Evacuation Modelling Cognitive Biases: Research, Development, & Application

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Motivations

- Evacuation modelling forms a core component within the building design process with increases in performance-based analysis with ever novel building designs
- Evacuation model research, model development, and application:
  - Originally conducted by university researchers
  - Now, commonly performed by different parties/organisations.
  - Increasingly complex
  - Limited standard guidance (due to relative immaturity)
- Increased potential for mistakes to be made

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Mistakes

- Sometimes we make the wrong/suboptimal decision which are caused by:
  - **Finite resources** – limited time, mental ability, information etc,
  - **Imperfections in the decision making process** – even with sufficient resources, we can make mistakes in how we process information due to cognitive biases.
- If mistakes are made during evacuation modelling the consequence can be disastrous.
- Intelligence can mitigate against making mistakes but does not grant immunity of making them through cognitive biases.
- Propose biases in evacuation model research, model development, and application (focus).
- Conducted a survey to gauge extent evacuation model user bias occurs.

Mensa
The High IQ Society

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Dual Process Theory

Automatic (System 1)

- Fast
- Nonconscious
- Intuitive
- Effortless (Saves energy)
- Associative
- Senses / Environmental Awareness (Always on)
- You prefer using it and is used for most decisions.

e.g. speaking, reading, walking a familiar route, eating, etc.

Reflective (System 2)

- Slow
- Conscious
- Rule-based/Systematic
- Self-aware
- Effortful (Hard to maintain)
- You can only use it for relatively short burst.

e.g. learning a foreign language, navigating an unfamiliar route, solving a complex maths problem.

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Heuristics

- The world is complex and we often need/prefer to simplify it to make decisions.
- Heuristics = Shortcuts / Simple rules of thumb
- Developed by:
  - Learning formal rules
  - Repeat experience
- Often used when there is:
  - Incomplete information or knowledge to make a decision.
  - Limited time to make a decision.
  - Known well performing rules.
- Development of the rule often use substitution where decision is substituted for a more simple/manageable/familiar decision.
- Used by both reflective and automatic systems.

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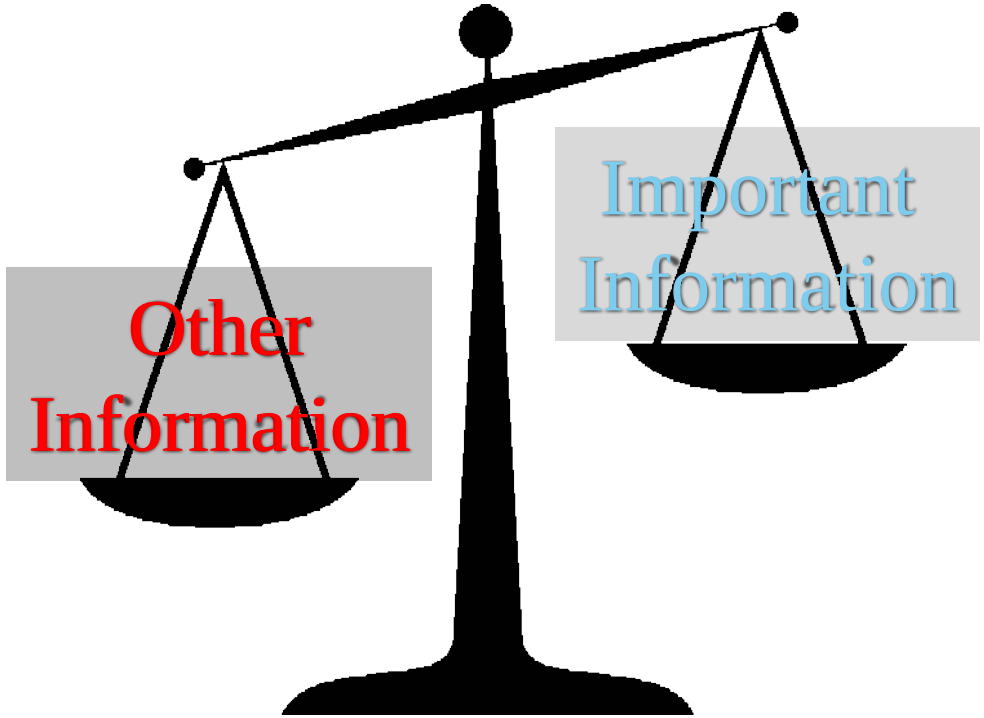
Cognitive Biases

- Cognitive biases occur in decision making where information is inappropriately processed and/or overly focused upon (at the expense of other and more relevant information) which can lead to inappropriate decision being made.
- Commonly occurs in decision making involving the automatic system and using heuristics (though these can occur during any decision making process).
- Cognitive biases are extremely common and you are likely to experience multiple biases everyday.



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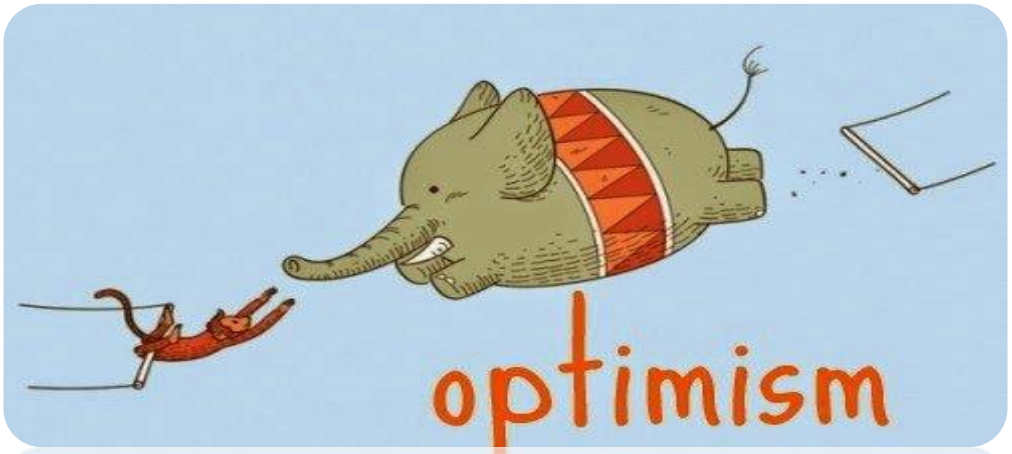
Cognitive Biases

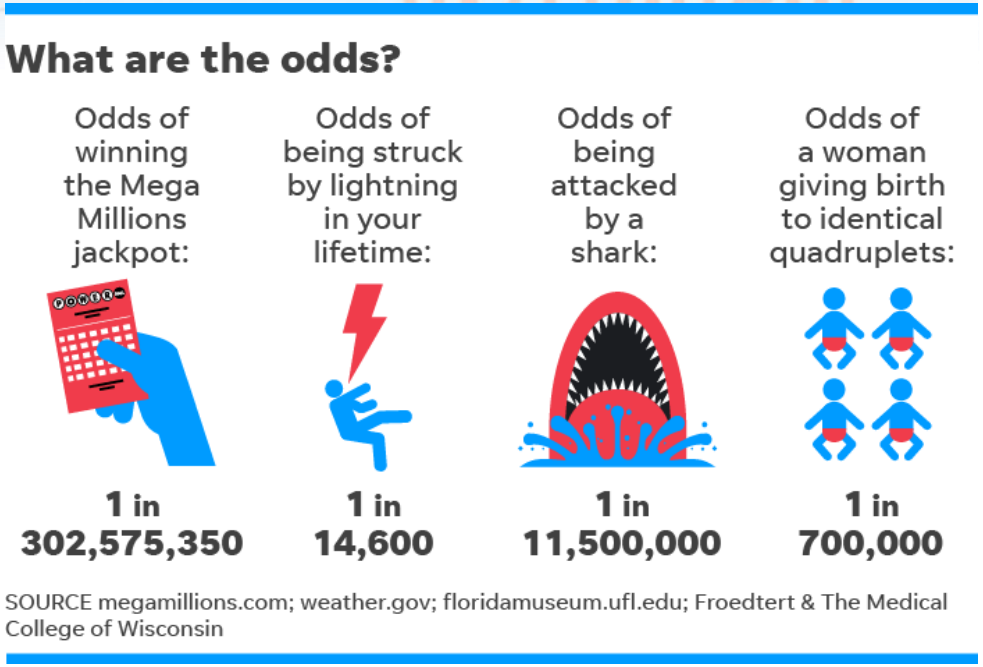
- Optimism bias …

  Believing its ok to eat unhealthy food if you exercise after.

  People who just got married believing they won't get divorced.

  People buying lottery tickets each week without full appreciation of how unlikely they will win.





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Decision Making Context

- Based on general decision making literature, potential cognitive biases have been identified in evacuation modelling context:
  - Research
  - Evacuation model development
  - Application
- Potential application to other fire engineering modelling fields (e.g. fire/smoke modelling, structural fire engineering, etc)
- Bias decision making does not always result in negative outcomes (can be positive).

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Evacuation Modelling Biases

Researcher

Collecting data from an easily available demographic sample (e.g. students, cadets, etc.), whilst applying the results to a wider demographic in an evacuation modelling assessment.

Researcher

Having a funding source that requires a given approach leading to the practitioner to overly focus on the benefits of the product rather than its limitations.

Developer

Developing a component of an evacuation model and then searching for research that supports the model development giving little/less consideration to alternate apposing research or appreciation there is insufficient research to develop such a component which can be used with sufficient confidence.

User

Using a model because a practitioner/company has experience of it (or obligation to use it), irrespective of the suitability of the model for a specific engineering application.

User

Using default values within a model/calculation without questioning the suitability or underlying assumptions.

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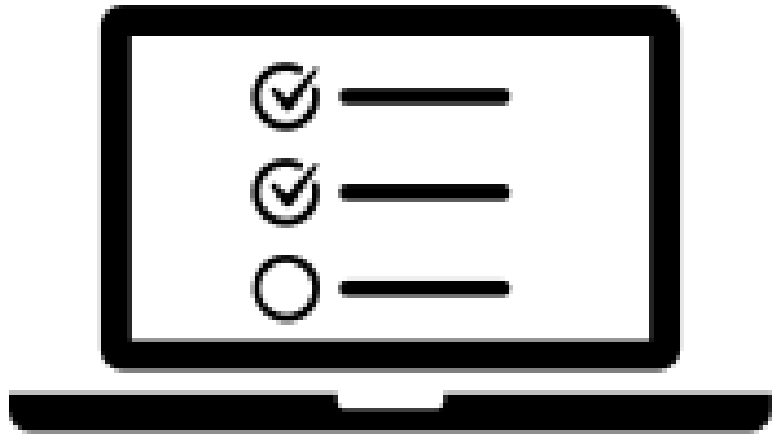
Survey

- Online survey conducted to provide empirical basis
- Gauge extent certain cognitive biases exits in evacuation modelling usage
- Participants were informed that they were employed to conduct an evacuation modeling analysis.
- The survey consisted of 21 questions which was split into five sections including:

1. Evacuation model selection
2. Scenario specification
3. Model configuration
4. Results analysis and presentation



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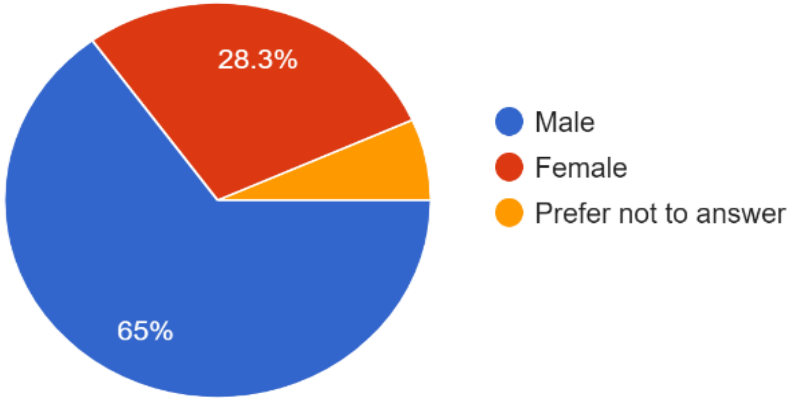
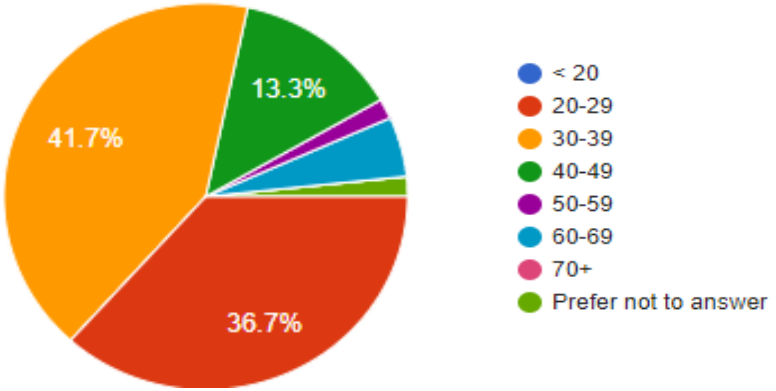
Participants

- 60 participants
- Two-thirds (65%) were male and approximately one third female (28.3%).
- Most participants were aged between 20-39 (78.4%)
- Participants were located in Europe (53.3%), Australasia (20%), Asia (11.7%), North America (11.7%), and Middle East/South America (3.3%).
- Two-thirds (66.7%) either received informal training or were self-taught.
- Just under a third (28.3%) reported having attended a university course and under a half also received some in-house training within their company.

Gender



Age



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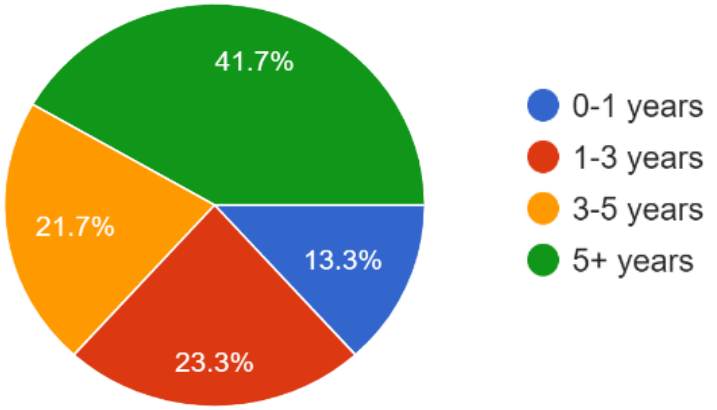
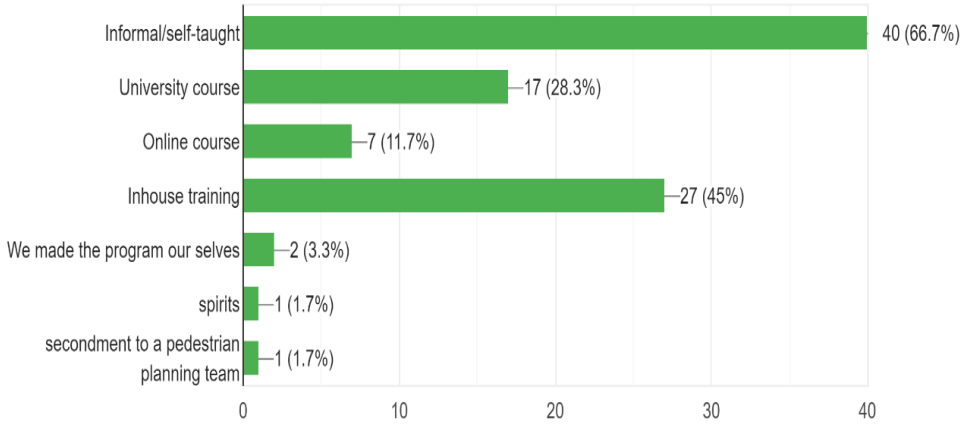
Participants

- Almost one half (45%) of participants stated they were proficient with two evacuation models with 38.3% stating they could use only one evacuation model with 16.7% stating they could use 3 or more evacuation models
- Over half of participants (58.3%) stated they had less than 5 years' experience
- Data generally reflects that evacuation modelling is commonly conducted by relatively young users.

Years experience



Training



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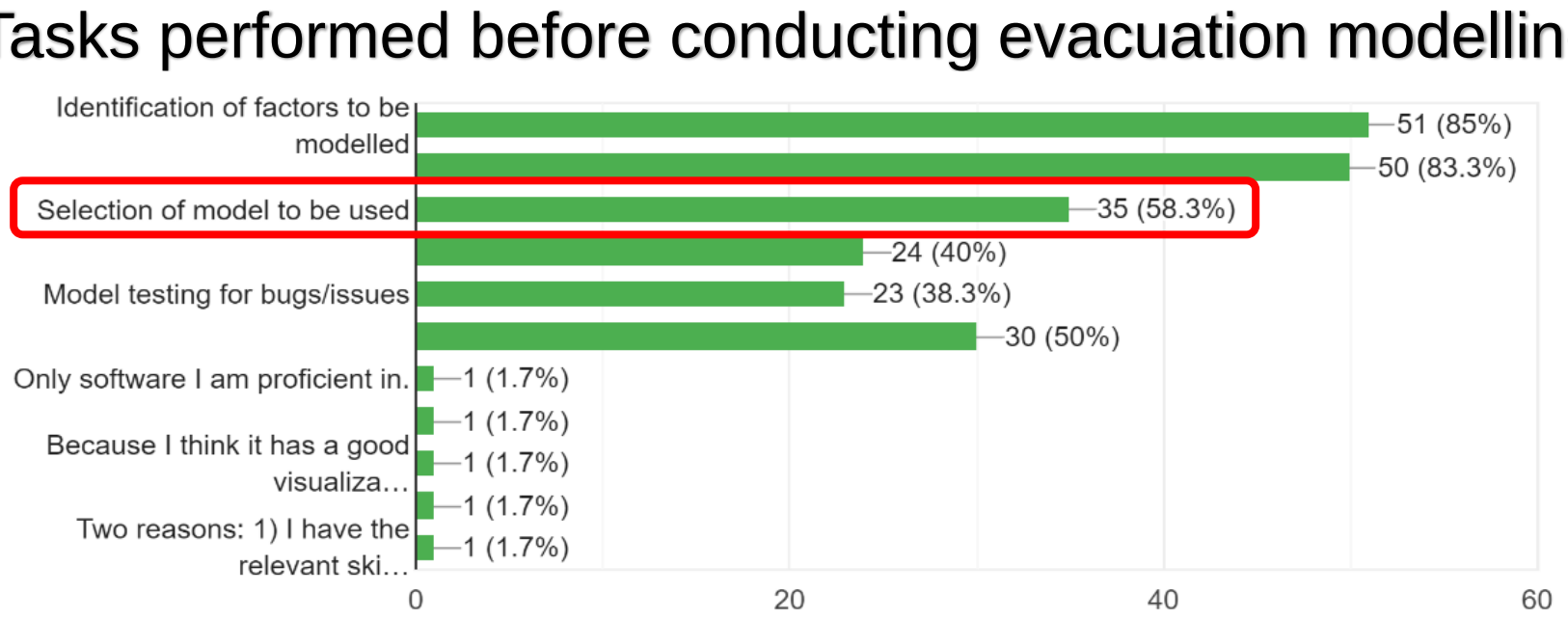
Model Selection

- Participants were asked what tasks they would typically perform before conducting the evacuation modelling analysis.
- Elicit if participants considered alternatives when selecting an evacuation model to use.
- Just over a half (58.3%) of participants stated they would consider which evacuation model to use.



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Model Selection

- Just over a half (58.2%) have access to only 1 evacuation model: these participants do not have a choice of which evacuation model to use.
- Just over a third (38.2%) of participants have access to 2-3 evacuation models.
- Considering company resources are limited
  - software licenses
  - costs regarding training
- Results highlight that evacuation model selection bias occurs and it can be imposed on users by commercial constraints (not due to ignorance or lack of consideration of information).

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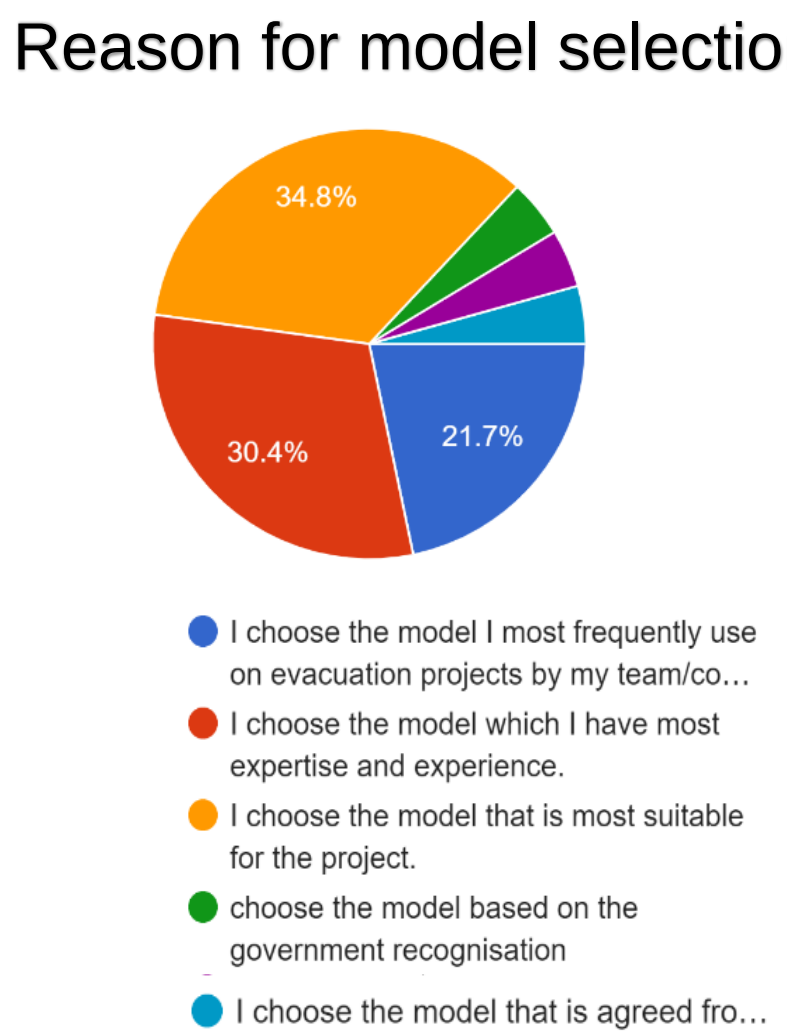
Model Selection

- Of the participants which have access to more than on evacuation model:
  - Just 34.8% of participants stated they would use the model which was most suitable for the project.
  - Around a half (52.1%) stated they would either use the evacuation model they most frequently used on past projects (21.7%) or they would choose the model that have most experience/expertise in (30.4%).
- Where there is a choice of which evacuation model to use, familiarity bias can occur with evacuation model selection.



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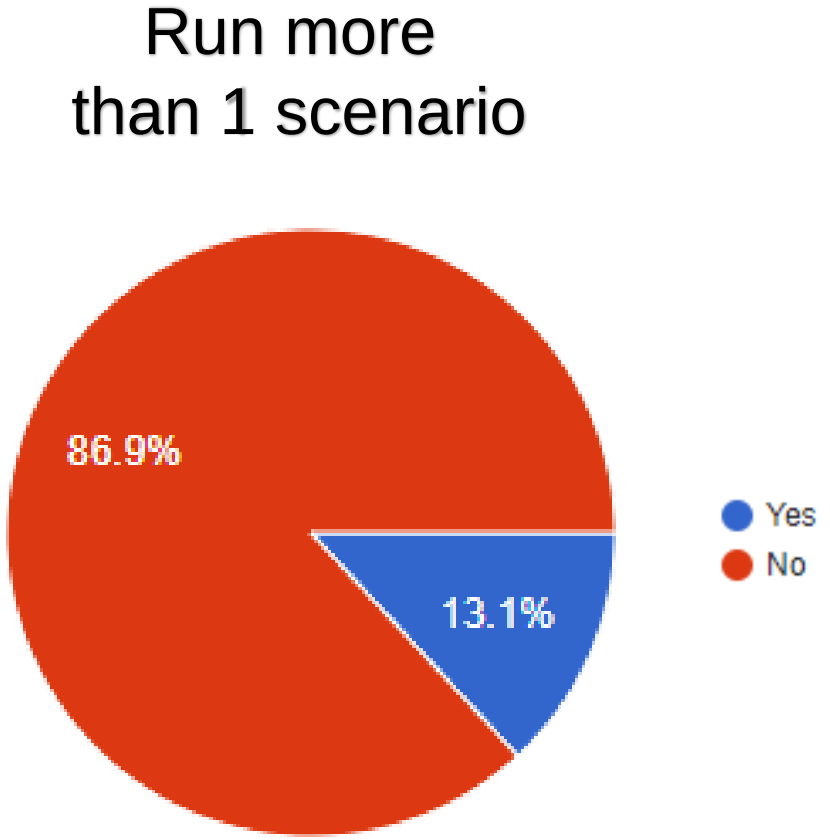
Scenario Specification

- Understanding the scenarios participants would conduct to identify any trends in the selection of scenarios and/or potential biases in the process.
- 86.8% of participants stated they would likely run more than one evacuation scenario: widespread understanding of the need to consider multiple evacuation scenarios.
- Small minority (13.2%) that would only consider running a single evacuation scenario.



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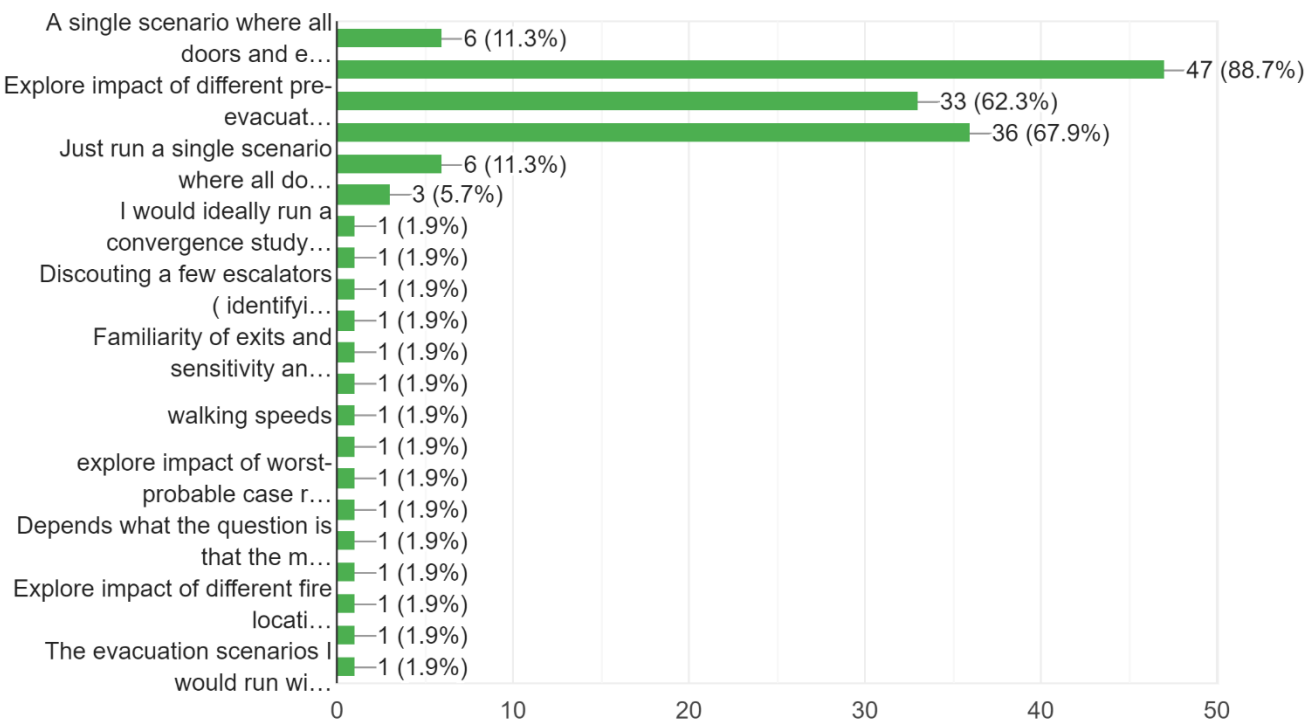
Scenario Specification

- Of the 86.8% who would run more than one scenario, three factors were more frequently identified:
  1. Doors/stairs being blocked by fire/smoke (88.7%)
  2. Different demographics groups (67.9%)
  3. Different pre-evacuation time distributions (62.3%)
- These factors are expected to potentially heavily affect results.
- Results suggest generally there are range of factors people would consider exploring the sensitivity of the design (not overly bias to one factor).



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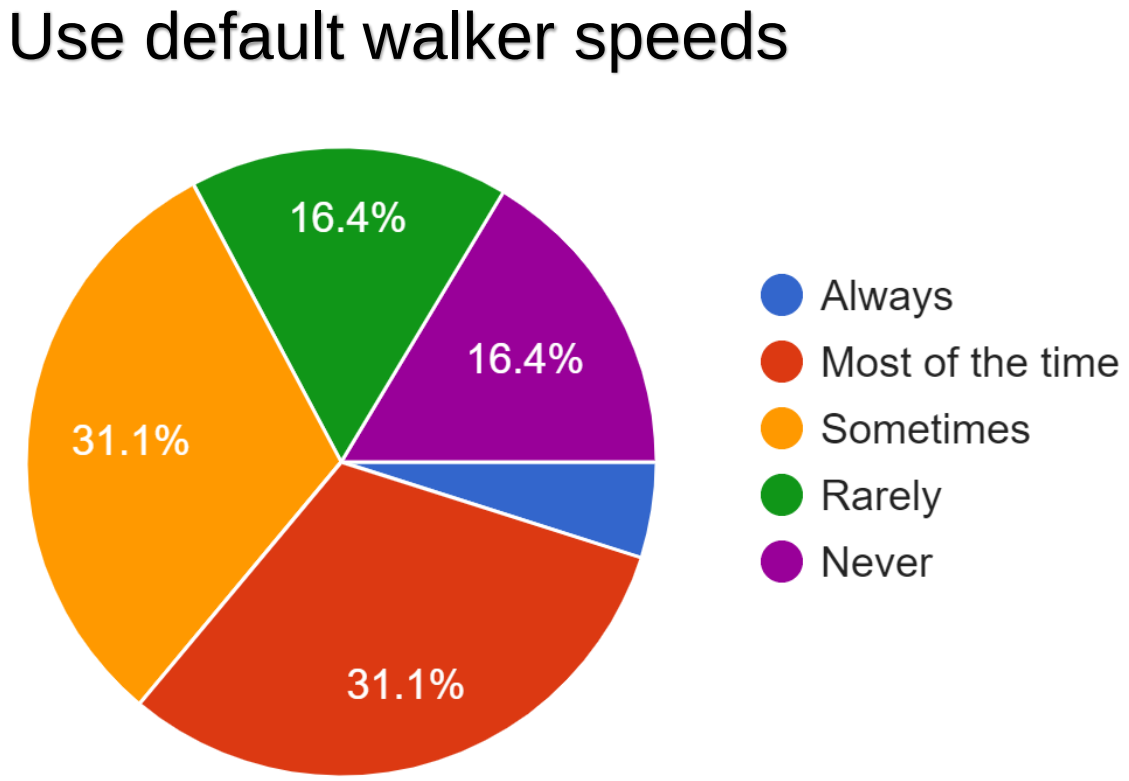
Model Configuration

- Model configuration requires specifying input parameters/settings to reflect a scenario.
- These questions explored whether these parameters were set to best reflect the scenarios or influenced by other factors (e.g. using default settings irrespective of their suitability).
- Over a third (36%) of participants stated they would always or most of the time use the default speeds.



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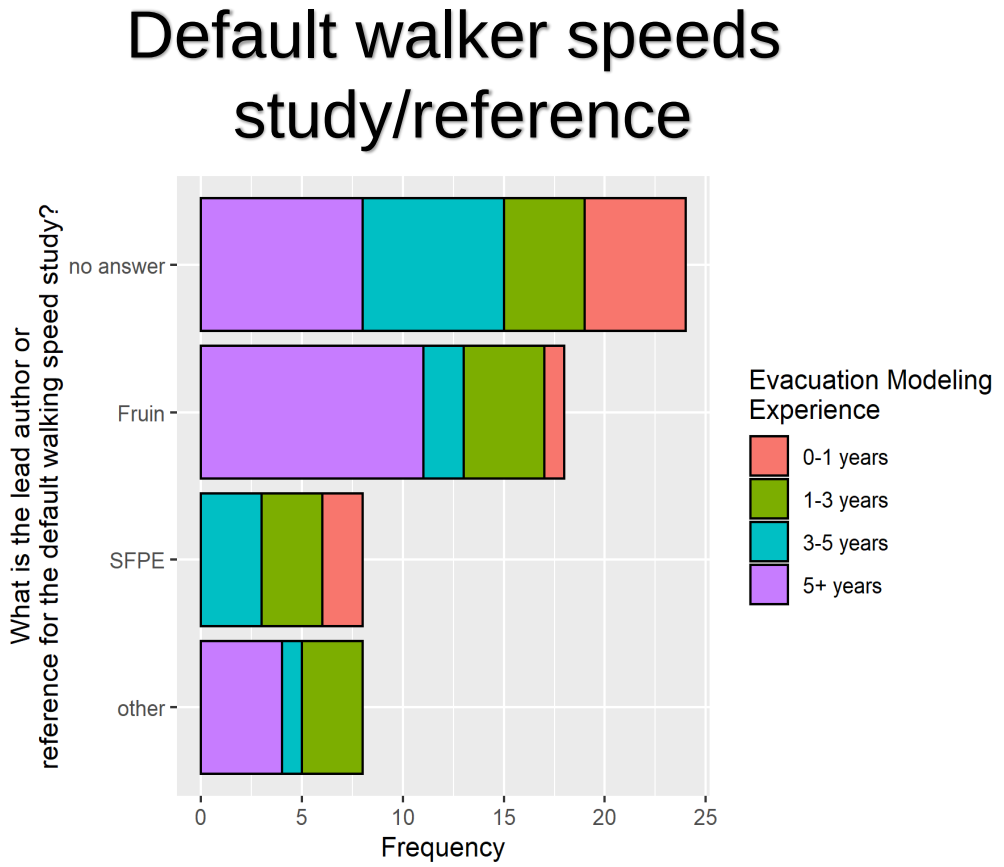
Model Configuration

- Over a third (38.3%) stated they did not know study/reference of the default walker speeds used.
- Of those participants which stated they did know the default speed source(61%), they were asked to name the study/reference: almost half (46.7%) could not name the study.
- Those with 5+ years experience were more likely to state the study.
- A sizeable proportion (36%) of evacuation model users will exhibit default bias regarding walker speed selection regardless of the analysis.



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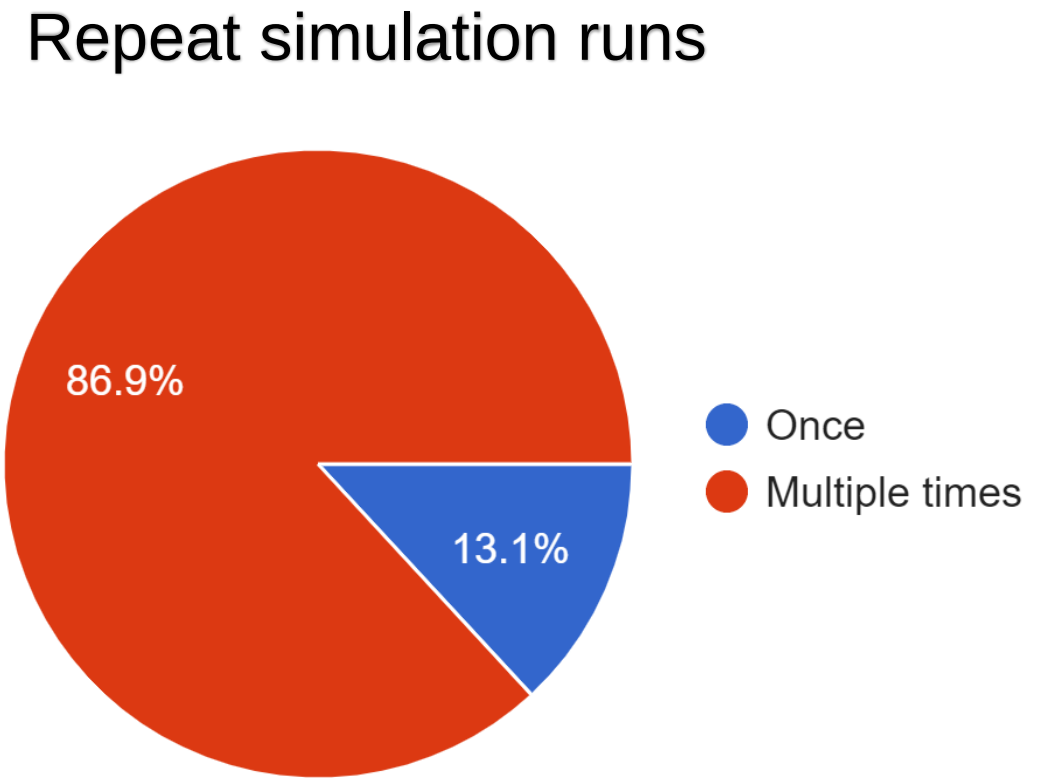
Model Configuration

- Participants were asked more generally if they would use the default settings within an evacuation model for other aspects of model configuration: 51.1% stated they would very likely do so.
- Participants were asked if they would run repeat simulation runs (i.e. to account for stochastic elements within a model).
- 86.9% stated they would run multiple repeat simulation runs.
- A small number (13.1%) would be bias to only running a single run: maybe due to financial/project constraints/lack of awareness



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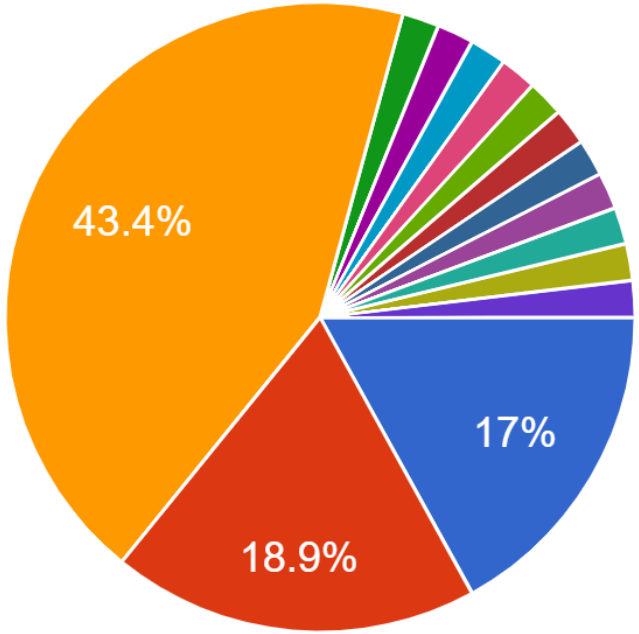
Model Configuration

- Participants were then asked how they determined the number of repeat simulation:
  1. 44.2% would measure some output variable(s) or series for variance and repeat simulation runs until the level of variance stabilized.
  2. 18.9% would run a predefined fixed number of repeat runs given guidance. recommendations.
  3. 17% would run a predefined fixed number of repeat runs **as this is what they normally did.**
- Almost a fifth (17%) would generally adopt default behavior in selecting the number of repeat runs to run without consideration of variability in the results produced or recommendations.

How to determine the number of repeat simulation runs



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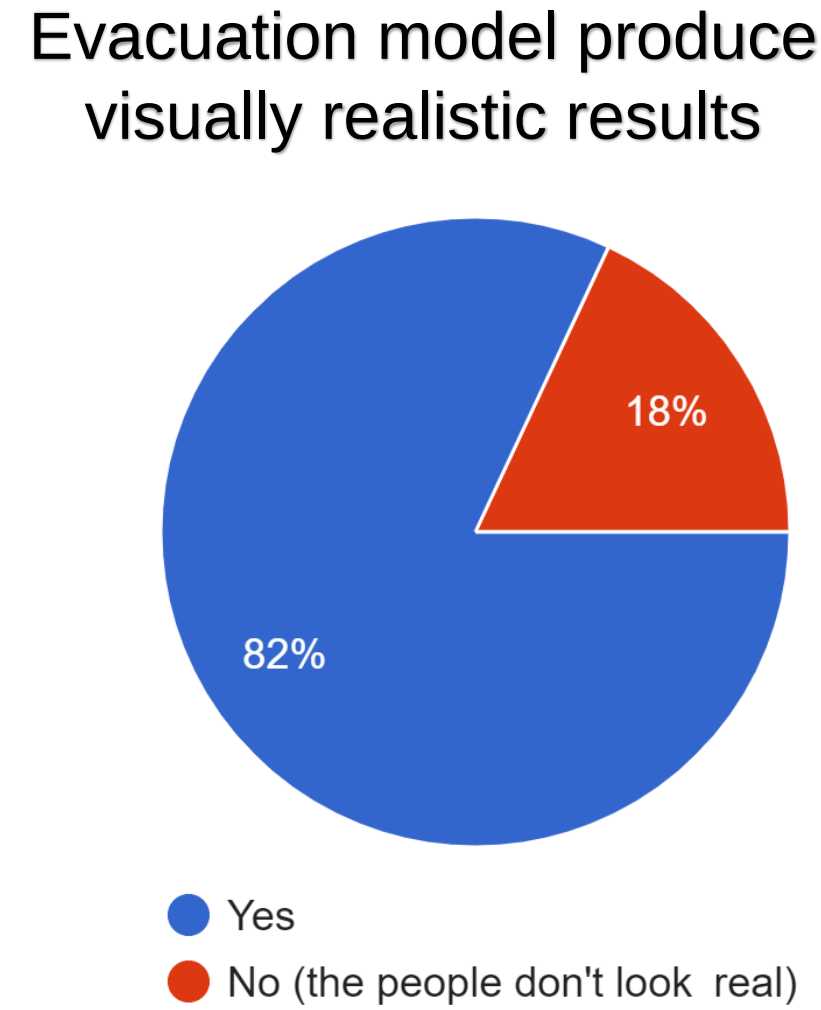
Results analysis

- Questions about this analysis attempted to establish if any biases existed regarding the graphical realism and implied reliability of the results.
- Many evacuation models employ visually realistic looking graphical representation of people evacuating
- Halo-bias could occur: the more visually realistic the model looks the increased likelihood that the user will think the underlying behavioral model is realistic.
- 82% of participants stated that evacuation models allow them to produce convincing and visually realistic looking animations of people evacuating.



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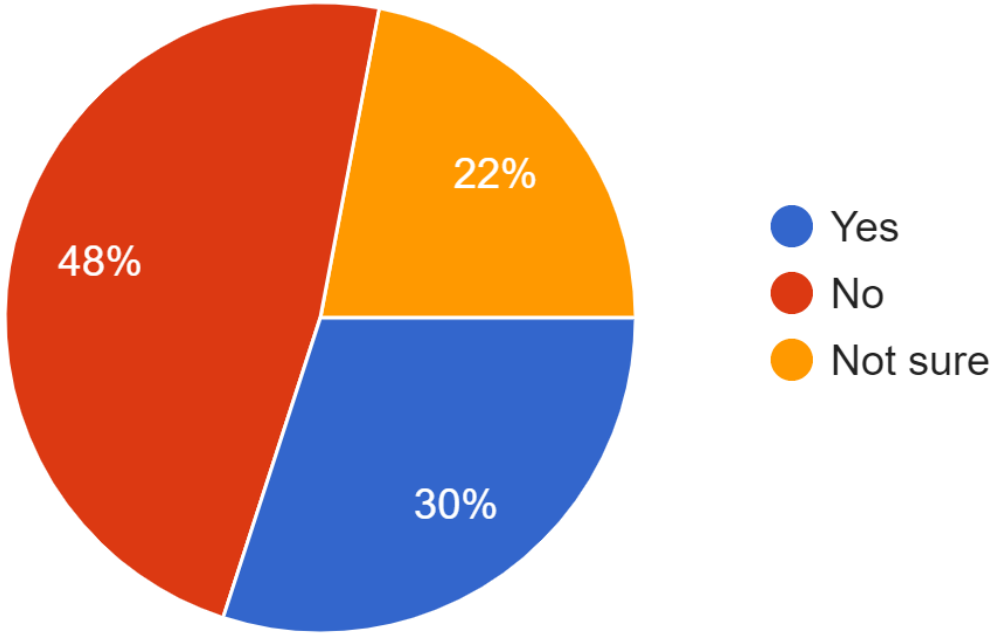
Results analysis

- Over two thirds of participants (69.3%) stated either it did not give them confidence (46.9%) or they were not sure if it gave them more confidence (22.4%).
- Nearly a third (30.6%) of participants were biased by the visual realism of a model which gives them confidence that the simulated behavior is also realistic.

Visual realism gives confidence that the simulated behaviour is also realistic



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Summary

- General Decision Making Theory
- Proposed potential evacuation modelling biases:
  - Research, Development, Application
- Survey results demonstrate/quantify the extent some biases exist in a variety of evacuation modelling tasks:
  - Model/parameter selection
  - Scenario selection
  - Repeat simulation selection
  - Results analysis
- Common biases: Default bias & Familiarity bias
- Further research is needed to address limitations of the survey (i.e. conduct experimental trials)

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