	ewr
5/8/2004	2:59:34 PM	Sylvain	Subject	no
5/8/2004	2:59:44 PM	Subject	Sylvain	How many planes will land at JFK?
5/8/2004	3:01:04 PM	Sylvain	Subject	3
5/8/2004	3:01:16 PM	Subject	Sylvain	Where is going GF23?
5/8/2004	3:01:28 PM	Sylvain	Subject	jk
5/8/2004	3:01:44 PM	Sylvain	Subject	How many planes are going to HVN?
5/8/2004	3:02:50 PM	Sylvain	Subject	2
5/8/2004	3:03:02 PM	Subject	Sylvain	Where is flight TW474?
5/8/2004	3:03:55 PM	Sylvain	Subject	bdr
5/8/2004	3:04:16 PM	Subject	Sylvain	How many plane still have to exit via a VOR?
5/8/2004	3:04:59 PM	Sylvain	Subject	4
				stop now!

Workload was controlled by the number of planes (4 planes for the low workload case, and 12 planes for the high workload case). Following are successive caption of scenarios with 4 and then 12 planes.

Flow of instant messages was subjectively controlled by the experimenter: no IM in the "no IM" case, an IM every minute or two in the "low IM" case and a constant flow of IM during the "high IM" situation. Each message consisted in a question relative to the current situation in the game. Here is a sample of questions asked:

Results

- Score/(max score) = performance on scenario
- Delay = average delay over scenario
- Skin Conductivity = phasic + tonic components
- SCtR:
 - Tonic
 - Baseline
- SCpR:
 - Phasic
 - Changes



The ratio of the first two gave the task performance.

Time delays were averaged to give an average time response for each scenario. Even if the questions were of variable difficulty, the proportion and occurrence of easy and more difficult were conserved during the different scenario. This measure can therefore be interpreted as a global amount of time allocated to the task of responding to the IM. Maybe a better way to quantify time response would be to average time delays over the 4 or 5 most difficult questions.

From the skin conductivity response, two values were quantified for each scenario:

- SCtR: skin conductivity tonic response (which corresponds to the overall, global level of conductivity, typically from 0 to 10 microSiemens);

- SCpR: skin conductivity phasic response (which corresponds to the fast varying responses to particular events, ranging from 0 to 0.1 microSiemens).

In this experiment, SCpR was averaged among all the particular distinctive responses. In the scenarios with no IM, SCpR corresponded to the influence of the game and its particular events; whereas it corresponded to the impact of the game and of the incoming IM in the scenarios with IM. SCR is shown here in microSiemens. Nevertheless, in order to perform the statistical analysis, the direct output of the GSR measurement device was used. It is given by the linear relation:

$$\text{GSR_output} = 6.55 \times 10^8 \times \text{Skin_Conductance}$$

Analysis / Discussion

- **SCtR**
 - Data not normally distributed: 1 subject with abnormally high skin conductivity (> 16 microSiemens). Subject removed.
 - Multiple ANOVA: only IM flow ($p<0.014$, with 0.727 of power) significant influence on the tonic response:
 - IM is VERY intrusive: it modifies the component associated to mood and overall emotional state
 - Correlation tests: SCtR positively correlated with SCpR ($p<0.01$)
 - The higher the tonic component is, the bigger the phasic modifications will be. In this situation, people with high tonic response will have a tendency to respond even more to interruptions
- **SCpR**
 - Multiple ANOVA: IM flow ($p<0.005$, with 0.883 of power) and workload ($p<0.003$, with 0.908 of power) affect the phasic response.
 - Post-hoc analysis: difference between no IM and high IM is extremely significant ($p<0.004$).
 - Correlation tests:
 - # SCpR inversely correlated with score ($p<0.002$)
 - Subjects performing well showed less skin conductivity variation.
 - # SCpR positively correlated with time delay ($p<0.022$)
 - subject delaying responses to IM had higher phasic components (stress, anxiety...)

Analysis / Discussion

■ *Delay*

- Multiple ANOVA: no statistical result appeared.
- Correlation tests: delay inversely correlated to score ($p<0.012$).
 - Subjects performing well on the game (high scores) have more time to answer the IM, and thus have shorter delays.

■ *Score*

- Data not normally distributed: almost all subjects at 100% for easiest scenario (data skewed to the right). Scenario 1 removed.
- Multiple ANOVA:
 - workload is a significant factor ($p<0.005$, power of 0.869)
 - IM is a significant factor ($p<0.028$, power of 0.620)
 - gender*IM is also significant ($p<0.037$, power = 0.568)...
...but gender itself is not significant ($p=0.581$).

Discussion

- IM influences tonic response
 - IM and WL influence phasic response
 - Tonic and phasic responses are positively correlated
 - Phasic response inversely correlated to score
 - Phasic response positively correlated to delay
-
- >> IM is a stressing factor (despite being informal)
- >> IM modifies mood under high pressure

Discussion

■ Expected results:

- delay inversely correlated with score
- workload influences (badly) score

■ New results:

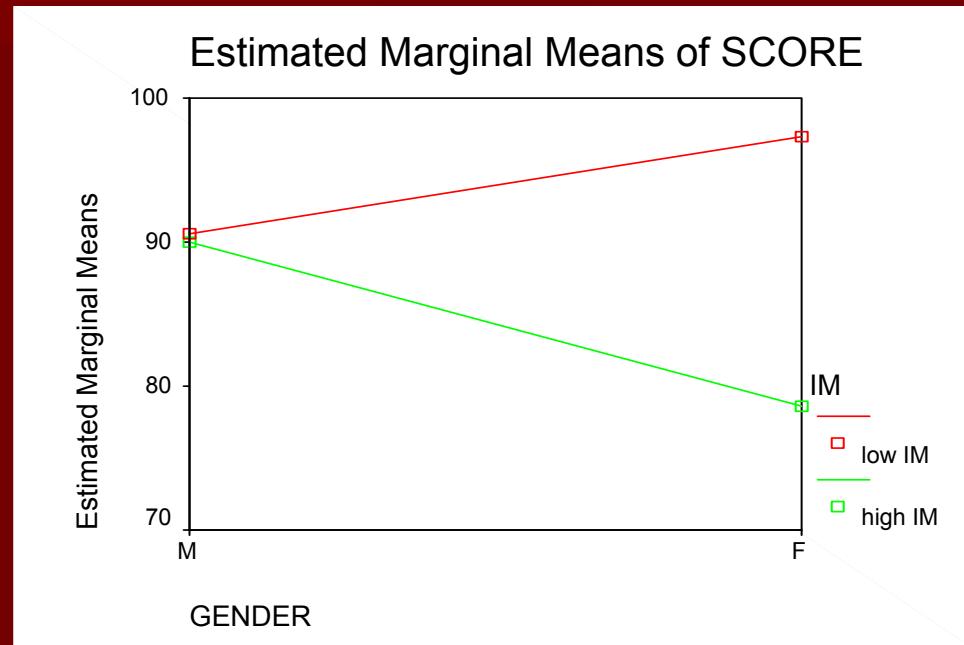
- IM influences (badly) score
- Especially significant with women

>> IM affects significantly task performance under high workload scenarii

>> Men and women do not handle the situation the same way

Discussion

- But be careful: only 6 subjects (4M, 2F)
- Women: the only to send “irrelevant” messages (smileys, “ok” confirmation)
- Men tend to focus more...
- ... but overall result is comparable (women perform better in low IM)



Conclusion

- Issue still needs work: more subject, more control of IM disruptiveness (level of difficulty of questions, rhythm...)
- Even if IM not answered, still influence behavior (alert sound, expectations, stress of not answering...) and task performance
- Better design of IM needed: SA indicator would be recommended

Resources

- <http://courses.media.mit.edu/2004spring/mas630/04.projects/sbruni/index.html>
- Literature review
- Presentation
- Final Paper
- GSR Socket (Python) file
- Questions?