#### Designing the Optimal Reading Room: A Radiology Perspective

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### **Clinical Relevance**

- High-tech modalities increasing
- More studies & more images being read
- Reading increased volume takes time
- More studies read after hours or by on-call radiologists, especially CT & MRI
- Radiologist shortages
- Increased workloads





















# Design Goals

- Accurate & efficient conveyance of information
- Diagnostic accuracy
  - Detection
  - Discrimination/classification
  - Measurement
  - · Recommended action
  - Consistency
- · Interpretation efficiency
  - Viewing time
  - · Use of tools & decision aids
  - Reporting





### Ambient Lights

- Patrick Brennan, PhD
- Mark Mc Entee, PhD
- Michael Evanoff, PhD
- Peter Phillips, MSc
- David Manning, PhD



American Board of Radiology



# **Ambient Conditions**

- 19 Radiologists at 480 lux
  - Simulates office lighting
- 15 under each of the following
  - 100 lux current recommendations
  - 40 and 25 lux dim lighting
  - 7 lux the absence of all light
- 30 bone images with & without subtle fractures















### **Eye-Tracking Study**

- Total viewing time (F = 4.372, p = 0.0394)
  - 8MP = 54.65, sd = 24.09
  - 5 MP = 62.86, sd = 27.58
- Total # fixations (F = 4.073, p = 0.0466)
  - 8MP = 134.47, sd = 65.14
  - 5MP = 154.29, sd = 65.09
- # scans between images (F = 10.305, p = 0.0018)
  - 8MP = 6.83, sd = 2.58
  - 5MP = 8.22, sd = 2.99





# Challenges?

- All-purpose workstation
  - Multi-modality
  - Multi-specialty
  - EHR
  - Integrated decision aids
  - Integrated user tools
  - Ergonomics & efficiency
  - New reading environments
- Reader fatigue
- Retrofitting old reading rooms
- · Convincing planners build new ergonomically



WARNING

CHALLENGES

AHEAD





"We could try a larger monitor with an ergonomic glare filter...but you're still going to get headaches if you keep banging your head against the screen."

# **Physical Complaints**

- Tired & overworked
- Carpal tunnel syndrome
- Elbow & shoulder (cubital tunnel)
- Neck, back & shoulder strains
- Computer vision syndrome
  - Corneal erosion and abrasions
  - Eye strain
  - Dry eyesContact lens problems
  - Contact lens probl
     Glaucoma
  - Headaches















8



http://ergo.human.cornell.edu/ahmsquest.html





shows the approximate parts reflected to in the example by making		During the last work yangk here athan did you experience adis, pair, documing in:			If you experienced sche, pain, disconders, have unconfortable was this?			If you experienced adue, poin, discondist, did the interface with your ability to work?				
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Lower Back												
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-	(55gM) (5.45)	8	8	8	8	8	8	8	8	8	8	8
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Xaar	(0140) (5.44)	0	0	0	0	0					0	0
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Foot	(Sight)	8	8		8	8	8		8		8	8

#### Seated worker (m/f) Standing worker (m/f) Hand (r/l)

Area	Never	Sometimes
Neck	34	66
RT Shoulder	64	36
LF Shoulder	70	30
Upper Back	57	43
Lower Back	39	61
RT Upper Arm	84	16
LF Upper Arm	91	9
RT Forearm	85	15
LF Forearm	92	8
RT Wrist	67	33
LF Wrist	86	14
Hip/Buttocks	68	32
RT Thigh	89	11
LF Thigh	89	11
RT Knee	84	16
LF Knee	88	12
RT Lower Leg	89	11
LF Lower Lea	92	8

"How often did you experience ache, pain or discomfort in.."

Area	Slightly Uncomfortable	Very Uncomfortable
Neck	60	40
RT Shoulder	57	43
LF Shoulder	64	36
Upper Back	67	33
Lower Back	67	33
RT Upper Arm	69	31
LF Upper Arm	73	27
RT Forearm	73	27
LF Forearm	78	22
RT Wrist	56	44
LF Wrist	69	31
Hip/Buttocks	58	42
RT Thigh	60	40
LF Thigh	80	20
RT Knee	80	20
LF Knee	83	17
RT Lower Leg	83	17
LF Lower Leg	91	9

"If you experienced ache, pain, discomfort, how uncomfortable was this?"

Area	Not at All	Interfered
Neck	47	53
RT Shoulder	53	47
LF Shoulder	60	40
Upper Back	60	40
Lower Back	59	41
RT Upper Arm	60	40
LF Upper Arm	82	18
RT Forearm	53	47
LF Forearm	82	18
RT Wrist	46	54
LF Wrist	67	33
Hip/Buttocks	69	31
RT Thigh	72	28
LF Thigh	79	21
RT Knee	78	22
LF Knee	81	19
RT Lower Leg	81	19
LF Lower Leg	87	13

"If you experienced ache, pain, discomfort, did this interfere with your ability to work?"

#### Results

 87% of radiologists reported ache, pain or discomfort in at least one body area at least 1-2 times in the week prior to the survey

- Respondents reported discomfort 1-2 times per week or more most frequently in the
  - Neck (66%)
  - Lower back (61%)
  - Upper back (43%)
  - Right shoulder (36%)
  - Right wrist (33%)
- Radiologists who spent greater than 90% of their day seated were more likely to report discomfort in their left shoulder (P = 0.01) and upper back (P = 0.0007)



- Females > males report right shoulder, left shoulder & left forearm symptoms
- Females > males report moderately or very uncomfortable neck, low back & hip/buttock pain
- Females > males right thigh pain slightly or substantially interfered with ability work
- Radiologists older & board certified > 10 years more likely report neck pain interfered with work



# Comfortable chairs with good lumbar support & easy height adjustment

- Place keyboards & mice properly avoid stress injuries
- Place displays proper heights avoid neck & shoulder stress injuries
- Height-adjustable workstations





# Visual Strain

- Occurs when oculomotor system works to maintain convergence, accommodation & direction of gaze
- Accommodative asthenopia caused by strain of ciliary muscles leads to blurred vision, headaches & pain in/around eyes
- headaches & pain in/around eyes
  Breakdown in physiological mechanism could underlie symptoms radiologists experience & lead to *diagnostic performance changes*



#### WAM-5500 Auto-Refkeratometer











51	VEDISH	1000	UPAT	TION/	L FA	TIGU	E INV	ENTO	DRY		
To what extent doe	s the exp	pressio	m desc	cribe h	ow yo	u feel	now.	Answe	r spon	taneo	usly and
mark the number t	hat corr	espon	ds to h	10m J.0	u feel	right	now. 7	he nu	mbers	vary	between
0 (not at all) and 10	) (to a ve	ry hig	h degr	ree).							
	Not at All							Tes	Very	High D	egree
Palpitations	0	1	2	3	4	5	6	7	8	9	10
Lack of Concern		1	2	3	4	5	6	7	8	9	10
Lazy	0	1	2	3	4	5	6	7	8	9	10
Worn Out		1	2	3	4	5	6	7	8		10
Tense Muscles	0	1	2	3	4	5	6	7	8	9	10
Numbness	0	1	2	3	4	5	6	7	8	9	10
Sweaty	0	1	2	3	4	5	6	7	8	9	10
Exhausted	0	1	2	3	4	5	6	7	8	9	10
Listless	0	1	2	3	4	5	6	7	8	9	10
Falling Asleep	0	1	2	3	4	5	6	7	8	9	10
Spent	0	1	2	3	4	5	6	7	8	9	10
Drowsy	0	1	2	3	4	5	6	7	8	9	10
Passive	0	1	2	3	4	5	6	7	8	9	10
Stiff Joints	0	1	2	3	4	5	6	7	8	9	10
Warm	0	1	2	3	4	5	6	7	8	9	10
Indifferent	0	1	2	3	4	5	6	7	8	9	10
Harting	0	1	2	3	4	5	6	7	8	9	10
Out of breath	0	1	2	3	4	5	6	7	8	9	10
Yawning	0	1	2	3	4	5	6	7	8	9	10
Drained	0	1	2	3	4	5	6	7	8	9	10
Sleepy	0	1	2	3	4	5	6	7	8	9	10
Overworked	0	1	2	3	4	5	6	7	8	9	10
Aching	0	1	2	3	4	5	6	7	8	9	10
Breathing heavily	0	1	2	3	4	5	6	7	8	9	10
Uninterested	0	1	2	3	4	5	6	7	8	9	10











# Impact Performance?

- Bone fx
- Chest nodules
- CT chest nodules
- Satisfaction of search





#### **Diagnostic Performance**

 Fitted proper binormal model to rating data
 Analyzed Az with ANOVA with independent variables institution, training & time-of-day

Significant drop in detection accuracy: Early vs Late ~ 5%



Zenker's diverticulum with residual barium + nodule CR images instead of film 25 years after 1<sup>st</sup> study







# What To Do?

- Take advantage technological solutions
  - CAD & image-analysis tools designed to assist radiologists should be used – as long as properly integrated into clinical reading workflow & not impediment
- Properly optimizing (e.g., calibration, luminance, contrast, viewing angles, ambient light levels) display & viewing environment



- Standing on periodic basis
- Take periodic breaks simply stand up & walk around for 5 minutes
  - Gives chance to unwind & use muscles not used when simply sitting all day
- Yoga, light aerobics
- Power naps
  - 15-20 min = boosts alertness & motor skills
  - 30-60 min = boosts memory, creativity, decisionmaking skills
  - Cannot "buy back" lost sleep need to make up



### **Conclusions**

- Good reading room design in critical
- Fatigue & stress common problems
- Particularly important for residents
- Guidelines available
  - ACR-AAPM-SIIM Electronic Practice
  - ACR-AAPM-SIIM Digital Radiography
- Much of what can do is common sense
- JUST DO IT!



# **Questions?**

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