

# Introduction to Structural Equation Modeling: Implications for Human-System Interactions



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National Research Council.  
(2007). *Human-system  
integration in the system  
development process: A new look.*  
National Academies Press.

“System designers, like people in general, can be subject to an “over-confidence” bias, focusing on the potential benefits of new technology while failing to anticipate the complex interactions and new problems that may emerge (Feltovich et al., 2004).

... There is an urgent need for improved HSI methods and tools that will enable system designers to anticipate and head off potential problems earlier in the design process (Woods, 2002).”

# OVERVIEW

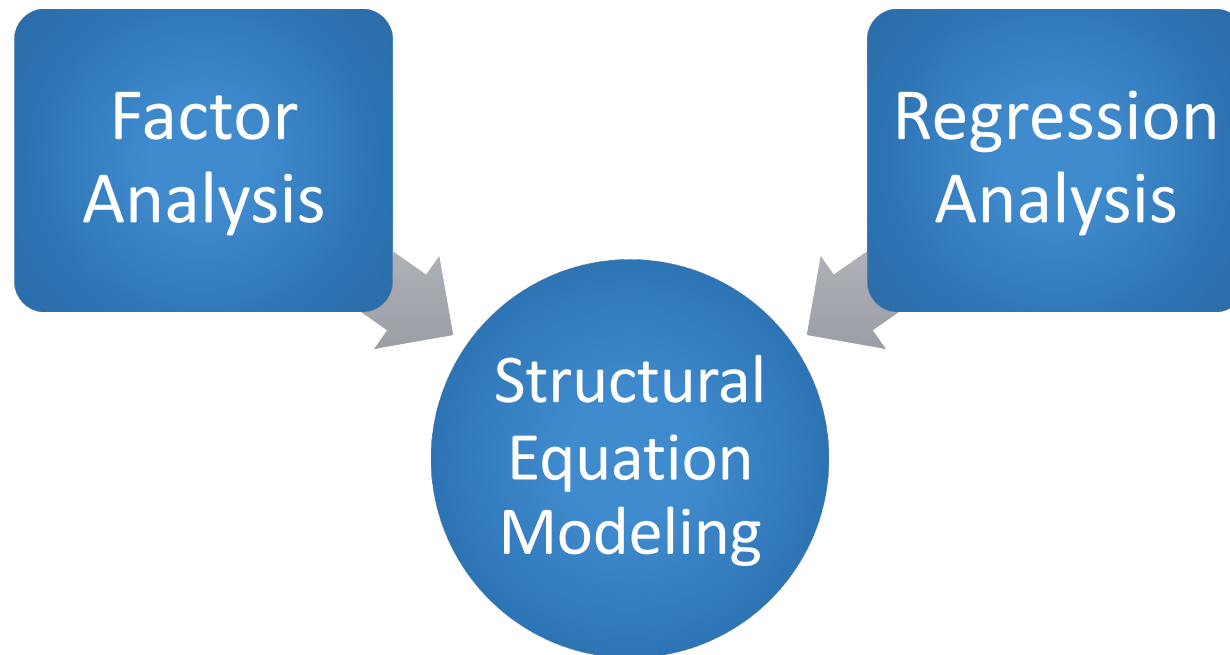
## Introduction

- What is SEM?
- Connections with
  - Factor analysis (not PCA)
  - Regression analysis
- Path diagrams

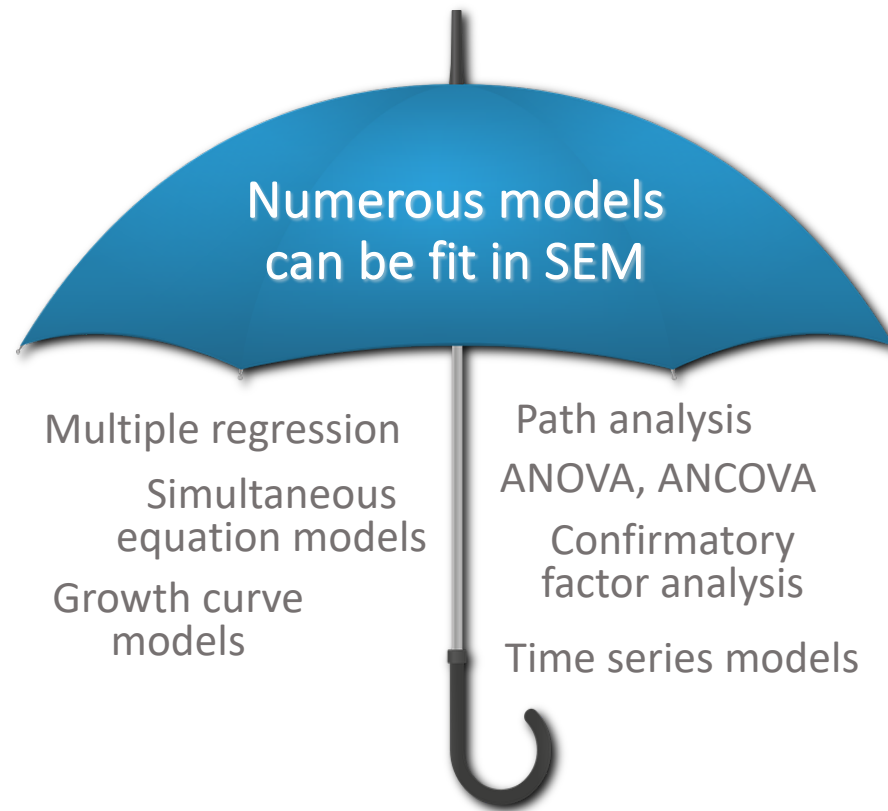
## Hands on Examples

- Data: COVID-19 Threats
- Model specification and interpretation
- Answer specific questions
  - Confirmatory factor analysis
  - Path analysis
- Wrap up: HSI Examples

# What is SEM?



# SEM is a General Framework



# Unobservables in Human-Systems Interactions Research

Perceived Performance

Satisfaction

Quality

Trust

Mental Workload

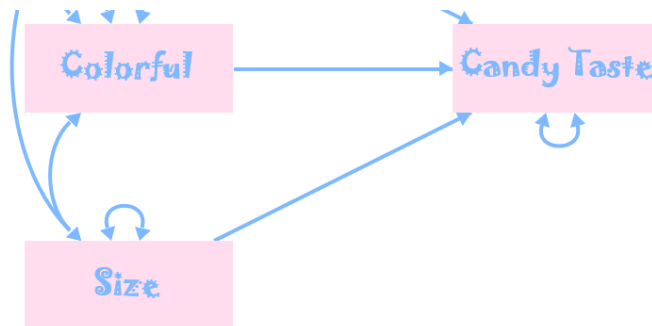
# SEMs as Path Diagrams

$$CandyTaste_i = \tau_1 + \beta_1 Sugar_i + \beta_2 Colorful_i + \beta_3 Size_i + \varepsilon_{ci}$$

$$Sugar_i = \tau_2 + \varepsilon_{sui}$$

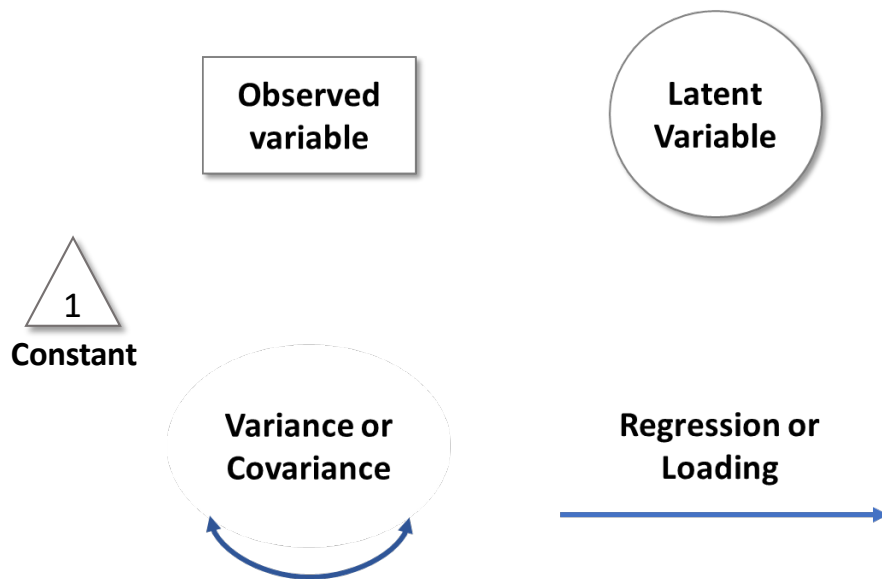
$$Colorful_i = \tau_3 + \varepsilon_{coi}$$

$$Size_i = \tau_4 + \varepsilon_{si}$$



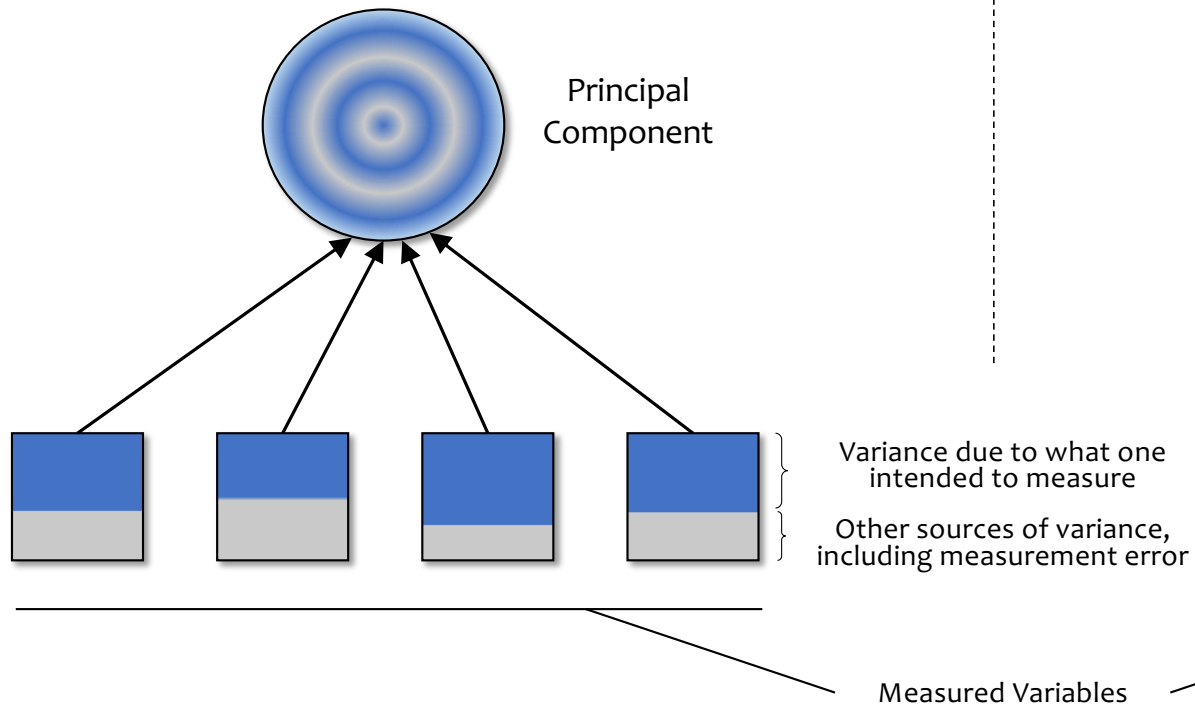
# SEMs as Path Diagrams

## SEM Path Diagram Elements

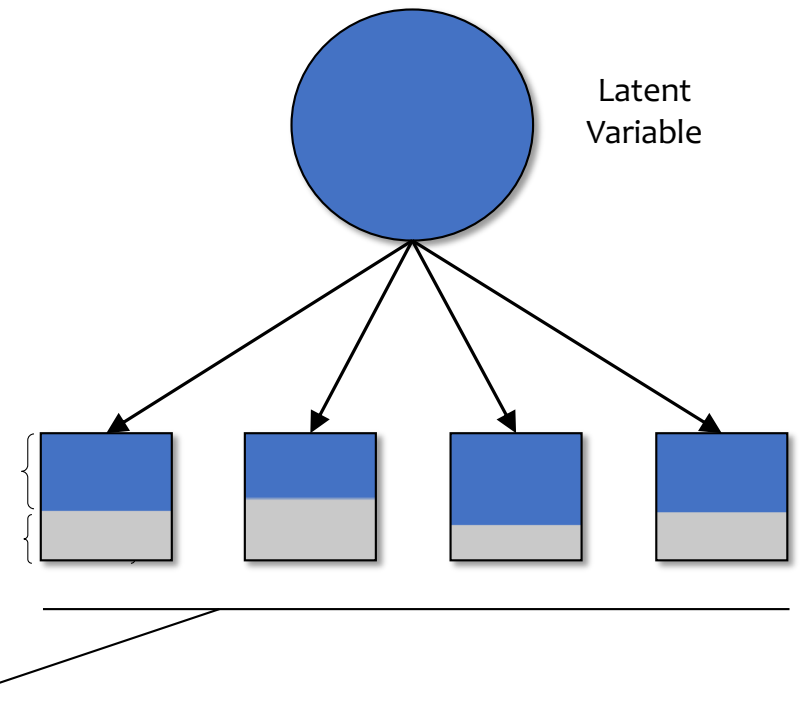


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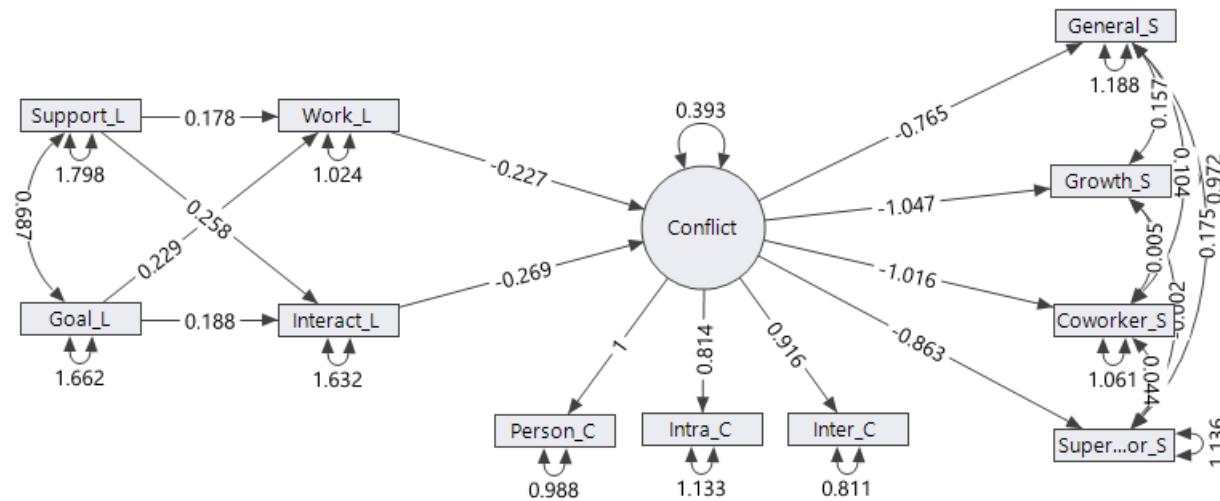
## Principal Components Analysis



## Factor Analysis

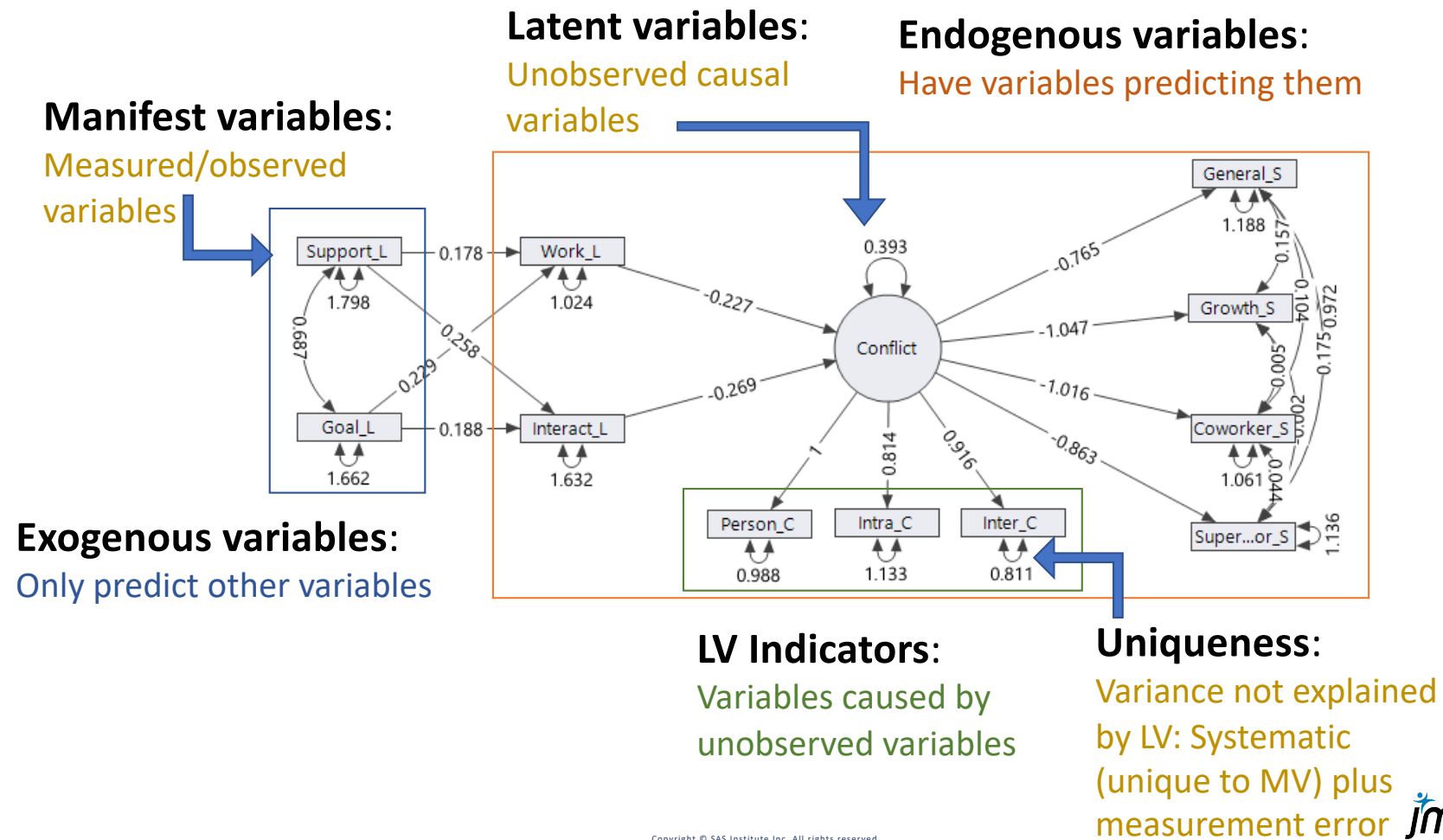


# Why Use SEM?



- Unobserved variables
- Account for measurement error
- Sequential relations between variables (observed/unobserved)
- Missing data
- Test a theory about variable relations

# SEM Terminology



# SEM Analysis

## Shift in focus

Multivariate analysis of *covariance* structures (and means)

### Data

Variances and covariances (and means)

### Residuals

WRT variances and covariances (and means)

### Degrees of freedom

WRT variances and covariances (and means)

df = knowns – unknowns

|       | BDW_2    | BDW_3    | BDW_4    | BDW_5    | BDW_6    | BDW_7    | BDW_8    |
|-------|----------|----------|----------|----------|----------|----------|----------|
| BDW_2 | 2.86174  | -1.60938 | 1.51513  | 1.59817  | -1.24045 | 1.89967  | -1.48280 |
| BDW_3 | -1.60938 | 3.30554  | -1.54342 | -1.43866 | 1.62067  | -1.50560 | 2.24953  |
| BDW_4 | 1.51513  | -1.54342 | 2.74292  | 1.15966  | -1.49853 | 1.63612  | -1.43812 |
| BDW_5 | 1.59817  | -1.43866 | 1.15966  | 3.48178  | -1.01895 | 1.35102  | -1.52319 |
| BDW_6 | -1.24045 | 1.62067  | -1.49853 | -1.01895 | 2.84589  | -1.51472 | 1.63232  |
| BDW_7 | 1.89967  | -1.50560 | 1.63612  | 1.35102  | -1.51472 | 3.12378  | -1.37096 |
| BDW_8 | -1.48280 | 2.24953  | -1.43812 | -1.52319 | 1.63232  | -1.37096 | 3.06218  |

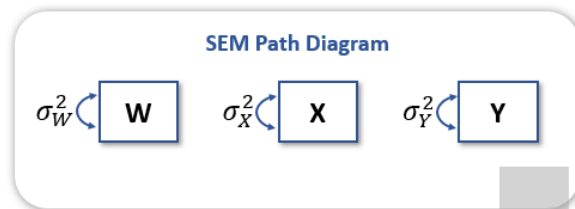
  

|    | All rows | Selected | Excluded | Hidden | Labelled |
|----|----------|----------|----------|--------|----------|
| 21 | 0        | 0        | 0        | 0      | 0        |
| 16 | 0        | 0        | 0        | 0      | 0        |
| 17 | 0        | 0        | 0        | 0      | 0        |
| 18 | 0        | 0        | 0        | 0      | 0        |
| 19 | 0        | 0        | 0        | 0      | 0        |
| 20 | 0        | 0        | 0        | 0      | 0        |
| 21 | 0        | 0        | 0        | 0      | 0        |

Example: 7 variances + 21 covariances

df = 28 – unknowns (# of estimates)

# SEM Inner Workings



*Depicts a model that implies a covariance structure*

**Model-implied covariance**

|   | W            | X            | Y            |
|---|--------------|--------------|--------------|
| W | $\sigma_W^2$ |              |              |
| X | 0.00         | $\sigma_X^2$ |              |
| Y | 0.00         | 0.00         | $\sigma_Y^2$ |

*This model implies non-zero variances and zero covariances*

**Sample covariance**

|   | W    | X    | Y    |
|---|------|------|------|
| W | 1.32 |      |      |
| X | 0.61 | 1.40 |      |
| Y | 0.53 | 0.74 | 1.14 |

*Model estimation tries to match the data as close as possible*

**Model Estimates**

$\sigma_W^2 = 1.32$   
 $\sigma_X^2 = 1.40$   
 $\sigma_Y^2 = 1.14$

**Difference (residuals)**

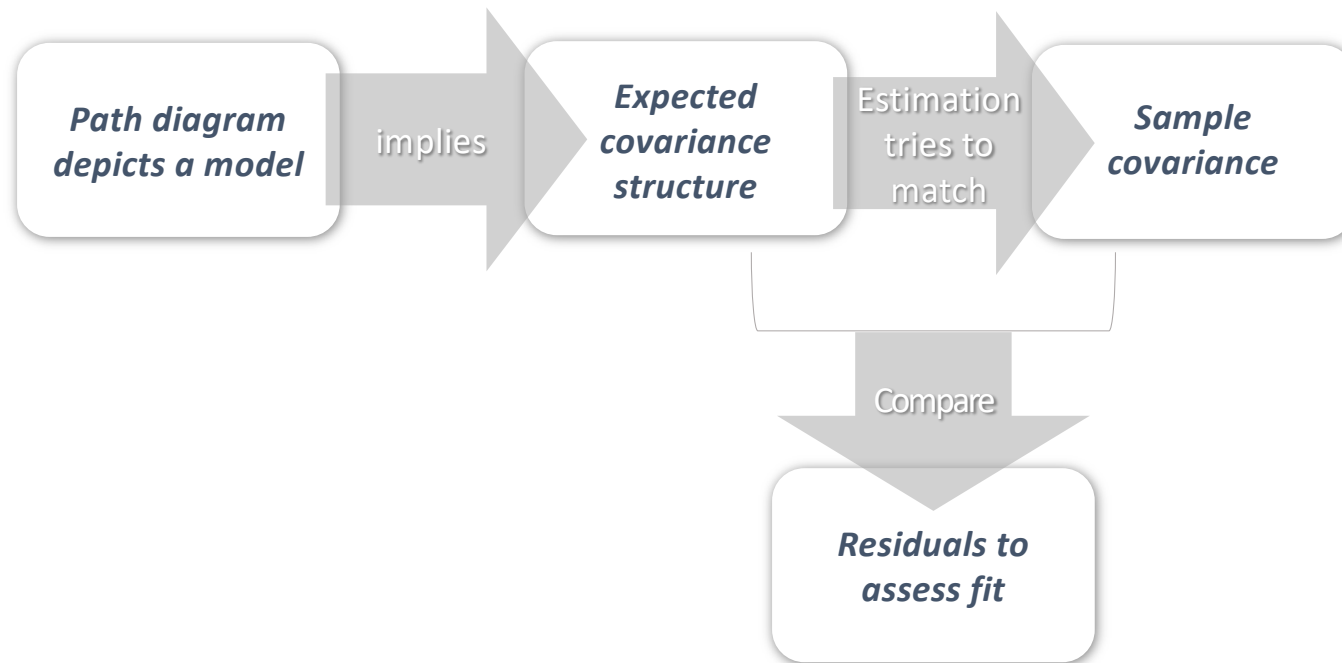
|   | W    | X    | Y    |
|---|------|------|------|
| W | 0.00 |      |      |
| X | 0.61 | 0.00 |      |
| Y | 0.53 | 0.74 | 0.00 |

*Differences of what the model implied and what the data said are summarized to produce many indices of model fit*

**How many degrees of freedom?**  
**knowns - unknowns**

**6 - 3**  
**df = 3**

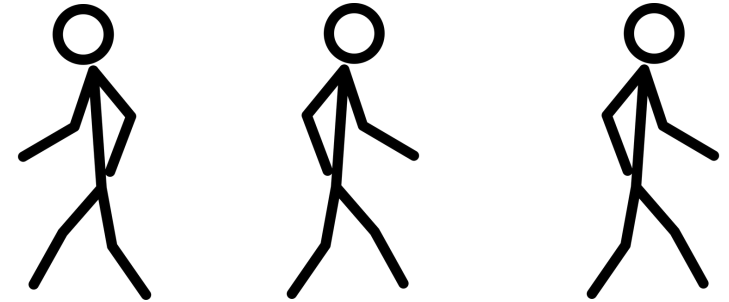
# SEM Inner Workings



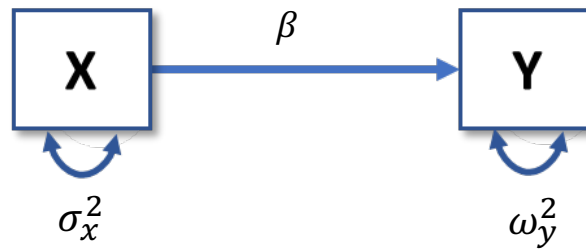
# Path Tracing Rules

Sewall Wright (1920)

Obtain expected moments from a path diagram



*Go Back, Turn Around, Go Forward*



# Path Tracing Rules

Sewall Wright (1920)

Obtain expected moments from a path diagram

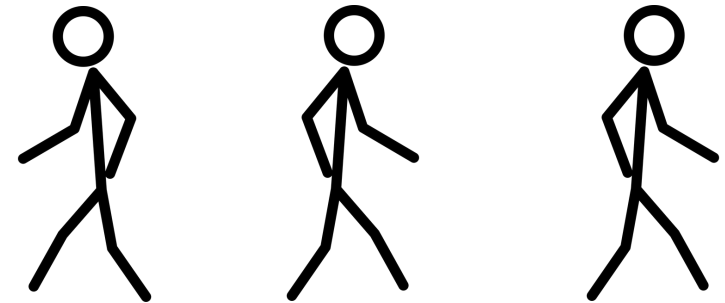
## Variations

Leave and come back to the same variable.

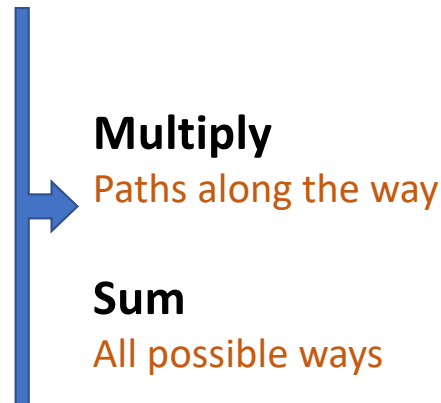
## Covariances

Leave and arrive to another variable.

\*Means omitted today



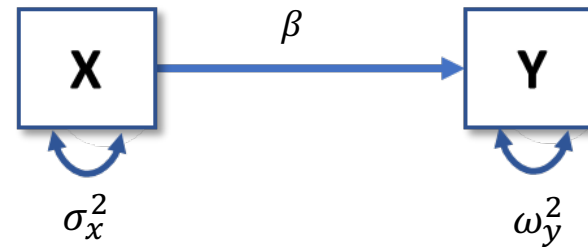
*Go Back, Turn Around, Go Forward*



## Rules

1. We can only leave through a double-headed arrow or “going back” on an arrow
2. You can only turn once (no limit on backward/forward)
3. Turn around through double-headed arrows
4. You only arrive through an arrowhead

# Path Tracing Rules



Model-Implied  
Variance-Covariance  
Matrix

|   | X                  | Y                                     |
|---|--------------------|---------------------------------------|
| X | $\sigma_x^2$       |                                       |
| Y | $\beta \sigma_x^2$ | $\beta \sigma_x^2 \beta + \omega_y^2$ |



[PollEv.com/lauracastros462](https://PollEv.com/lauracastros462)

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# Data for Examples



Coping with stress during the 2019-nCoV outbreak

My Hero is You, storybook for children on COVID-19



9 April 2020 | News release

Children's story book released to help and young people cope with COVID-19

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FIRST OPINION

The novel coronavirus is a serious threat. We need to act now.

# THREAT PERCEPTION AND COVID-19

CHRISTOPHER A. PREBLE  
Vice President for Defense and Foreign Policy Studies, Cato Institute

CALEB O. BROWN  
Director of Multimedia, Cato Institute

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TEST NEWS

Not just a physical health threat, COVID-19 pandemic has found effect on daily lives of adults



GREELEY, CO, July 30. Sylvia Bedingfield stoops to pick up her groceries outside her Greeley home Thursday, July 30. The groceries were delivered to her door by a service called 60+ Rides, of which Bedingfield is a member. Bedingfield, 68, serves as director. Cuyler Meade/Staff report. STATISTICAL DISCOVERY FROM SAS

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Full Article

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- Method
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## Measuring Realistic and Symbolic Threats of COVID-19 and Their Unique Impacts on Well-Being and Adherence to Public Health Behaviors

Frank J. Kachanoff, Yochanan E. Bigman, Kyra Kapsaskis, more...

First Published July 24, 2020 | Research Article | Check for updates

<https://doi.org/10.1177/1948550620931634>

Article information



### Abstract

COVID-19 threatens lives, livelihoods, and civic institutions. Although restrictive public health behaviors such as social distancing help manage its impact, these behaviors further sever our connections to people and institutions that affirm our identities. Two studies ( $N = 1,195$ ) validated a brief 10-item COVID-19 Threat Scale that assesses (1) realistic threats to physical or financial safety and (2) symbolic threats to one's sociocultural identity. Studies reveal that both realistic and symbolic threats predict distress and lower well-being and demonstrate convergent validity with other measures of threat sensitivity. Importantly, the two kinds of threats diverge in their relationships to restrictive public health behaviors: Realistic threat predicted greater self-reported adherence, whereas symbolic threat predicted less self-reported adherence to social disconnection behaviors. Symbolic threat also predicted using creative ways to affirm identity even in isolation. Our findings highlight how social psychological theory can be leveraged to understand and predict people's behavior in pandemics.

How do Perceived Threats of COVID-19 Impact Well-Being and Public Health Behaviors

# Integrated COVID-19 Threat Scale

The integrated COVID-19 threat scale has 10 items (random order). Five items assess perceived **realistic threats** of the COVID-19 pandemic. Five items assess perceived **symbolic threats** of the COVID-19 pandemic.

**Preamble:** On March 11th, 2020 the World Health Organization officially declared the COVID-19, a viral disease that has swept the globe, a pandemic. How much of a **threat**, if any, is the coronavirus outbreak for ...

| Not a threat | Minor threat | Moderate threat | Major threat |
|--------------|--------------|-----------------|--------------|
| 1            | 2            | 3               | 4            |

- Your personal health
- The health of the U.S. population as a whole
- Your personal financial safety
- The U.S. economy
- Day-to-day life in your local community

**Realistic Threat**

- What it means to be American
- American values and traditions
- The rights and freedoms of the U.S. population as a whole
- American democracy
- The maintenance of law and order in America

**Symbolic Threat**

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# Using SEM to Answer Specific Questions

- Exploratory factor analysis
- Confirmatory factor analysis
- Assessing measurement

1. How do we measure *perceptions* of COVID-19 threats?

- Two types of threat

2. Do perceptions of COVID-19 threats predict

- Well-being markers
- Public health behaviors

3. Are effects of each type of threat on outcomes equal?

- Simple regression
- Multiple regression
- Path analysis (multivariate multiple regression)

- Equality constraints
- Model comparisons

# SEM Software

## R Packages

lavaan  
sem  
MIIVsem  
openMx

## SAS

PROC CALIS  
JMP Pro

And many more!

# Examples



## Using structural equation modeling to predict cabin safety outcomes among Taiwanese airlines

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### ARTICLE INFO

**Keywords:**  
 Flight attendant  
 Cabin crew  
 Cabin safety  
 Safety culture  
 Safety climate  
 Structural equation modelling

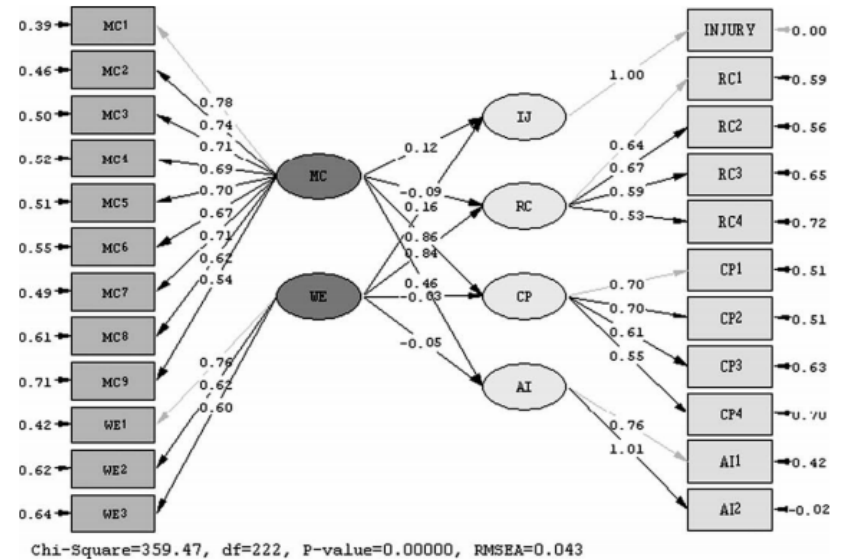
### ABSTRACT

The aim of the study was to examine the relationship between safety culture (e.g. management commitment, various work environment factors) and flight attendant safety performance (e.g. rule compliance, crewmember involvement and participation, accident investigation, injury incidence). A comprehensive questionnaire was derived from the Loughborough University "Safety Climate Assessment Toolkit" and several similar surveys. Additional items were designed for an airline cabin work environment. The questionnaire was distributed to four major Taiwanese national airlines and achieved a valid response rate of 84.65%. Structural equation modeling was used to test a hypothesized model concerning safety culture and cabin safety performance. A variety of fit indices confirmed the overall model fit but not all of the paths in the model were statistically significant. The findings show that safety culture was a predictor of cabin safety outcomes. Specifically, it indicated that high management commitment was significantly related to higher member participation, and that safe cabin work environment was significantly related to member's individual behavior. However, the findings showed no relationship between management commitment and injury incidence which means injury incidence cannot be predicted by management commitment.

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### 1. Introduction

The primary job of flight attendants is to ensure that all safety regulations are followed as well as make flights comfortable and enjoyable for passengers. Flight Safety Foundation – Taiwan (FSF – Taiwan) collects statistics on Taiwan national airlines cabin abnormal events and cabin personnel injury rates. From 2001 to 2005 it was reported that 269 persons were injured in a total of 4954 events. In 2005, almost two persons were injured every week. The study also pointed out that Taiwan national airlines cabin abnormal events continued to increase at a rapid rate. The USA Federal Aviation Administration (FAA) and the International Air Transport Association (IATA) showed that cabin crewmembers are exposed to a notable risk of injury compared to other air transport workers (FSF Editorial Staff, 2001; IATA, 2006). IATA's report also quoted DuPont's study that safety performance for all air carrier workers in civil aviation, at least in the United States, is worse than in the lumber or metal industries. In the aviation industry, flight attendants are among the most affected, second only in injuries and lost workdays to ramp personnel (IATA, 2006). This paper raises the question of what can be done to improve cabin safety.



Chi-Square=359.47, df=222, P-value=0.00000, RMSEA=0.043

Fig. 1. Full structural equation model among Taiwanese airlines (N = 331). Measurement and structural components with standardized estimates.



Original Article

## Inter-relationships between performance shaping factors for human reliability analysis of nuclear power plants

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<sup>b</sup> Integrated Safety Assessment Team, KAERI, 989-111 Daedeok-daero, Yuseong-gu, Daejeon, 34057, Republic of Korea



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**Keywords:**  
Performance shaping factor  
Human reliability analysis  
Digital main control room  
Inter-dependency  
Inter-correlation

### ABSTRACT

Performance shaping factors (PSFs) in a human reliability analysis (HRA) are one that may affect human performance in a task. Most currently applicable HRA methods for nuclear power plants use PSFs to highlight human error contributors and to adjust basic human error probabilities (HEPs) under nominal conditions of NPPs. Thus far, the effects of PSFs have been treated independently. However, many studies in the fields of psychology and human factors revealed that there may be relationships between PSFs. Therefore, the inter-relationships between PSFs need to be studied to better reflect their effects on operator errors. This study investigates these inter-relationships using two data sources and also suggests a context-based approach to treat the inter-relationships between PSFs. Correlation and factor analyses are performed to investigate the relationship between PSFs. The data sources are event reports of unexpected reactor trips in Korea and an experiment conducted in a simulator featuring a digital control room. Thereafter, context-based approaches based on the result of factor analysis are suggested and the feasibility of the grouped PSFs being treated as a new factor to estimate HEPs is examined using the experimental data.

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### 1. Introduction

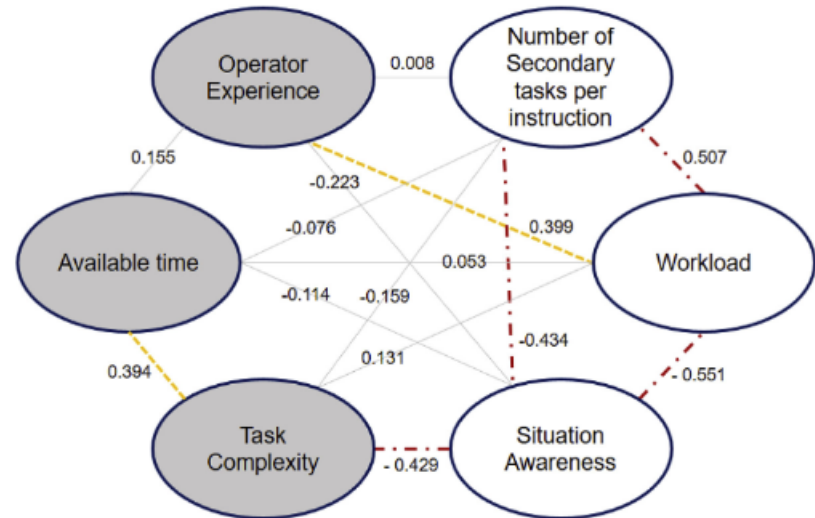
A performance shaping factor (PSF) is defined as a variable that may affect human performance in a human reliability analysis (HRA) [1,2]. Most currently applicable HRA methods for nuclear power plants (NPPs) use PSFs to highlight human error contributors and adjust basic human error probabilities (HEPs) that assume nominal conditions in NPPs [3,4]. PSFs that are generally adopted in HRA methods include experience, complexity, stress, adequacy of procedure, human-system interface, and workload. They are also called by different terminologies depending on the HRA methods, such as performance influencing factors (PIFs) in Holistic Decision Tree (HDT) [5], performance affecting factors (PAFs) in Cognitive Reliability Assessment Technique (CREATE) [6], error producing conditions (EPCs) in Human Error Assessment and Reduction Method (HEART) [7], or common performance conditions (CPCs) in Cognitive Reliability and Error Analysis Method (CREAM) [8].

There is sufficient evidence in the fields of psychology and

human factors to indicate that there exists inter-relationship between PSFs. The term of *inter-relationship* comprehensively includes all the possible interactions between the states of the PSFs and between the influences of the PSFs on human performances, such as correlation, dependency, overlapping, or combinational effects with the causal relations, i.e., the direction of influence. First, Park and Jung showed that the task complexity of emergency operating procedures has a relationship with the operator's workload in NPPs [9]. Second, the relationship between experience and workload has been reported in various areas: for example, in driving [10], aviation [11], and NPPs [12]. However, most HRA methods treat PSFs independently, although they already recognized that the PSFs undoubtedly contain some overlap and are thus non-orthogonal [13]. If a HRA ignores the inter-relationships of PSFs, it is possible that HEPs may be over- or under-estimated. For example, when a complex task imposes a high workload on operators, separate consideration of the task complexity and workload may double-count the effect of complexity and lead to the over-estimation of HEPs or vice versa. However, most HRA methods treat PSFs independently and generally do not consider this combined effect of PSFs on human performance in the estimation of HEPs.

Recent interest in the inter-relationships of PSFs has been

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E-mail addresses: [zxas1156@chosun.kr](mailto:zxas1156@chosun.kr) (J. Park), [wjjung@kaeri.re.kr](mailto:wjjung@kaeri.re.kr) (W. Jung), [jonghyun.kim@chosun.ac.kr](mailto:jonghyun.kim@chosun.ac.kr) (J. Kim).



## AI-based self-service technology in public service delivery: User experience and influencing factors

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### ARTICLE INFO

**Keywords:**  
 Artificial intelligence  
 Self-service technology  
 User experience  
 Trust in government

### ABSTRACT

Public sectors are utilizing AI-based self-service technology (SST) at an accelerating rate, given its potential for improving work efficiency and user experience, reducing service costs, and relieving human workloads. However, there is a limited understanding of the factors influencing citizens' user experience when AI-based SST are provided. Thus, with insights from the Consumer Value Theory, this paper explores the factors that are important to AI-based SST user experience and the conditional role of government. The on-site survey of 379 citizens in a public service center in China indicates that user experience is positively related to personalization and aesthetics and negatively associated with perceived time spent on AI-based self-service machines. In addition, the results suggest that citizens with more trust in government are more likely to have a pleasant experience coming from AI-based SST's personalization and aesthetics. Public sectors should ensure that the AI-based SST is aesthetically appealing and should be able to personalize the service to the right contents to the right person at the right time. Furthermore, they should always prioritize building more trust from citizens to achieve a more positive user experience.

### 1. Introduction

With the rapid development of artificial intelligence (AI), smart self-service technologies (SSTs) provide unprecedented opportunities for governments to improve public services and strengthen their interaction with citizens. SSTs refer to technological interfaces that enable users to avail of services mostly independent of direct service employee involvement (Meuter, Ostrom, Roundtree, & Bitner, 2000). While SSTs have been widely used in almost all service industries, the integration of AI technologies and SSTs is an emerging tendency. Compared with conventional SST, AI-based SST has unique attributes (Table 1). First, intelligent features like natural language processing, face recognition, machine learning, recommendation algorithm, and OCR recognition are integrated into the AI-based SST to provide users with 24-h self-service. Second, AI-based SST collects and processes data based on previous business transactions (Rijdsdijk, Hultink, & Diamantopoulos, 2007). As AI can learn by itself, the accuracy of the algorithms will increase if more transactions are processed. Therefore, by using the recommendation algorithm, AI-based SST contributes to a personalized, seamless, and improved user experience. Third, AI-based SST could provide users with more consistent, timely, and effective services with the support of its advanced data storage capabilities, high processing

speed, and accurate personalization capabilities (Campbell & Frei, 2010; Atkinson, 2018). In contrast, conventional SST provides a fixed interface that limits users to handle their business within a fixed time period.

Government agencies are utilizing AI-based SST at an accelerating rate, given its potential for improving work efficiency and user experience, reducing service costs, and relieving human workloads (Buell, Campbell, & Frei, 2010). However, we know little about what influences citizens' user experience when they are provided with AI-based services. A knowledge gap like this could significantly prevent the quality improvement of AI-based service. At worst, it may trigger citizens' service dissatisfaction, which may ultimately impede governments from pursuing AI-innovations.

This case study thus focuses on investigating factors that influence citizens' user experience with AI-based SST. We looked at the use of AI-based SST in the Wuhou Administrative Approval Bureau (Wuhou AAB) in China. Starting from 2018, Wuhou AAB introduced AI-based self-service machines in its public service center. These self-service machines integrate AI technologies, such as natural language processing, face and fingerprint recognition, and big data analysis, to provide citizens and enterprises with 24/7 self-service consultation, self-check, self-service handling, self-service pickup, and more. With embedded

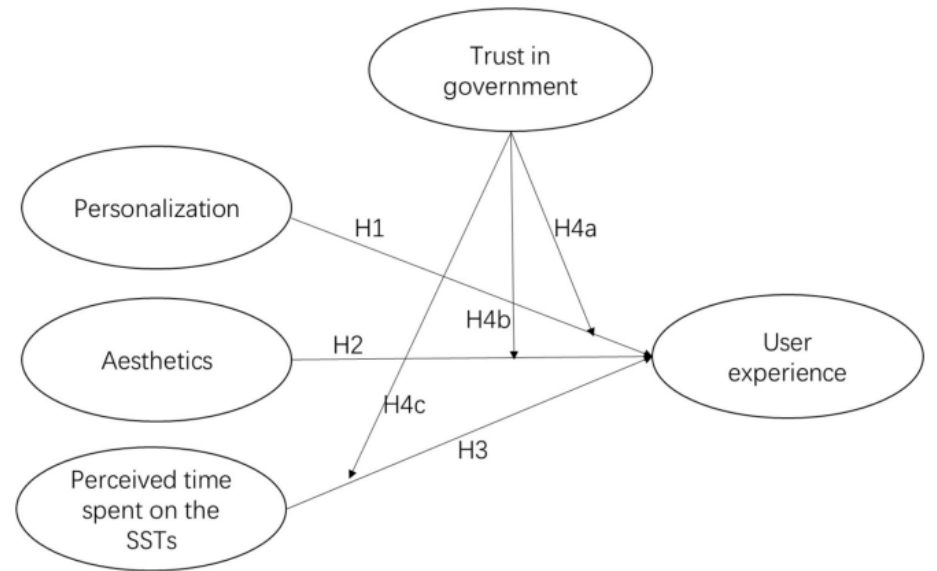


Fig. 1. Research model.

# Why travelers trust and accept self-driving cars: An empirical study

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ARTICLE INFO

**Keywords:**  
 Self-driving cars  
 Trust  
 Mass media  
 Self-efficacy  
 Subjective norms

ABSTRACT

Automated vehicle technology is becoming increasingly mature with the development of Artificial Intelligence and information communications technology. It is important to understand the factors affecting the use of self-driving cars. This study investigates user acceptance and the willingness to use fully driverless vehicles. Based on Social Cognitive Theory (SCT), we developed a theoretical model to explore the impact of mass media on adopting self-driving cars. A survey was designed to collect data from 400 respondents. The results show that 84.4% of the respondents are willing to accept driverless cars. This study finds that mass media reports significantly influence people's perception of self-driving cars, self-efficacy and subjective norms, and thereby people's trust and behavior change. Self-efficacy, and trust significantly influence their intention to use self-driving cars. This study provides guidance to promote self-driving cars: positive media reports will significantly enhance people's intention to use driverless cars.

1. Introduction

Self-driving cars, which are also termed as driverless cars or autonomous cars (AVs), can sense their environment and navigate without a human operator. These cars have been deemed as one of the key innovations in the next technology revolution along with drones and the Internet of Things, and they have been recognized as a key area for future research (Kaur and Rampersad, 2018). Their implementation relies on communication, sensing, computing and automation technology (Narla, 2013). Six levels of automation of driverless cars are defined by the Society of Automotive Engineers (SAE, 2016). This paper focuses on privately-owned full automation, in which the automated driving system controls all aspects of the dynamic driving task under all roadway and environmental conditions.

The global driverless car market is forecasted to reach \$7.03 billion by 2021 and \$21 billion by 2035 (Alibaba, 2018). Many high-tech companies are already producing high-level self-driving cars (Madigan et al., 2017). According to Hewitt et al. (2019), many car manufacturers are also incorporating increased levels of autonomous functionality in their vehicles and aggressively researching high-level self-driving cars.

Compared with traditional manually controlled vehicles, self-driving cars can reduce human error-induced crashes, which account for 93% of those in the U.S. (Xu et al., 2018). Furthermore, with better route planning and more efficient vehicle operation, self-driving cars

can reduce road congestion and fuel emissions (Kockelman, 2015). Riding in a self-driving car frees the driver from driving tasks and enables him to engage in his choice of leisure or non-driving activities (Clark et al., 2016). Moreover, self-driving cars provide a means of traveling for people unable to drive (elderly and the disabled), which can improve their mobility (Kaur et al., 2019).

Despite its advantages, people differ in their attitudes toward self-driving cars. Several researches say that most people are not willing to use self-driving cars (Payre et al., 2014; Bazilinskyy et al., 2017; Kaur and Rampersad, 2018; Zhang et al., 2019). For example, Kaur (2018a) indicates that people consider the possibility of self-driving cars as a supplement to public transportation. On the other hand, the public's intention to purchase and use self-driving cars is not high (Abraham et al., 2017), especially for those who hold driving licenses. Schoettle and Sivak (2014) report that the acceptance of vehicle automation decreases as the level of automation increases, and 85.6% of licensed US drivers do not accept fully autonomous vehicles. Similarly, the AAA survey (2016) finds that 75% of Americans are "afraid to allow an autonomous vehicle to drive itself with them in it," and female respondents express more concern (81%).

This paper tries to confirm two reasons why consumers reject the idea of using self-driving cars: recognition of persons and negative report bias. Self-driving cars require individuals to trust mechanisms

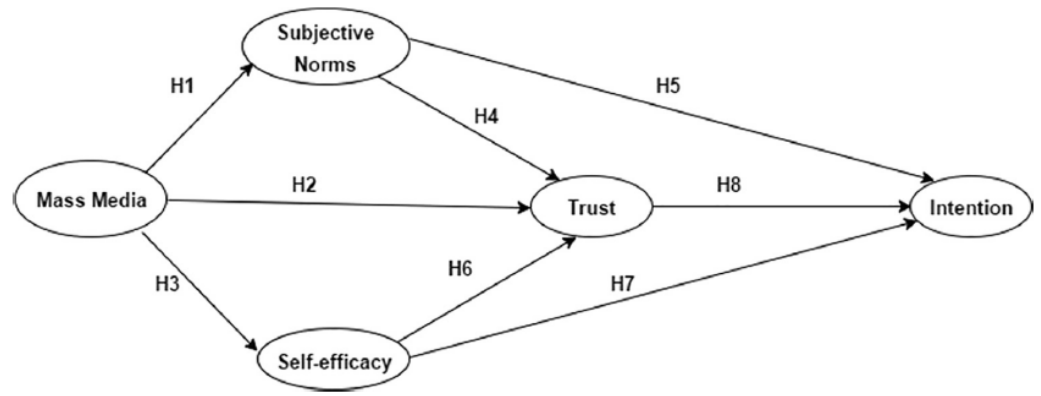


Fig. 1. Theoretical model of accepting self-driving cars.

RESEARCH ARTICLE

Open Access

## Virtual reality among the elderly: a usefulness and acceptance study from Taiwan



Shabbir Syed-Abdul<sup>1,2</sup>, Shwetambara Malwade<sup>1</sup>, Aldilas Achmad Nursetyo<sup>1,2</sup>, Mishika Sood<sup>3</sup>, Madhu Bhatia<sup>4</sup>, Diana Barsasella<sup>1,2,9</sup>, Megan F. Liu<sup>3,9</sup>, Chia-Chi Chang<sup>5,6</sup>, Kathiravan Srinivasan<sup>7</sup>, Raja M.<sup>7</sup> and Yu-Chuan Jack Li<sup>1,2,8</sup>

### Abstract

**Background:** Virtual reality (VR) has several applications in the medical domain and also generates a secure environment to carry out activities. Evaluation of the effectiveness of VR among older populations revealed positive effects of VR as a tool to reduce risks of falls and also improve the social and emotional well-being of older adults. The decline in physical and mental health, the loss of functional capabilities, and a weakening of social ties represent obstacles towards active aging among older adults and indicate a need for support. Existing research focused on the effects of VR among older populations, and its uses and benefits. Our study investigated the acceptance and use of VR by the elderly.

**Methods:** This pilot study was conducted on 30 older adults who voluntarily participated during March to May 2018. Nine VR applications that promote physical activities, motivate users, and provide entertainment were chosen for this study. Participants were asked to use any one of the applications of their choice for 15 min twice a week for 6 weeks. At the end of 6 weeks, participants were asked to fill out a questionnaire based on the Technology Acceptance Model and a literature review, to evaluate their acceptance of VR technology. Cronbach's alpha reliability analysis was used to test the internal consistency of the questionnaire items. Pearson's product moment correlation was used to examine the validity of the questionnaire. A linear regression and mediation analysis were utilized to identify relationships among the variables of the questionnaire.

**Results:** In total, six male and 24 female participants aged 60–95 years volunteered to participate in the study. Perceived usefulness, perceived ease of use, social norms, and perceived enjoyment were seen to have had significant effects on the intention to use VR. Participants agreed to a large extent regarding the perceived usefulness, perceived enjoyment, and their experience of using VR. Thus, VR was seen to have high acceptance among this elderly population.

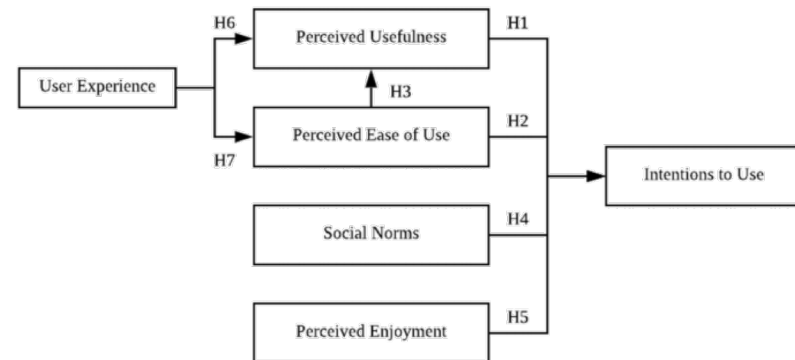
**Conclusions:** Older people have positive perceptions towards accepting and using VR to support active aging. They perceived VR to be useful, easy to use, and an enjoyable experience, implying positive attitudes toward adopting this new technology.

**Keywords:** Virtual reality, Active aging, Older people, Technology acceptance model

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**Fig. 1** Research model for the study. This figure describes the research model developed for the study based on TAM and reviewed literature. H1-H7 are hypotheses 1~7, which describe the influence of one variable on the other

# Human Performance in Agile Production Systems

Layer (2005)

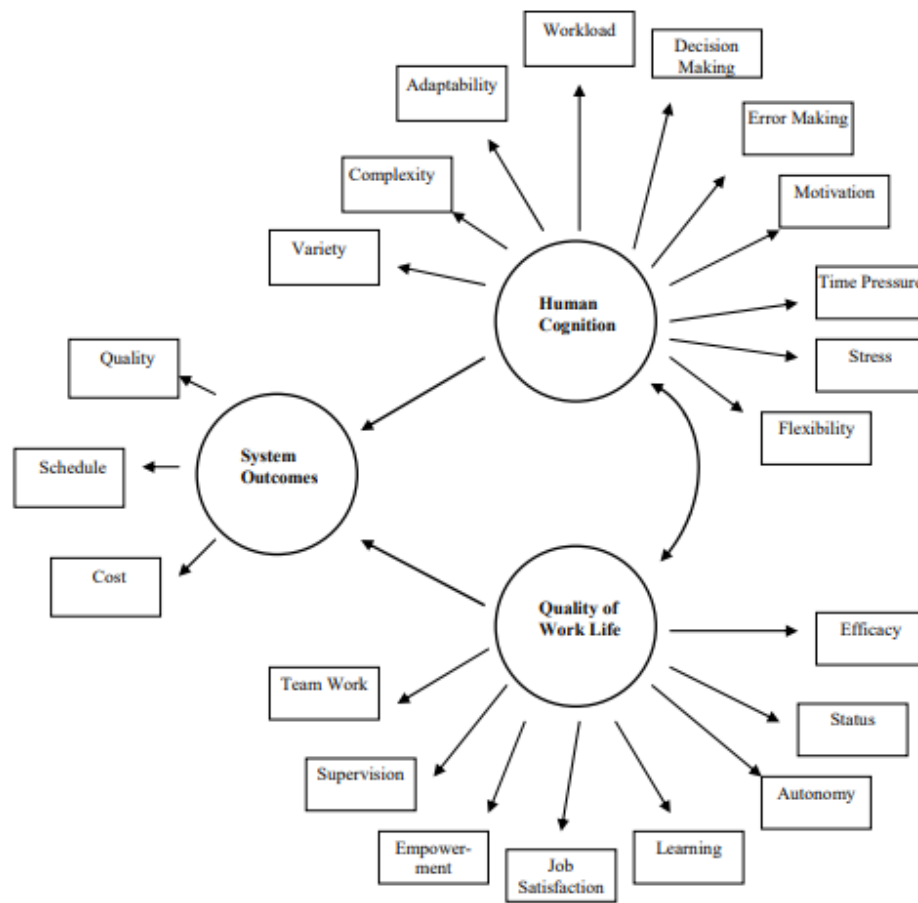


Figure 9. Proposed Human-Work Domain Causal Model

id.



### Continued use of an interactive computer game-based visual perception learning system in children with developmental delay

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#### ARTICLE INFO

**Keywords:**  
 Game-based learning systems  
 Perceived interactivity  
 Perceived playfulness  
 Technology acceptance model  
 Visual perception

#### ABSTRACT

This study developed an interactive computer game-based visual perception learning system for children with developmental delay. To investigate whether perceived interactivity of the system, this study developed a theoretical model of the process in which learners continue using an interactive computer game-based visual perception learning system. The model, which considers perceived ease of use, perceived usefulness, and perceived playfulness, is extended by integrating perceived interaction (i.e., learner-instructor interaction and learner-system interaction). Then analyzing the effects of these perceptions on satisfaction and continued use. 150 participants (rehabilitation therapists, medical paraprofessionals, and parents of children with developmental delay) recruited from a single medical center in Taiwan. Structural equation modeling and squares techniques were used to evaluate relationships within the model. The results showed that both perceived ease of use and perceived usefulness were positively associated with learner-instructor interaction and learner-system interaction. However, perceived playfulness was positively associated with learner-system interaction and not with learner-instructor interaction. Moreover, perceived ease of use, perceived usefulness, and perceived playfulness were positively affected by perceived ease of use, perceived usefulness, and perceived playfulness, respectively. These factors affected continued use of the system. The data obtained by this study can be used by researchers to design computer game-based learning systems, special education workers, and medical professionals.

#### 1. Introduction

Studies of human-computer interaction have focused on the development, implementation, and performance evaluation of interactive computing systems and software designed for human use [1]. Human-computer interaction is widely considered an integral component of many education and training systems at various levels of technology access [2]. Of the many education and training systems developed in recent years, one of the most intensively studied is interactive computer game-based learning systems, which have been developed and applied in many teaching-learning activities, especially for children and adolescent learners [3–7] because children in these age groups are

intrinsically motivated to play games and often lack interest or motivation in their courses [4].

Studies agree that various approaches to gamification-in-learning are more effective for increasing knowledge absorption and cognitive development compared to traditional learning approaches (non-gamification in learning) [4,8]. Issues related to computer game-based learning systems and their applications have attracted interest in many fields of education technology [3–7,9]. In the literature on antecedents and consequences of education technology adoption and use by learners, one important stream of research that has emerged in the past decade is learner acceptance of computer-based learning systems. Studies show that the key factors in user acceptance of these systems are

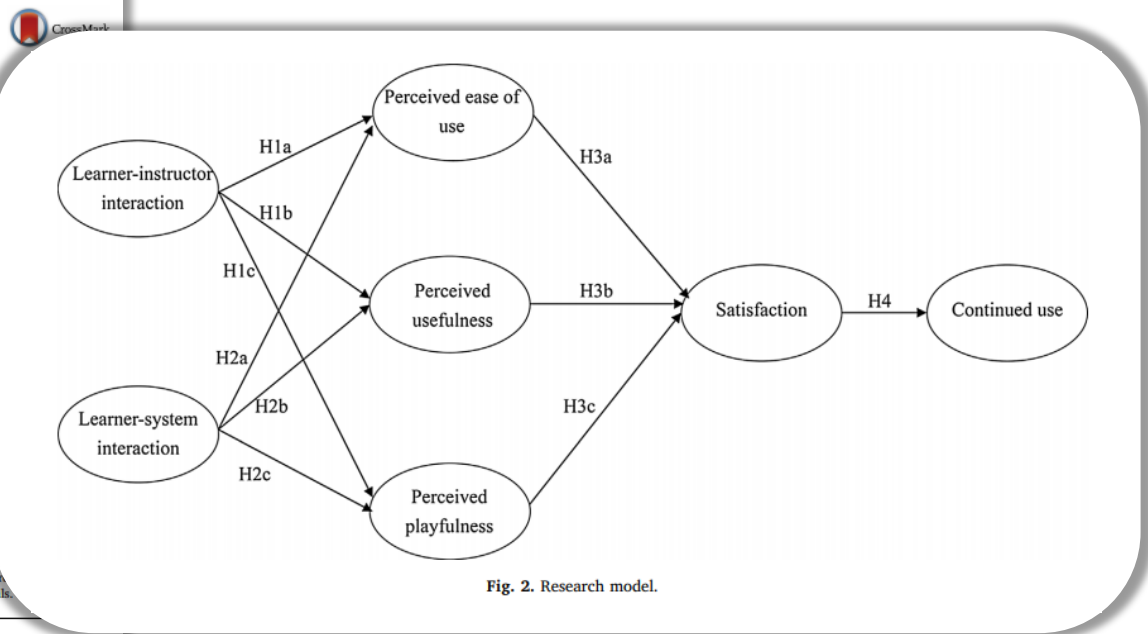


Fig. 2. Research model.

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MISSION EVALUATION-PSYCHOLOGICAL AND  
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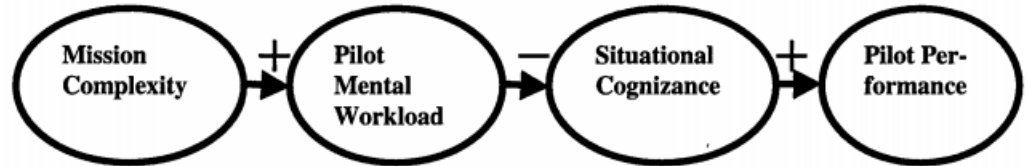
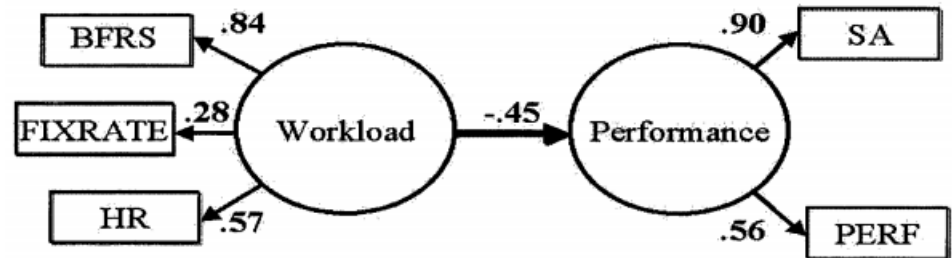


Figure 3. A model of causal relationships between the concepts mission difficulty, pilot mental workload, situational cognizance, and pilot performance.





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Table 1. Nine indices of analysis and their reliability.

| Index                        | Chronbach's alfa |
|------------------------------|------------------|
| Percieved Performance (PeP)  | .74              |
| Situational Cognizance (SC)  | .80              |
| Difficulty (DIFFIC)          | .84              |
| Mental Effort (EFF)          | .86              |
| Pilot Mental Workload (PMWL) | .87              |
| Ment. Capacity Red. (CAPAC)  | .77              |
| Motivation (MOTIV)           | .84              |
| Comp.Inform. TSD (COMP TSD)  | .92              |
| Comp.Inform. TI (COMP TI)    | .93              |

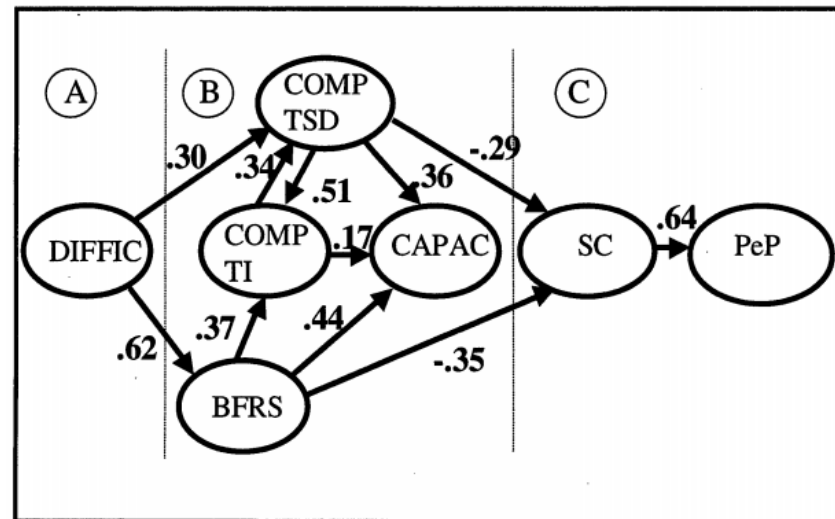


Figure 4. The final structural LISREL model of the relationships between six of the indices and the BFRS workload scale. All effects are significant ( $p < .05$ ). Adjusted Goodness of Fit is .85 and Root Mean Square is .053.

# THANK YOU

## Questions?

### Resources

**“Cheat-sheets” in the supplementary materials of this recorded presentation:**

<https://community.jmp.com/t5/Discovery-Summit-Americas-2020/ABCs-of-Structural-Equations-Models-2020-US-45MP-590/ta-p/281529>

**Books and article suggestions in this blog post:**

<https://community.jmp.com/t5/JMP-Blog/Structural-equations-models-A-favorite-amongst-those-who-use/ba-p/230334>