

# Job Analysis Rating Analysis via Item Response Theory

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# Importance of Job Analysis

- Court Cases
- Uniform Guidelines on Employee Selection Procedures (1978)
- Principles for the Validation and Use of Personnel Selection Procedures (1987)
- Standards for Educational and Psychological Testing (1999)

Conclusion – Necessary but not sufficient practice for many personnel programs

## Despite Importance ...

- Perceived as means to an end
- Measurement error
- Social and cognitive biases (Morgeson & Campion, 1997)
- Limited guidance concerning scale selection or combination
- Little research into the appropriateness of job analysis scale anchors
- Limited research concerning job analysis data into test plan

## **Current Study ...**

- Firefighter physical agility test development
- Task based job analysis
- Importance and Frequency scales
- Questionnaire completed by incumbents and immediate supervisors
- Provide alternate method of examining job analysis results

# Why Item Response Theory?

- Rasch Measurement Model
- Respondents and Items calibrated on same scale of measurement
- Compare items and persons
- True interval properties (scale points)
- Additional information about activities and respondents

# Method

- Physical agility test development
- Task and ability inventory focused on 55 tasks
- 141 respondents (engineers, captains, lieutenants)
- Confirmatory approach (link existing “events” to job analysis results)
- WinSteps software program

# Results

Two assumptions of Rasch model:

1. Unidimensionality
2. Local Independence

Data fit the model relatively well:

Principal components analysis of residuals (Linacre, 1998)

One dimension accounted for 64% of variance

## Summary of Measured Persons (Person Reliability .96)

	<b>Raw</b>			<b>Model</b>
	<b>Score</b>	<b>Count</b>	<b>Measure</b>	<b>Error</b>
<b>Mean</b>	83.8	54.2	.06	.20
<b>s.d.</b>	36.8	4.7	1.25	.10
<b>Max.</b>	161.0	55.0	4.04	1.27
<b>Min.</b>	1.0	1.0	-3.29	.17
	<b>INFIT</b>		<b>OUTFIT</b>	
	<b>MNSQ</b>	<b>ZSTD</b>	<b>MNSQ</b>	<b>ZSTD</b>
<b>Mean</b>	1.04	-.3	1.04	-.3
<b>s.d.</b>	.50	2.5	.49	2.3
<b>Max.</b>	2.80	7.3	2.86	7.0
<b>Min.</b>	.00	-6.6	.00	-5.4

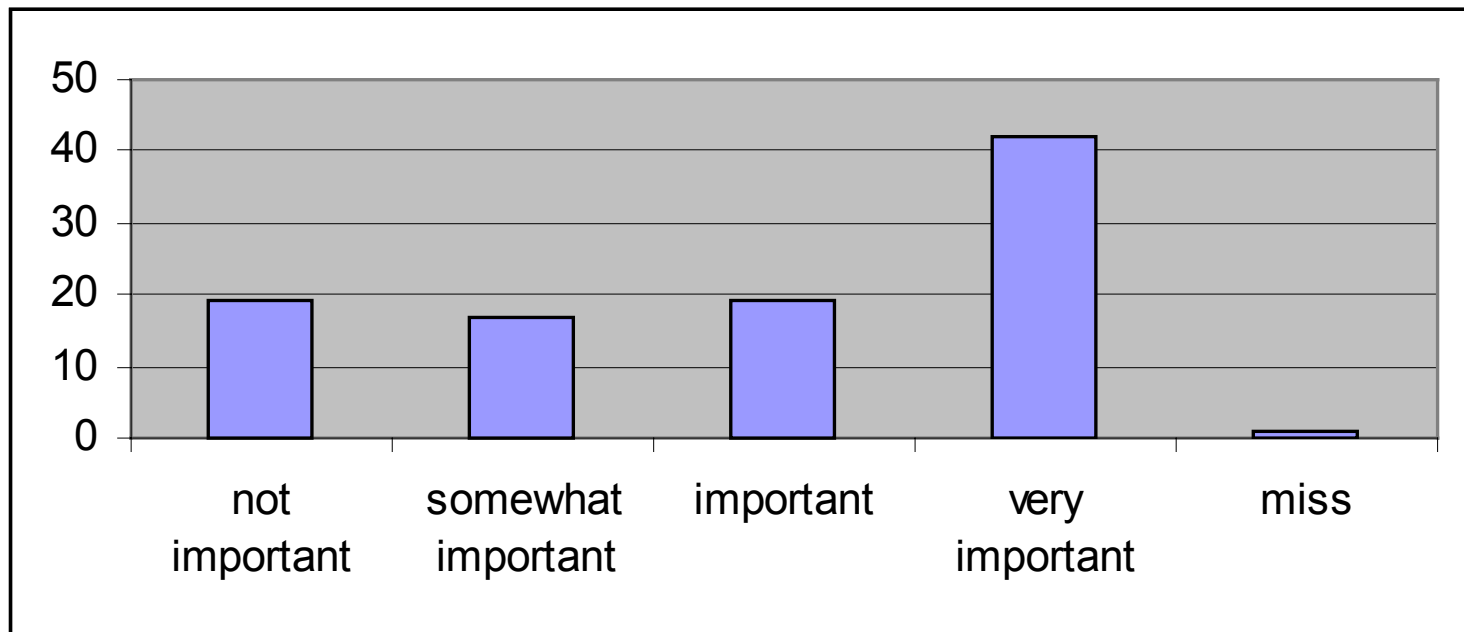


## Summary of Measured Items (Item Reliability .96)

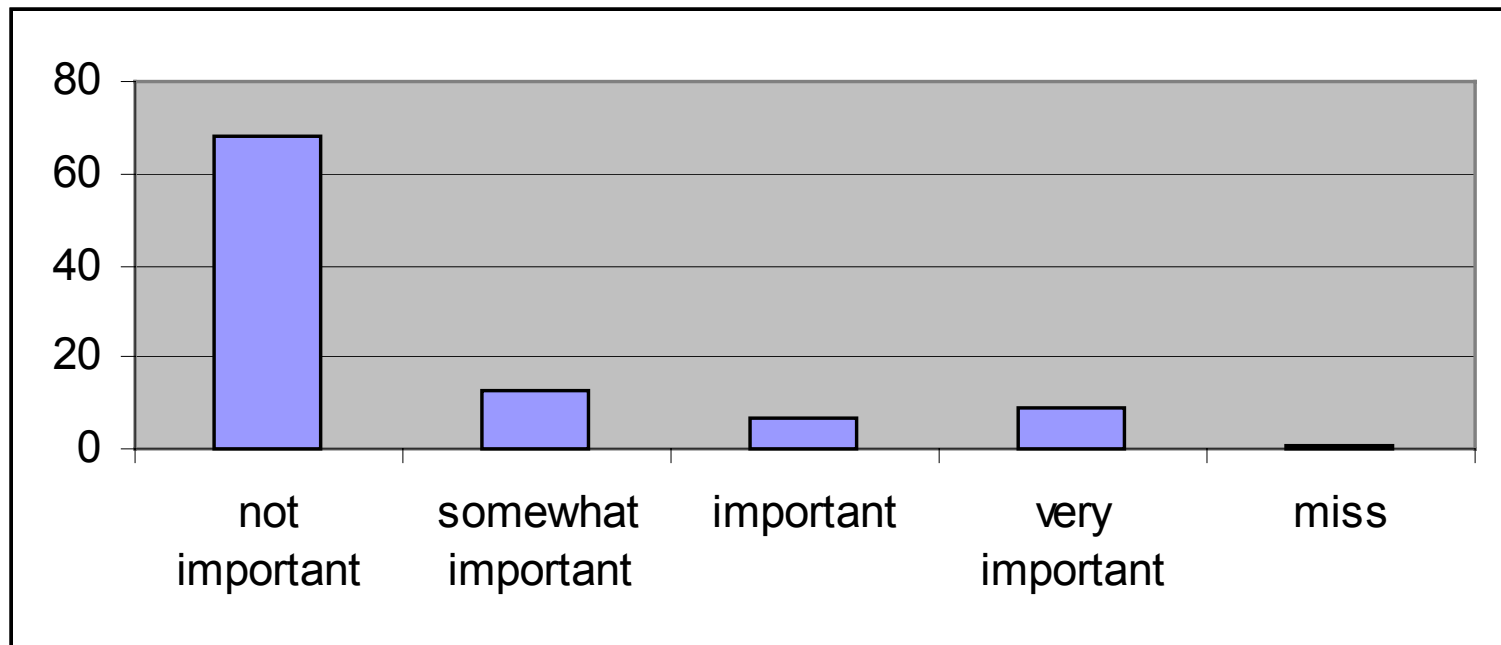
	<b>Raw</b>			<b>Model</b>
	<b>Score</b>	<b>Count</b>	<b>Measure</b>	<b>Error</b>
<b>Mean</b>	214.7	138.9	.00	.12
<b>s.d.</b>	48.8	1.3	.68	.01
<b>Max.</b>	315.0	141.0	2.00	.14
<b>Min.</b>	78.0	133.0	-1.38	.11
	<b>INFIT</b>		<b>OUTFIT</b>	
	<b>MNSQ</b>	<b>ZSTD</b>	<b>MNSQ</b>	<b>ZSTD</b>
<b>Mean</b>	1.01	-.7	1.05	-.5
<b>s.d.</b>	.55	3.7	.63	3.7
<b>Max.</b>	3.03	9.9	3.16	9.9
<b>Min.</b>	.41	-6.9	.46	-5.6

# Missfitting Items

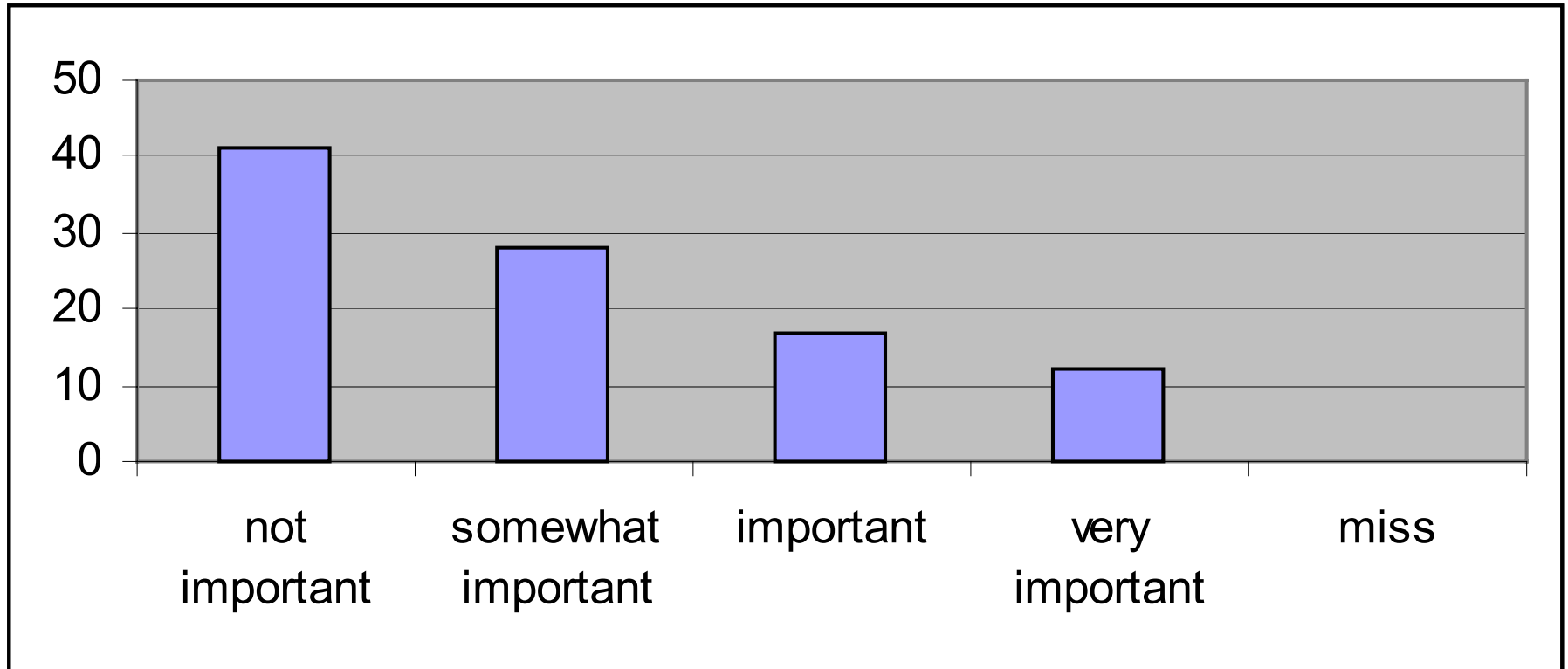
#21 Removes, carries, and maneuvers, straight ladders, extension ladders, roof ladders, pole ladders, attic ladders, and A-Frame unassisted (3.06);



#12 Locates Hidden Fire by Feeling walls and ceiling or by smelling fire (3.03);



## # 6 Lifts and carries SCBA's. (3.16)



PERSONS

MAP OF ITEMS

	<frequ>		<less>	
4	X	+		
3		+		
	XXX	T		
	XX			
2	XXX	+	Locates hidden fire by feeling walls and ceiling	
	X		Unfolds fire shelter and covers oneself in it ...	
	X			
	XXXXX			
	XXXXXXXXX	S	T	
	XXXX		Constructs fire line in grassy area by scraping...	
1	XXXXXXXXX	+	Mai Sta	
	XXXXXXXXXXXXX		Cli Rem	
	XXXXXXXXXXXXX	S	Wal	
	XXXXXX		Ope Pro Smo	
	XXXXXX		Con Con Cut Ign Jum Rel Sit Tra Wal Wal	
	XXXX			
0	XXXXXX	M+M	Cli Cre Ent Jum Rai Use Wal	
	XXXXXXXXXXXXX		Car Car Con Cut Lif Res Use	
	XXXX		Cli Hoi Mov Phy Sta Usi	
	XXXX		Car Dri Dri Rem	
	XXXX	S	Car Hoi Mov	
	XXXXXXXXXXXXX		Car Mak Rol	
-1	XXXXXX	+	Drags victims ... Drives emergency medical ...	
	XXX	S	Carries equipment and hose to upper floors ...	
	XXXXXX	T	Extinguishes grass fires with shovel or rake.	
	XXXX			
	X			
	X			
-2	X	+		
	XX			
	XXX	T		
	X			
-3	X	+		
	X			
-4		+		
	<rare>		<more>	

ITEMS

MAP OF PERSONS

```

<rare> | <more>
4      + ltt (35-44 yrs, 1-3 yrs class, 7-9 yrs exp)
      |
      |
3      + 1 (45-54 yrs, 10> yrs class, 10> yrs exp)
      | 2 (35-44 yrs, 1-3 yrs class, 10> yrs exp)
      | 3 (35-44 yrs, 4-6 yrs class, 7-9 yrs exp)
      | T eng1 ltt2 ltt3
      |
      |
2      X + cap ltt
      X | eng ltt ltt
      | | eng
      | | ltt
      | | cap cap cap ltt ltt
      | S | T cap cap eng ltt ltt ltt ltt ltt
      | X | cap eng ltt ltt
1      XX + cap eng eng eng ltt ltt ltt
      XX | cap cap eng eng eng eng eng ltt ltt ltt
      |
      |
ltt    X | S cap cap cap eng eng eng ltt ltt ltt
      XXX | cap cap eng eng eng eng
      XXXXXXXXXX | eng eng eng eng ltt ltt ltt
      | | cap eng ltt ltt
0      XXXXXXXX M+M cap cap eng eng eng eng ltt
      XXXXXXXX | cap cap eng eng eng eng ltt ltt ltt ltt
      XXXXXX | eng eng eng ltt
      XXXX | cap eng eng eng
      XXX | S eng eng ltt ltt
      XXX | cap eng eng eng eng eng ltt ltt ltt
-1     XX + cap eng eng eng ltt ltt
      X S | eng eng eng
      X | T eng eng eng eng ltt ltt ltt
      | | cap eng eng ltt
      | | eng
      | | ltt
-2     + | eng
      | | eng eng
      |
      |
      | T cap eng ltt
      | | eng (45-54 yrs, 10> yrs class, 10> yrs exp)
-3     + | cap (55> yrs, 7-9 yrs class, 10> yrs exp)
      | | ltt (55> yrs, 10> yrs class, 10> yrs exp)
      |
-4     + |
      |
      | <frequ> | <less>

```

EXPECTED SCORE: MEAN (":" INDICATES HALF-SCORE POINT)

-4	-3	-2	-1	0	1	2	3	4	5	NUM	ITEM		
				0	:	1	:	2	:	3	3	12	Locates hidden fire by feeling walls and ceil
				0	:	1	:	2	:	3	3	55	Unfolds fire shelter and covers oneself in it
			0	:	1	:	2	:	3		3	49	Constructs fire line in brush or wooded area
		0	:	1	:	2	:	3			3	34	Stands for more than half of shift while perf
		0	:	1	:	2	:	3			3	42	Maintains balance on narrow or uneven surface
		0	:	1	:	2	:	3			3	6	Climbs or crawls through confined spaces
		0	:	1	:	2	:	3			3	25	Removes ventilation fans or smoke ejectors
	0	:	1	:	2	:	3				3	35	Walks for more than half of shift while perf
	0	:	1	:	2	:	3				3	26	Probes with pike poles to determine if roof
	0	:	1	:	2	:	3				3	48	Operates portable hand operated pump to extin
	0	:	1	:	2	:	3				3	53	Smothers fire or potential fire restart areas
	0	:	1	:	2	:	3				3	36	Walks up and down stairs in a multiple story
	0	:	1	:	2	:	3				3	54	Ignites unburned areas within break lines
	0	:	1	:	2	:	3				3	37	Walks up and down rough terrain (e.g., hills)
	0	:	1	:	2	:	3				3	50	Transports wildland firefighting equip
	0	:	1	:	2	:	3				3	19	Reloads hoses, nozzles, and other equipment
	0	:	1	:	2	:	3				3	33	Sits for more than half of shift while perfor
	0	:	1	:	2	:	3				3	52	Cuts limbs, snags, brush, trees, etc. using
	0	:	1	:	2	:	3				3	51	Constructs fire line in a grassy area by scra
	0	:	1	:	2	:	3				3	32	Constructs fire line in a grassy area with ha
	0	:	1	:	2	:	3				3	41	Jumps down from high objects (e.g., 6 ft fenc
	0	:	1	:	2	:	3				3	7	Walks or crawls along joists where balance an
	0	:	1	:	2	:	3				3	40	Jumps down from low objects (e.g., window led
	0	:	1	:	2	:	3				3	22	Raises and lowers straight ladders, extension
	0	:	1	:	2	:	3				3	23	Creates ventilation openings by forcing doors
	0	:	1	:	2	:	3				3	38	Climbs up to elevated surfaces (e.g., roof)
	0	:	1	:	2	:	3				3	28	Uses axe to cut hole through roof
	0	:	1	:	2	:	3				3	8	Enters, walks, or crawls throu
	0	:	1	:	2	:	3				3	5	Rescues drowning persons by swimmming and usi
	0	:	1	:	2	:	3				3	46	Lifts and carries SCBA's.
	0	:	1	:	2	:	3				3	29	Uses pulling and prying tools (pike pole, pla
	0	:	1	:	2	:	3				3	14	Carries or drags charged hose lines to fire
	0	:	1	:	2	:	3				3	31	Constructs fire line in brush or wooded area
	0	:	1	:	2	:	3				3	30	Cuts or pries open vehicles, machinery, or
	0	:	1	:	2	:	3				3	43	Carries objects or equipment (e.g., ax, hose
	0	:	1	:	2	:	3				3	44	Physically reacts to sounds, signs, signals
	0	:	1	:	2	:	3				3	39	Climbs through small openings, such as window
	0	:	1	:	2	:	3				3	27	Starts and operates chain saw

EXPECTED SCORE: MEAN (":" INDICATES HALF-SCORE POINT)

-4	-3	-2	-1	0	1	2	3	4	5	NUM	ITEM
0	0	:	1	:	2	:	3			3	18 Hoists hose sections and other equipment usin
0	0	:	1	:	2	:	3			3	24 Using hooks or hangars, remove ventilation fa
0	0	:	1	:	2	:	3			3	1 Moves and carries heavy objects, equipment or
0	0	:	1	:	2	:	3			3	3 Carries or assists conscious, unconscious, or
0	0	:	1	:	2	:	3			3	20 Drives apparatus according to state and local
0	0	:	1	:	2	:	3			3	11 Drives emergency medical vehicle to transport
0	0	:	1	:	2	:	3			3	21 Removes, carries, and maneuvers, straight
0	0	:	1	:	2	:	3			3	10 Moves victims from scene to ambulance, corona
0	0	:	1	:	2	:	3			3	2 Carries equipment from emergency scene; cuts
0	0	:	1	:	2	:	3			3	4 Hoists and lowers victims, tools, and equip
0	0	:	1	:	2	:	3			3	16 Makes and unmakes hose connections to water
0	0	:	1	:	2	:	3			3	15 Carries or drags empty hose lines to fire sce
0	0	:	1	:	2	:	3			3	13 Rolls or folds hose sections; carries to and
0	0	:	1	:	2	:	3			3	45 Drives for extended periods of time (> 15 min
0	0	:	1	:	2	:	3			3	9 Drags victims while crouched low.
0	0	:	1	:	2	:	3			3	17 Carries equipment and hose to upper floors of
00	:	1	:	2	:	3				3	47 Extinguishes grass fires with shovel or rake.



MOST MISFITTING RESPONSE STRINGS

ITEM	OUTMNSQ	PERSON
		1 1 11 11 1 1 1 1
		674 185399392503 7663711 216232 41 723418542220207
		94747918761135653640251281622771466100092709013629

high-----

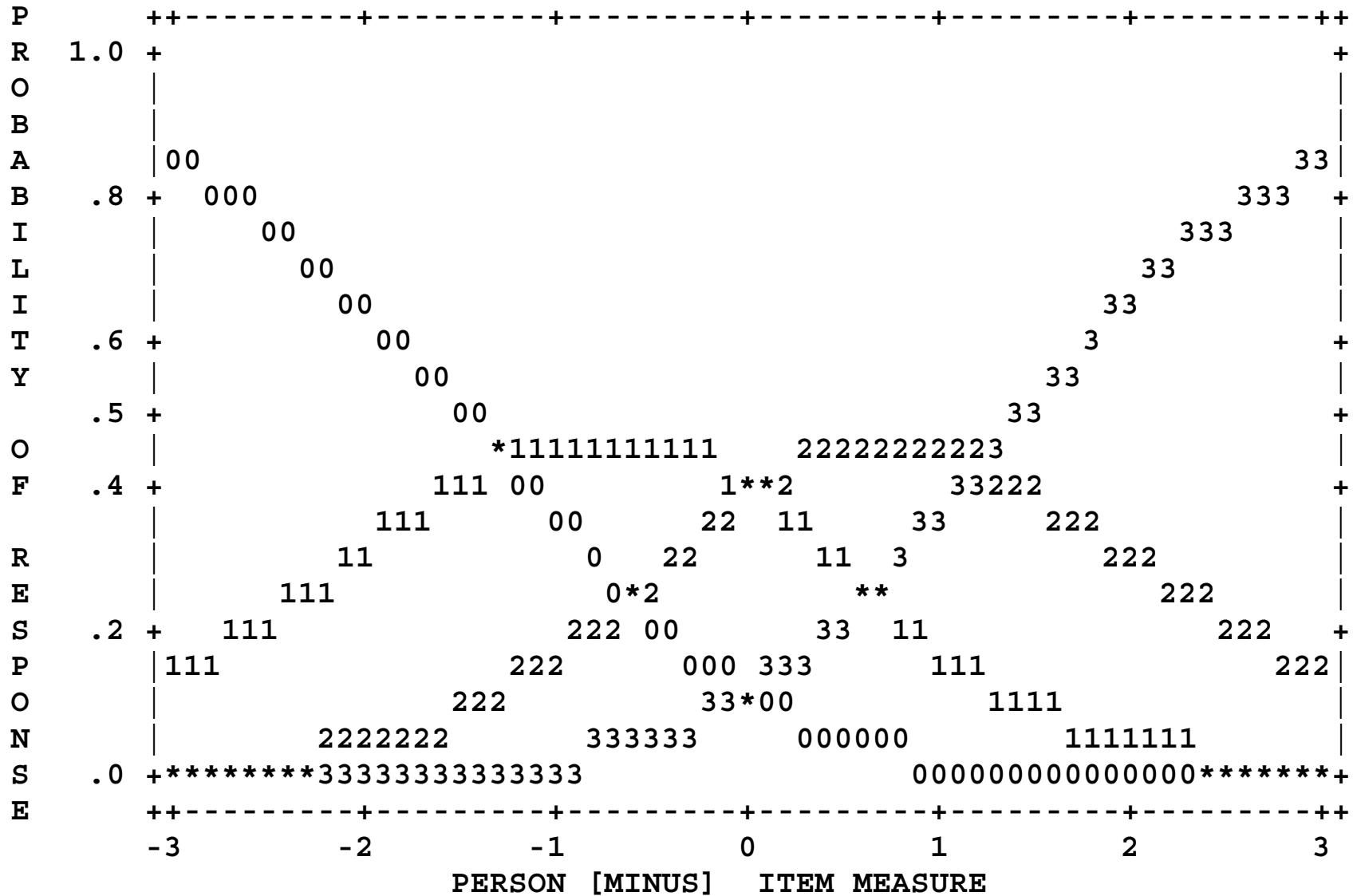
46 Lifts and carries SCBA's. 3.16 A | ....1.....0...00.0.....3 33..333333.33333.33.2...2

21 Removes, carries, and maneuvers, straight ladders, extension ladders roof ladders, pole ladders, attic ladders, and A-frame ladders unassisted. 3.06 B | .....011..000.00.....333333.33.33333.3.2.2

12 Locates hidden fire by feeling walls and ceiling or by smelling fire. 3.03 C | .00.....3..323.32.....213...2.....1...

1 Moves and carries heavy objects, equipment or materials to gain access to or to free trapped victims or bodies. 2.27 D | 22.1.1.1.....3..2..2.3.32

CATEGORY PROBABILITIES: MODES - Step measures at intersections



GUTTMAN SCALOGRAM OF RESPONSES:

PERSON | ITEM  
      | 41 4111 1212 21234433124 22234 435531535354232 43451  
      | 7795356420110314879430149658823807121239074638655624952  
      | -----  
69 +33333333333332333333333333333333333333333333333330333333  
74 +3333333333333233333333333333233333 333333333333033 31010  
47 +33333333333132233323333333333333333323333333333232033310

103 +0010100111010130000000000110000010000000000000100001  
26 +110001100020101000000001010000000000000010100010001000  
102 +000 000000000030000 000000000000001100101011000000100  
79 +000000000020002000000000200000000000000000010001000  
      | -----  
      | 4194111421212312123443312458222347435531535354232643451  
      | 77 5356 0110 48794301496 82380 121239074638655 24952

**Item 47** -- Extinguishes grass fires with shovel or rake. (1)

**Item 17** -- Carries equipment and hose to upper floors of buildings (2)

**Item 9** -- Drags victims while crouched low (3)

**Item 49** -- Constructs fire line in brush or wooded area using a brush hook, Pulaski, or double bit axe. (53)

**Item 55** -- Unfolds fire shelter and covers oneself in it when normal exits from a fire are blocked in order to shield oneself from advancing heat and flame. (54)

**Item 12** -- Locates hidden fire by feeling walls and ceiling or by smelling fire. (55)

## Conclusions

- Rasch model assumes interval properties (only way to examine data)
- Job analysis Guidelines:
  - Limited guidance regarding how to measure
  - No guidance regarding how to analyze
- Benefits of IRT
  - Additional means of analyzing data
  - Provides additional information beyond means and standard deviations
  - Method of assessing utility of scale anchors
  - Possibility of adaptive job analysis questionnaires

## Contact Information

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Scale discriminates between the persons well.

Items create a well defined variable (.96).

Outfit Mean of -.3 indicates less than expected; and more variability in the fit of these persons as expected.

Review outliers in summary statistics.

Item outfit of -.5 responses are more consistent than the model expects. S.D. suggests that there are some misfitting items.