Risk Perception and Safety Behavior : Implications for Laboratory Safety

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Contents

Importance of 'Safe Laboratory'

- Laboratory is a place where scientific knowledge is produced and future scientists are disciplined (Park & Park, 2008)
- The laboratory environment can be a hazardous place to work (OSHA, 2011)
  - exposure to a wide range of chemical, biological and physical hazards
  - adopt ergonomically poor postures for long periods of time

Prior Approaches

"Hierarchy of controls" for lab safety (Health and Safety Authorities)

1. engineering controls
2. administrative controls
3. work practices
4. personal protective equipment

Increased Complexity of Risk Events

- The number of the accidents has been increasing
- The 'cause' control is getting harder since the accidents are the result of the complex interplay of hazardous elements, human factors, environmental context, and individuals' risk related decision makings

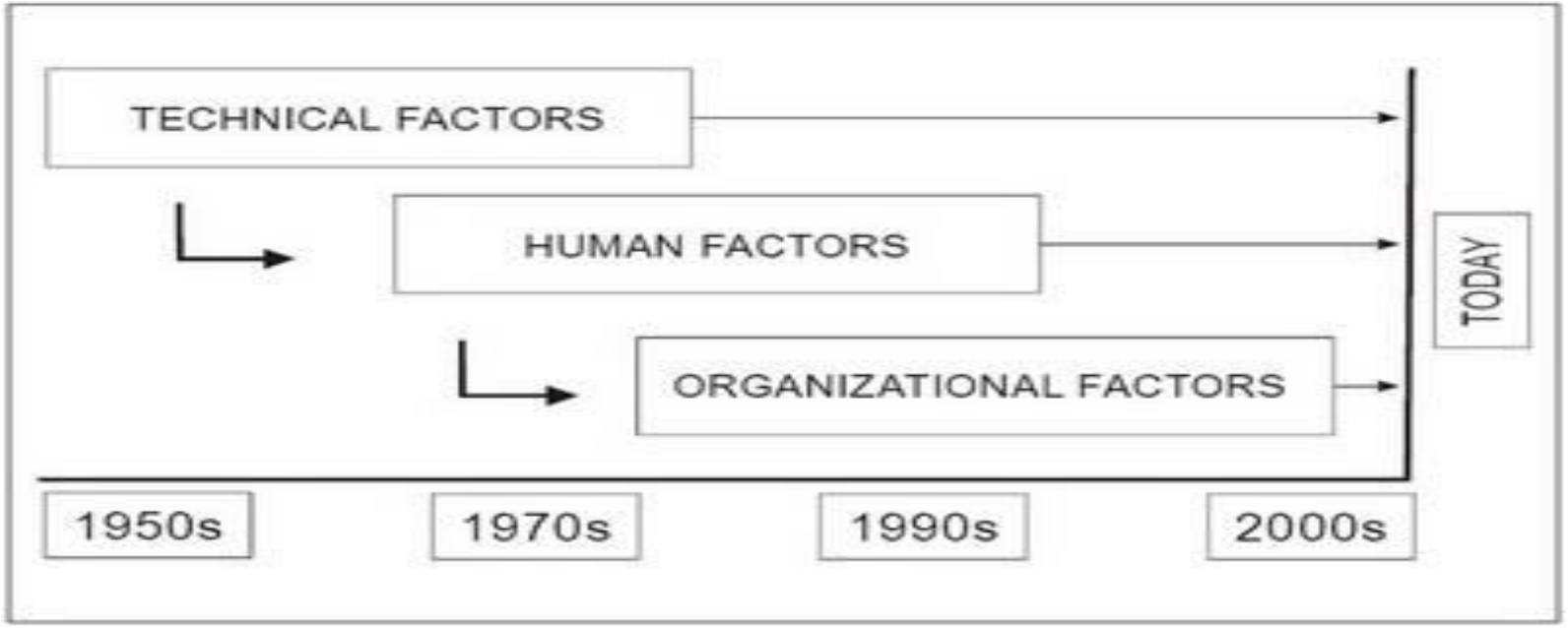
Table. Lab accident statistics

(Ministry of Science, ICT and Future Planning, 2015)

	2007	2008	2009	2010	2011	2012	2013	2014	2015	Total
4 year-College	26	85	125	117	144	98	88	130	117	930
2,3 year-Junior college	5	7	6	1	6	4	6	14	220	269
Research Institution	15	6	9	11	7	6	13	20	36	123
Total	46	98	140	129	157	108	107	164	373	1322

Evolution of the Concept of Safety

<International Civil Aviation Organization, 2013>



- Technical Factors : procedures, sources of information, databases,
- Human Factors : diversity of individuals from gender/age to attitudes/beliefs)
- Organizational Factors : interactions between the members to perform the activities

Increased Emphasis on Org. and Humans for Lab Safety

Organizational

- Climate, Culture, and Leadership
  - Group Silence
  - Mindfulness among lab workers
  - Organizational Learning (i.e. collective efforts for sharing information of the Safety)

Increased Emphasis on Org. and Humans for Lab Safety

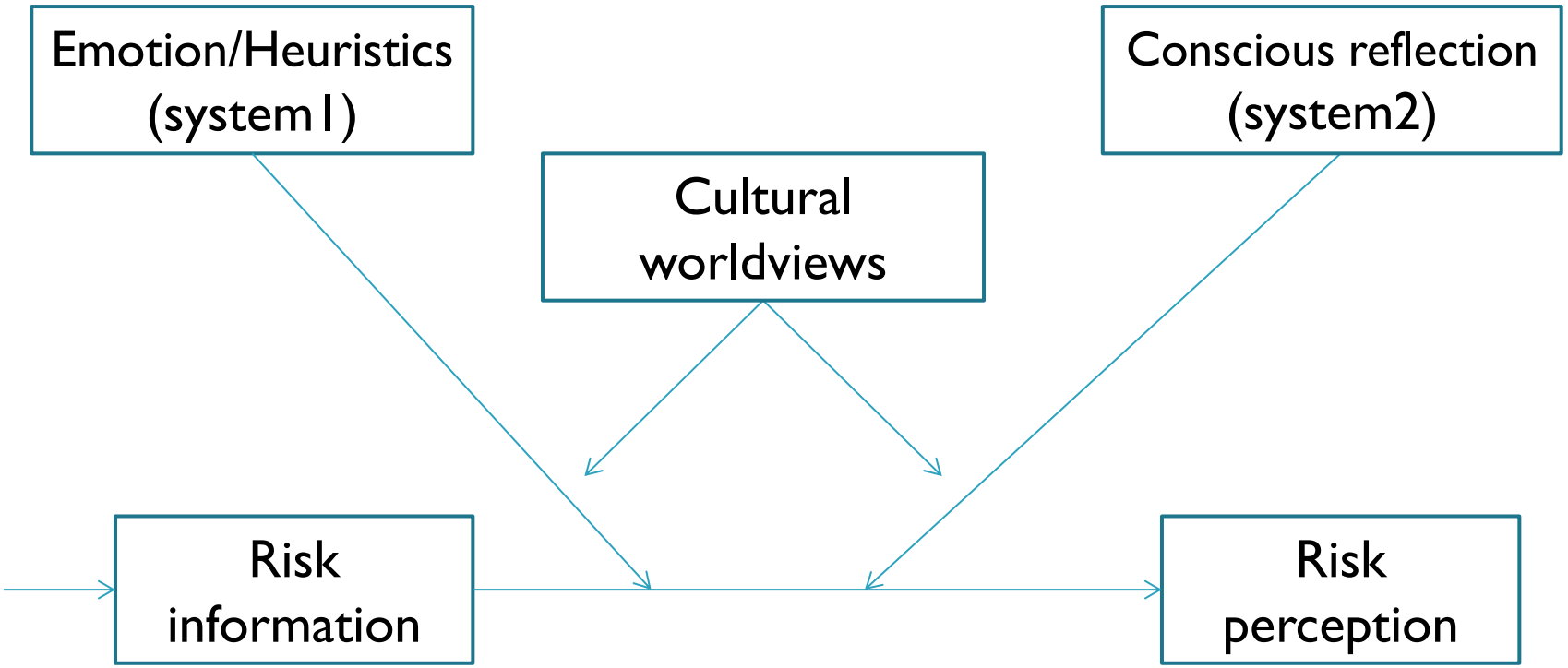
Individual

- Perceived Risk:
  - Subjective evaluation of a risk
  - Multidimensional
  - Experiential rather than inferential
  - Plays a major role for motivating individuals to take action to avoid, mitigate, adapt, or even ignore risks

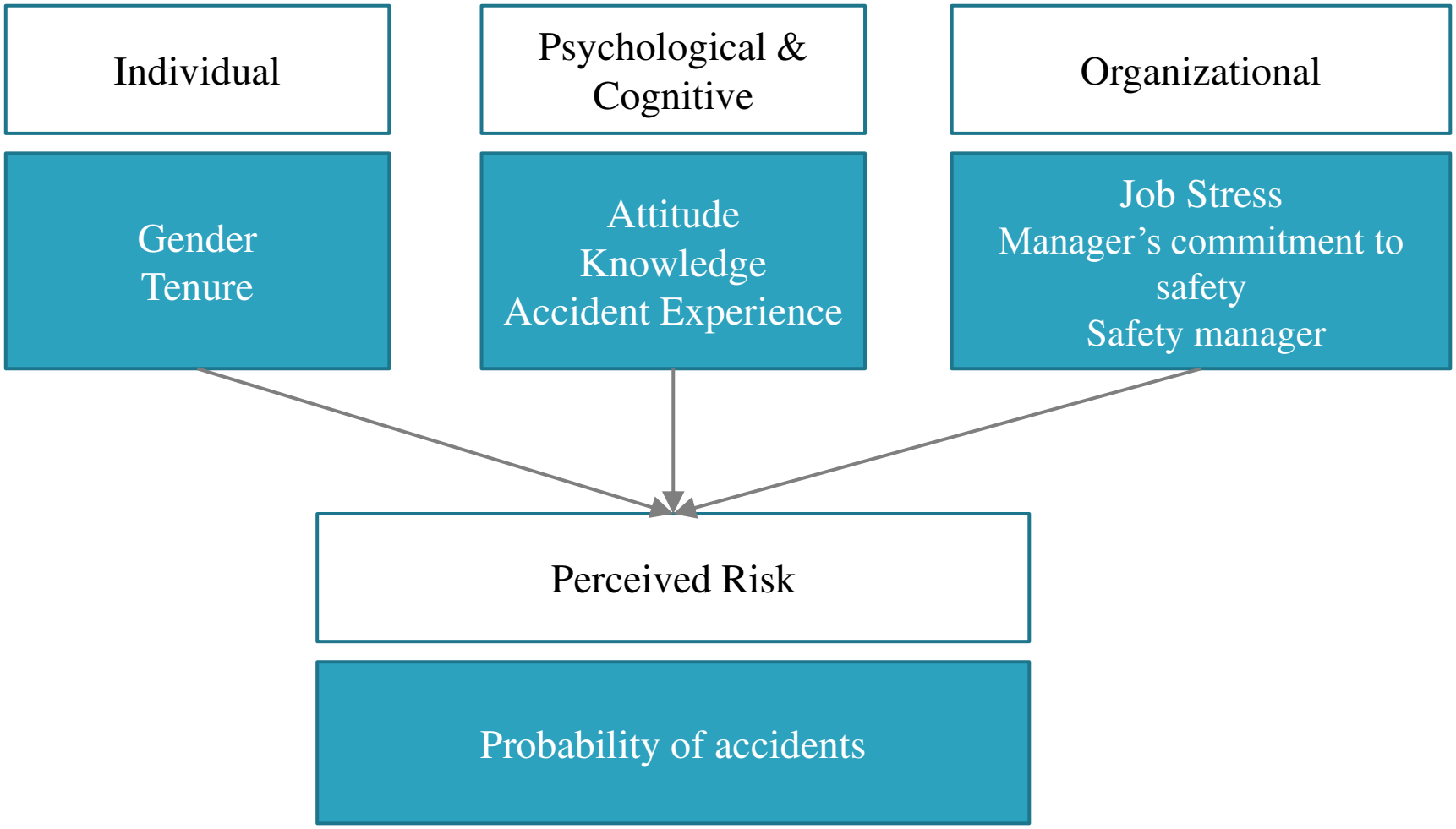
Two Possible Questions

- *Consider 'risk perception' as a dependent variable*
- *Determine the relation between perceived risk and safety behavior*

Theoretical Model



Modified Framework



A sample study

- Year : 2010.1 ~ 2010.4
- Data : Collected from 356 graduate students who are involved in laboratory in seven universities
- Methods : Self-reported survey
- Funding : National Research Foundation of Korea
- Co-investigators

Tae Hoon Kim (Hoseo Univ.)

Jeong Im Park (Soonchunhyang Univ.)

Chung Sik Yoon (Seoul Nat'l Univ.)

Kwang Won Rhie (Hoseo Univ.)

Yun Keun Lee (Wonjin Institute for Occupational and Environmental Health)

A sample study

Measurements

- **Perceived Risk**

"What is the probability to experience laboratory accident yourself for the next 3 years? (Response as %)"

Individual

- **Gender** male / female
- **Tenure** ( ) months

A sample study

Psychological & Cognitive

- **Experience**

(1:Yes, 0:No)

Whether I've directly experienced laboratory accidents in the past

- **Attitude**

5-point Likert scale (1: Very unlikely, 5:Likely)

"Many accidents just happen, there is little one can do to avoid them (R)"

"Sometimes it is necessary to take risks to get a job done (R)"

"Safety measures only shift the danger from one area to another (R)"

- **Knowledge**

5-point Likert scale (1: Very unlikely, 5:Likely)

Knowledge of protector in lab, safety facilitate, and evacuation location, First aid

A sample study

Organizational

- **Job stress**

5-point Likert scale (1: Very unlikely, 5:Likely)

Control speed of job, Authority to decide job method to progress
Relationship with research manager

- **Manager's commitment to safety**

5-point Likert scale (1: Very unlikely, 5:Likely)

Knowledge of protector in lab, safety facilitate, and evacuation location, First aid

Analysis

Correlation analysis

Pearson's correlation coefficient

Hierarchical Multiple Regression

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_7 X_7 + \beta_8 X_8 + \varepsilon$$

Y = Perceived Risk

X_1 = Gender

X_2 = Tenure

X_3 = Accident Experience

X_4 = Attitude

X_5 = Knowledge

X_6 = Job stress

X_7 = Manager's commitment to safety

X_8 = Presence of safety manager

Results

N=356

Variable	Classification	Frequency /Average	Relative frequency /Standard deviation
Gender	Male	234	65.73
	Female	122	34.27
Age (Year)		26.59	3.435
Tenure(month)		30.74	28.83
Academic Background	Bachelor's degree	8	2.25
	Master	195	54.77
	Ph.D.	141	39.61
	Post-Doctorial	12	3.37
Accident experience	Yes	53	14.89
	No	303	85.11

Results

N=356

Variable	Average	Standard deviation
Attitude	3.06	0.41
Knowledge	3.61	0.7
Job stress	2.47	0.53
Manager's commitment to safety	3.44	0.72
Presence of safety manager	Yes:308, No:47	
Norms	3.519	0.49
Perceived Controllability	85.45%	18.75%
Intention	3.998	0.545
Behavior	3.542	0.717

Results

Perceived Risk

	Average	Standard Deviation
"What is the probability to experience laboratory accident yourself for the next 3 years?"	11.25%	16.98

- Proportion of respondents who have experienced Laboratory accidents by themselves (14.89%), and Average of Probability to experience laboratory accident by themselves (11.25%) were quite similar.

Results

Correlation analysis

	Descriptive statistics		Pearson's correlation coefficient								
n=355	Mean	S.D.	1	2	3	4	5	6	7	8	9
Perceived risk	11.26	17	1								
Gender	Male:233, Female:122		.029	1							
Tenure	30.77	28.866	-.123*	-.126*	1						
Accident experience	Y:53, N:302		.163**	-.020	.150**	1					
Attitude	3.06	0.41	-.159**	-.069	-.038	-.083	1				
Knowledge	3.61	0.7	-.090	-.291**	.130*	.069	.236**	1			
Job stress	2.47	0.53	.119*	.099	-.200**	-.015	-.249**	-.375**	1		
Manager's commitment to safety	3.44	0.72	-.129*	-.101	-.021	.005	.231**	.491**	-.273**	1	
Presence of a Safety manager	Y:308, N:47		.002	.020	.006	.000	.057	.108*	-.091	.363**	1

*: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Results

- Accident experience ($r=0.163$, $p<0.01$), Job stress ($r=0.119$, $p<0.05$) have significant positive correlation with Perceived Risk.

- Tenure ($r=-0.123$, $p<0.05$), Attitude ($r=-0.159$, $p<0.01$), Manager's commitment to safety ($r=-0.129$, $p<0.01$) have a significant negative correlation with Perceived Risk.

Results

Hierarchical Multiple Regression

	Model 1		Model 2		Model 3	
Variable	B	β	B	β	B	β
Gender	0.541	0.015	-0.366	-0.01	-0.614	-0.017
Tenure	-0.071*	-0.121*	-0.088**	-0.149**	-0.094**	-0.160**
Direct Experience			8.48***	0.178***	8.271*	0.174*
Attitude			-5.831**	-0.139**	-6.01*	-0.143*
Knowledge			-1.27	-0.053	-0.090	-0.004
Job stress					1.501	0.047
Manager's commitment to safety					-2.429	-0.103
Presence of a Safety manager					2.804†	0.056†
adjusted R^2	0.01		0.061		0.075	
R^2 increment			0.051		0.014	
F-value	2.756		5.617		4.612	
P-value	0.065		0.000		0.000	

†: p<0.1, *: p<0.05, **: p<0.01, ***: p<0.001

Results

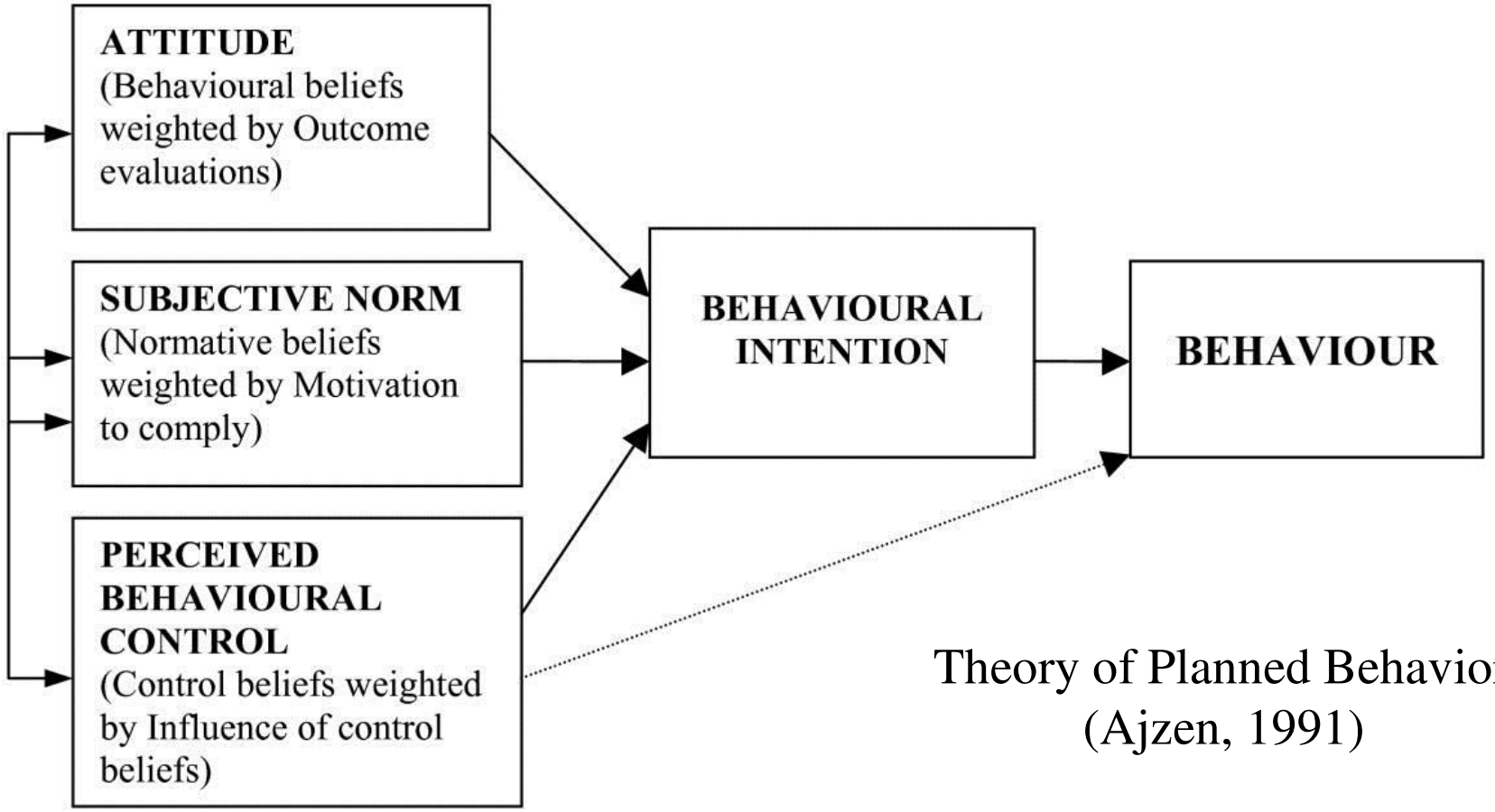
- Model 1 included Individual variable analysis, Psychological & Cognitive variable is added to Model 2, and Organizational variable is added to Model 3.

- Tenure (coeff=-0.094,$p<0.01$), Direct experience (coeff=8.271,$p<0.05$), Attitude (coeff=-6.01,$p<0.05$), Presence of a safety manager (coeff=2.804,$p<0.1$) had significant influence to risk perception.

Key Findings

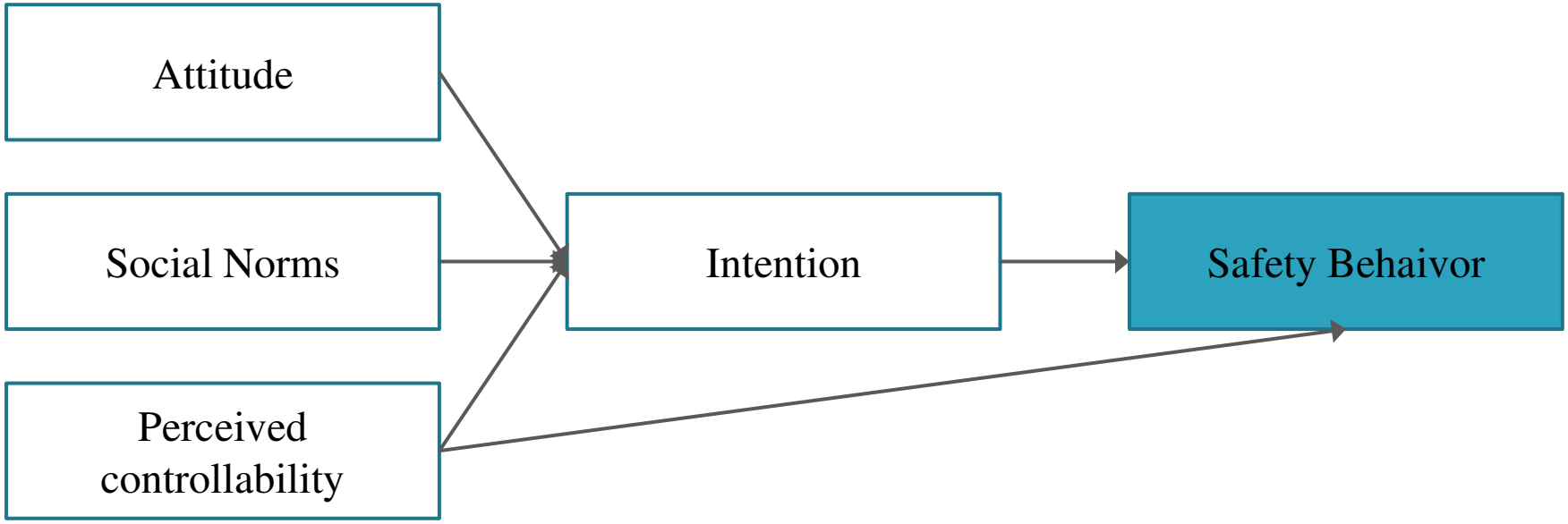
- Lab worker's risk judgment is not only relying on Individual, Psychological/Cognitive factors but also Organizational factors
- Past experience of the accident at the lab was the most powerful predictor of risk perception
- Graduate students who experienced any kind of lab accident and report high job stress are more likely to evaluate the likelihood of the occurrence of the accident at their lab higher than others. But those who have a long tenure, show safety attitude, and are working with a supervisor who emphasizes 'lab safety' tend to underestimate the probability of experiencing an accident at work

Theoretical Model



Theory of Planned Behavior
(Ajzen, 1991)

Modified Framework



A sample study

Measurements

- **Norm**

5-point Likert scale (1: Very unlikely, 5:Likely)

"People think that safety regulations are unnecessary constraints (R)"

"I do not persuade others to act safe (R)"

- **Perceived controllability**

Perceived controllability (%) = 100 - The probability of laboratory accident occurrence in next 3 years (%)

A sample study

Measurements

- **Intention**

5-point Likert scale (1: Very unlikely, 5:Likely)

"I will obey to safety regulations." "I always try to enhance safety."

- **Behavior**

5-point Likert scale (1: Very unlikely, 5:Likely)

"I use individual protection equipment while performing experiment."

"I follow standardized process while performing experiment."

Analysis

Correlation analysis

Pearson's correlation coefficient

Path Analysis

Maximum likelihood estimation
Model fit evaluation : $\chi 2$, TLI, CFI, RMSEA

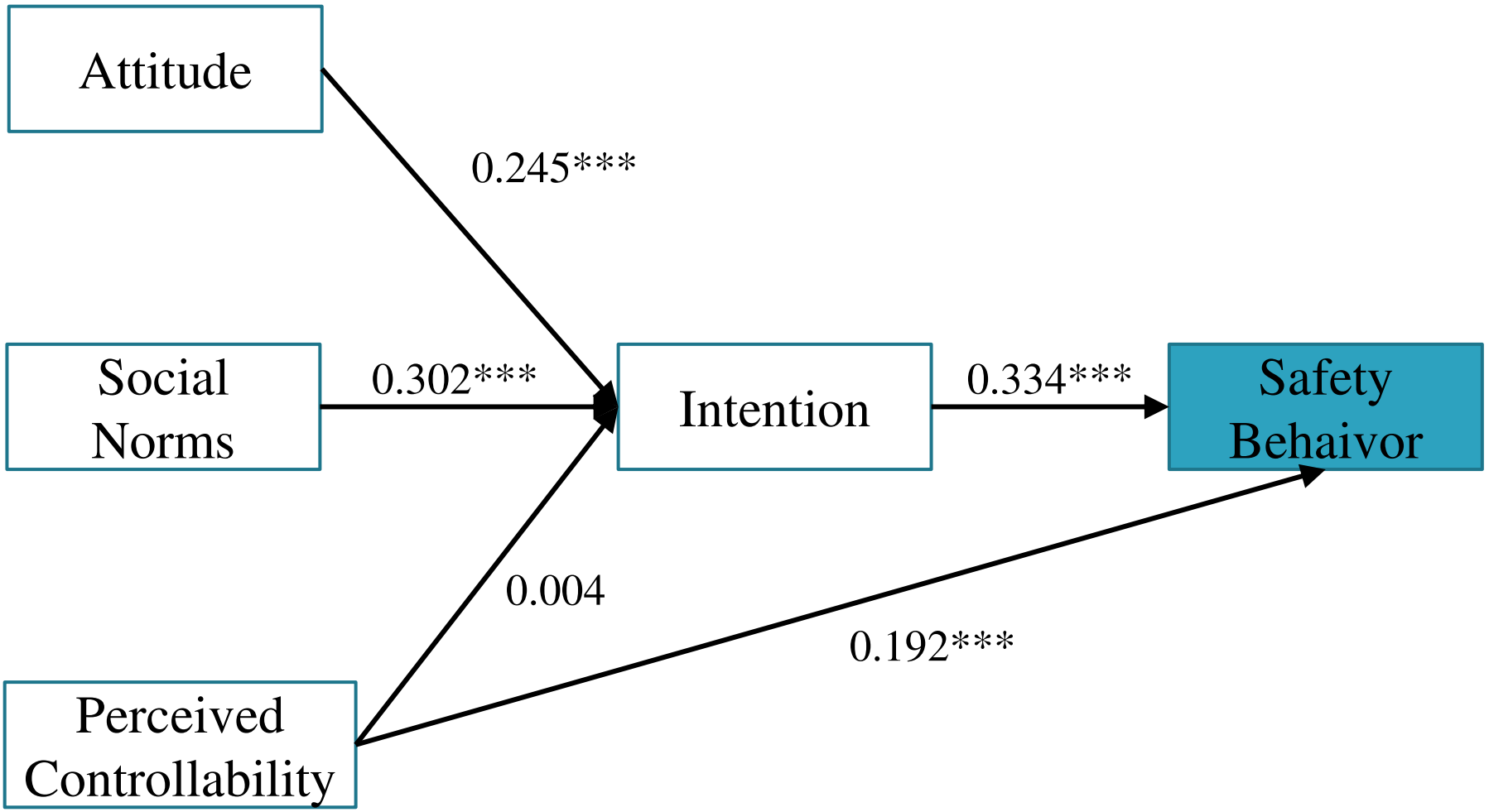
Correlation analysis

	Descriptive statistics		Pearson's correlation coefficient						
n=355	Mean	S.D	1	2	3	4	5	6	7
Gender	Male:233,Female:122		1						
Tenure	30.77	28.866	-.126*	1					
Attitude	3.06	0.41	-.069	-.038	1				
Norms	3.519	0.49	.030	.096	.228**	1			
Perceived Controllability	85.456	18.75	-.018	.055	.134*	-.113*	1		
Intention	3.998	0.545	-.059	-.111*	.549**	.228**	.182**	1	
Behavior	3.542	0.717	-0.061	-.110*	.551**	.228**	.183**	.445**	1

*: $p<0.05$, **: $p<0.01$, ***: $p<0.001$

Results

- Tenure ($r=-0.126$, $p<0.05$), had a significant negative correlation with safety behavior.
- Attitude ($r=0.551$, $p<0.01$), Norms ($r=0.228$, $p<0.01$), Perceived controllability ($r=0.183$, $p<0.01$), Intention ($r=0.445$, $p<0.01$) had significant positive correlation with safety behavior.



(n=356; χ^2(df=2)=14.024, p=0.001,
RMSEA=0.130, TLI=0.685; CFI=0.958)

Results

- Conducted Path Analysis to identify the causality between variables.
- Paths which gave direct impact to Intention were Attitude (β=0.245, $p<.001$), and Norms (β=0.302, $p<.001$)
- Intention gave direct impact on Behavior significantly (β=0.334, $p<.001$), Perceived controllability had no direct impact to Intention, but gave significant direct impact to Behavior (β=0.192, $p<.001$).

A sample study

- Key Findings

- Constructs of TPB framework showed a potential for studying lab safety
- Intention matters for increasing safety behavior at the lab
- Organizational norm was important for the use of safety equipment and the compliance with safety rules
- Students who believe the accidents can be controlled (by their efforts) are more likely to directly increase safety behavior

Implications

Limitations

- Weak theory-driven
- Cross-sectional survey
- Limited analytical strategy

Implications

- Researchers who have long tenure

– High risk group?

: longer tenure means more chance to experience accidents, more safety knowledge, and less job stress.

: negative impact to risk perception.

- Importance of subjective norm

– Key role for enhancing safety behavior

Implications & suggestions

- More focus on organization models
  - High Reliability Organization
  - High Team Functioning
  - SHELL model

Implications & suggestions

- SHELL model

(ICAO 2002; Hawkins,1987)

Safety is determined by the interfaces between Liveware in the center and other elements.

- Liveware : most valuable, most flexible. Personality, communication style, stress tolerance, knowledge, attitudes, Training systems, Recruitment system

Implications & suggestions

- SHELL model

(ICAO 2002; Hawkins,1987)

- Hardware : analysis machinery, microscopes, clean bench, experimental tools…
- Software : Safety manual, Protocols, Safety checklists, Non-physical aspects of the system…
- Environment : Ventilation system, Temperature, intensity of illumination, Affiliation, Funding resources…
- Liveware : Relationship between members, Leadership, Safety culture, Conflict, Communication…

Thank you

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