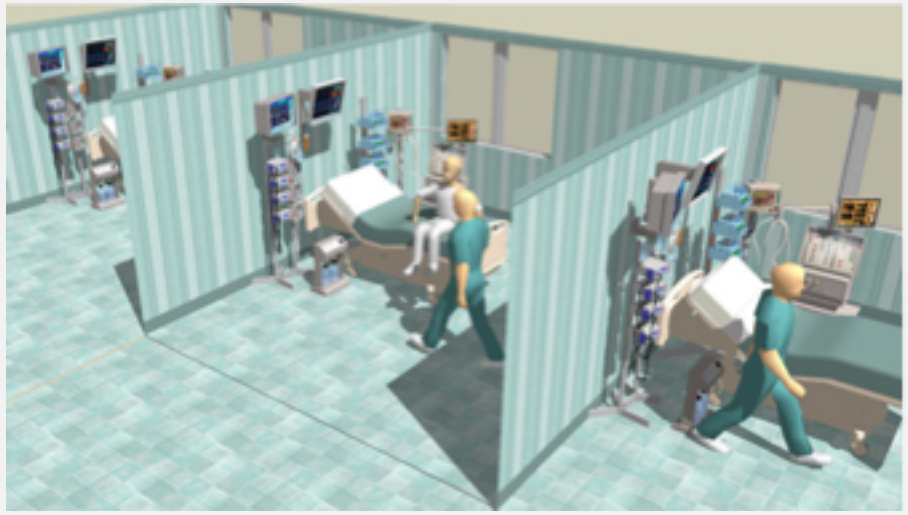
QUANTITATIVE MODEL VALIDATION

Michael Setteducati

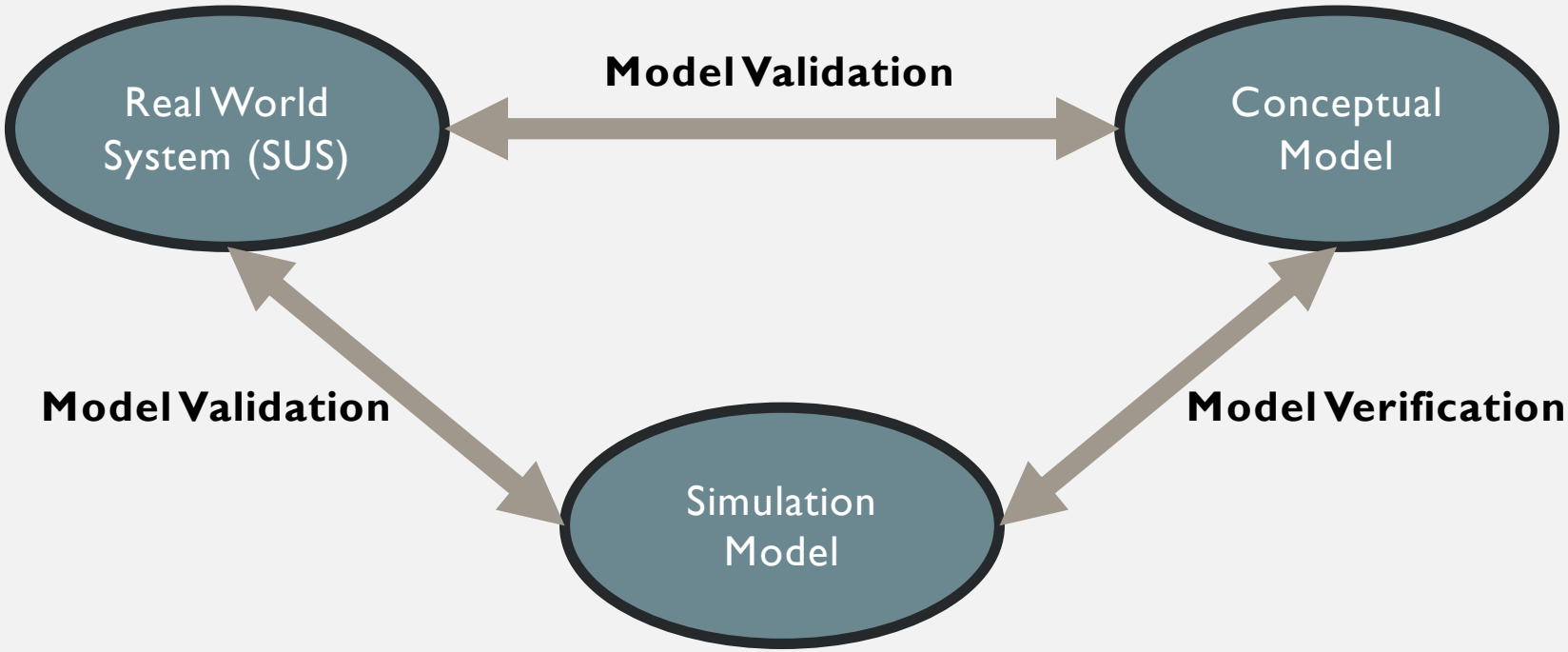
Advised By: Dr. Olsen and Dr. Raunak

SIMULATION MODELS

- Abstraction of a real-world system
- Simulation Study:
  - Develop Model
  - Verification and Validation
  - Experiments
  - Results



VERIFICATION AND VALIDATION



Establish Model Credibility

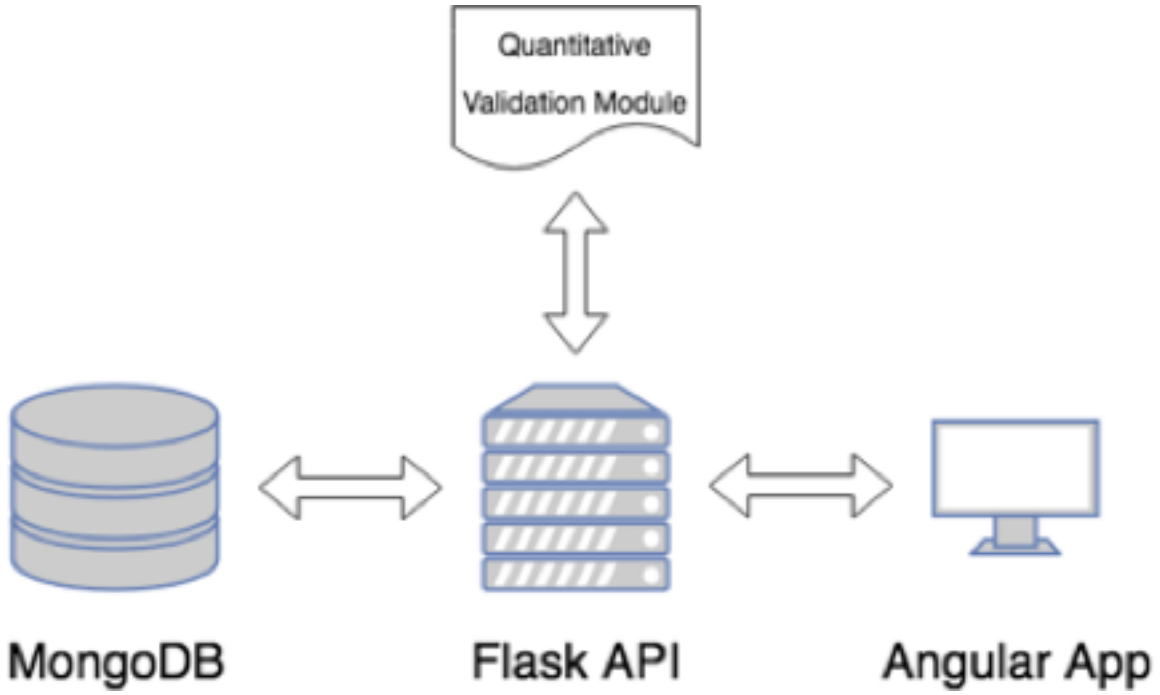
MOTIVATION

- No standard for quantifying model confidence
  - Validation has been considered qualitative
- Extent of validation is unknown
  - Difficult to reproduce
  - Poor validation documentation

QUANTITATIVE VALIDATION TOOL

- Information about framework
- Organize Validation efforts
- Automate calculations

SYSTEM DESIGN



QUANTITATIVE VALIDATION FRAMEWORK

Purpose

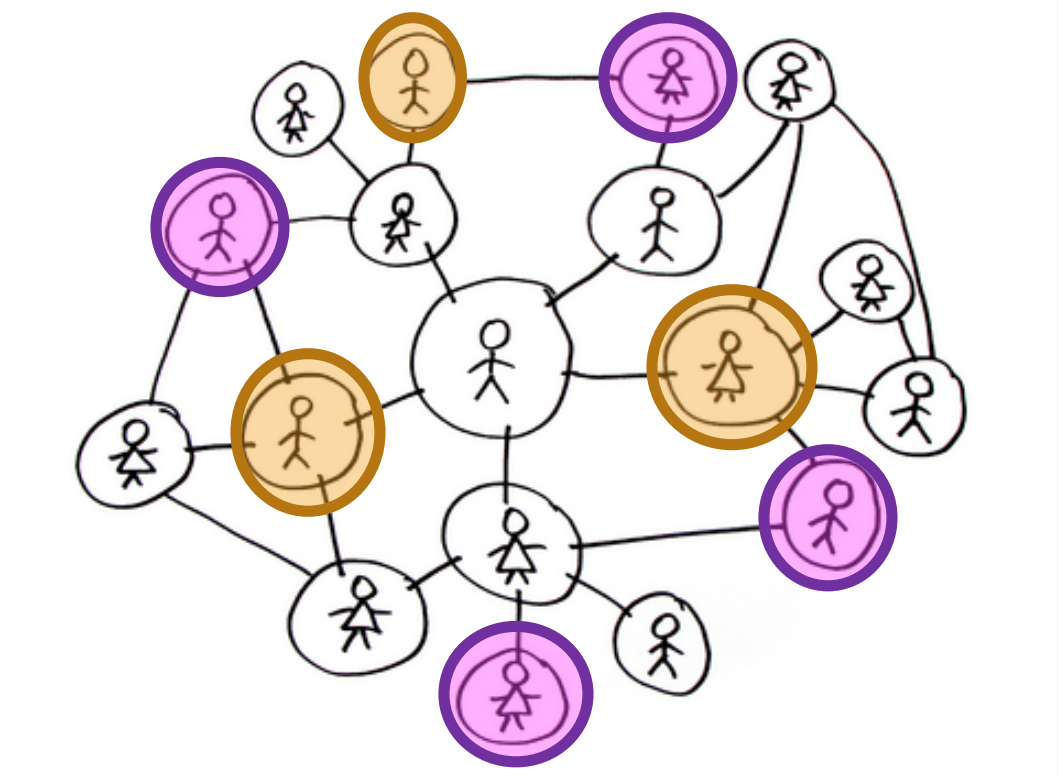
Structure ⇨ Validate Elements ⇨ Structural Confidence × 0.3

Behavior ⇨ Validate Elements ⇨ Behavioral Confidence × 0.5

Data ⇨ Validate Elements ⇨ + Data Confidence × 0.2

Overall Model Confidence

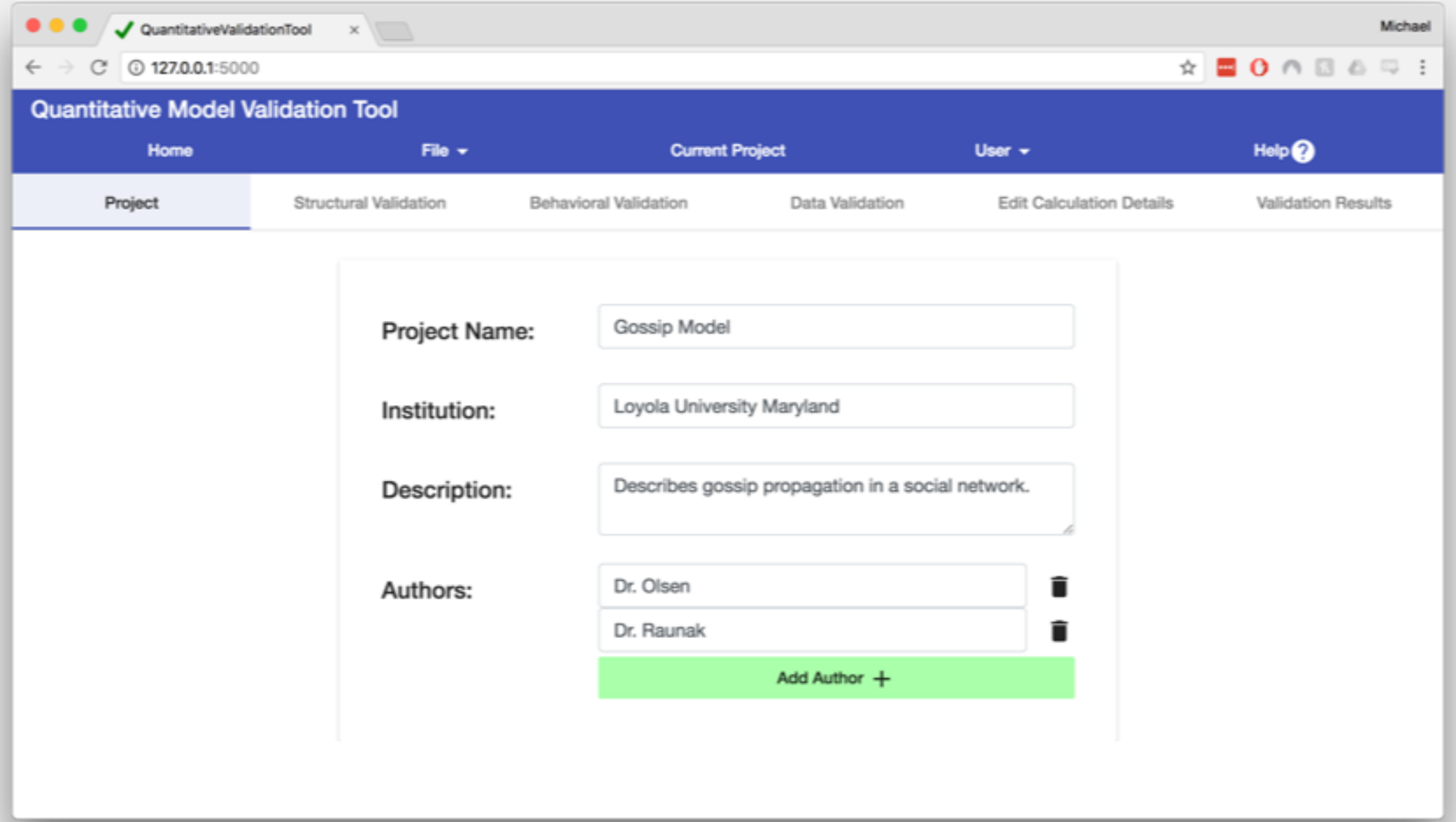
GOSSIP MODEL EXAMPLE



observers

distorters

Laidre, M., Lamb, A., Shultz, S., and Olsen, M. Making sense of information in noisy networks: human communication, gossip, and distortion. Journal of Theoretical Biology 317 (2013).


QuantitativeValidationTool
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User
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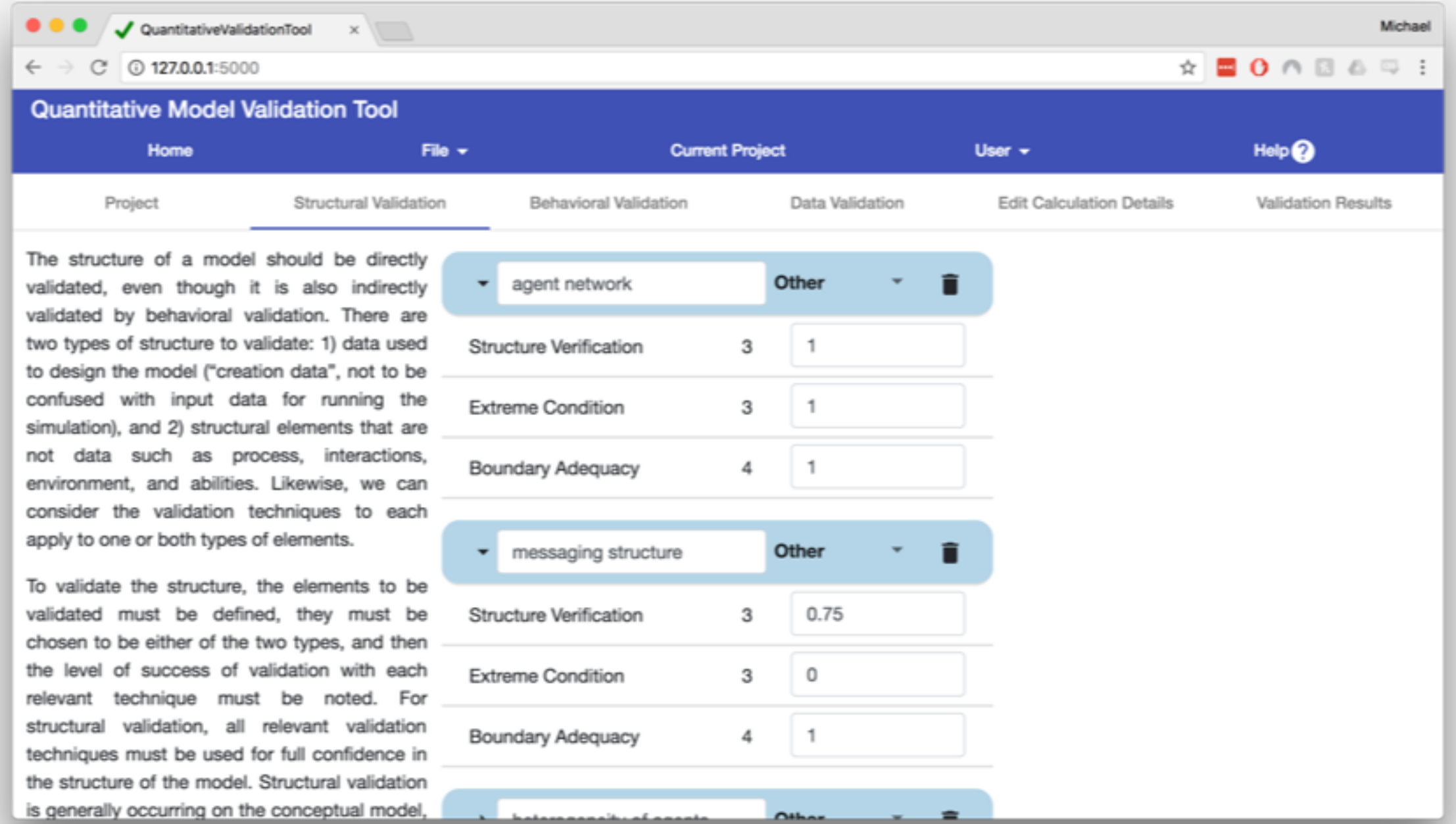
Project
Structural Validation
Behavioral Validation
Data Validation
Edit Calculation Details
Validation Results
Project Name:
Gossip Model
Institution:
Loyola University Maryland
Description:
Describes gossip propagation in a social network.
Authors:
Dr. Olsen
Dr. Raunak
Add Author +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Current Project
User
Help
Project
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Behavioral Validation
Data Validation
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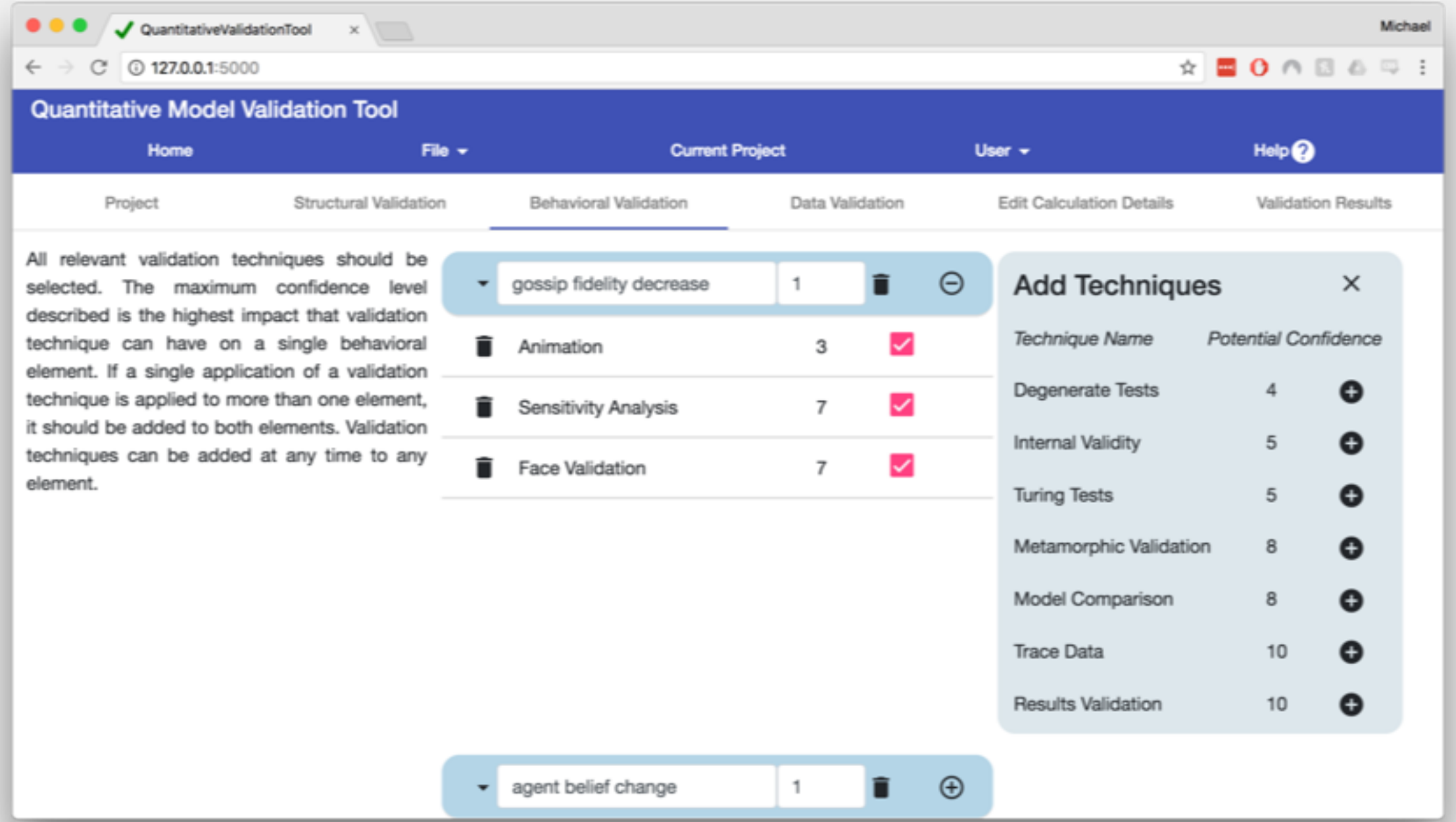
The structure of a model should be directly validated, even though it is also indirectly validated by behavioral validation. There are two types of structure to validate: 1) data used to design the model ("creation data", not to be confused with input data for running the simulation), and 2) structural elements that are not data such as process, interactions, environment, and abilities. Likewise, we can consider the validation techniques to each apply to one or both types of elements.
To validate the structure, the elements to be validated must be defined, they must be chosen to be either of the two types, and then the level of success of validation with each relevant technique must be noted. For structural validation, all relevant validation techniques must be used for full confidence in the structure of the model. Structural validation is generally occurring on the conceptual model,
agent network
Other
Structure Verification 3 1
Extreme Condition 3 1
Boundary Adequacy 4 1
messaging structure
Other
Structure Verification 3 0.75
Extreme Condition 3 0
Boundary Adequacy 4 1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User
Help
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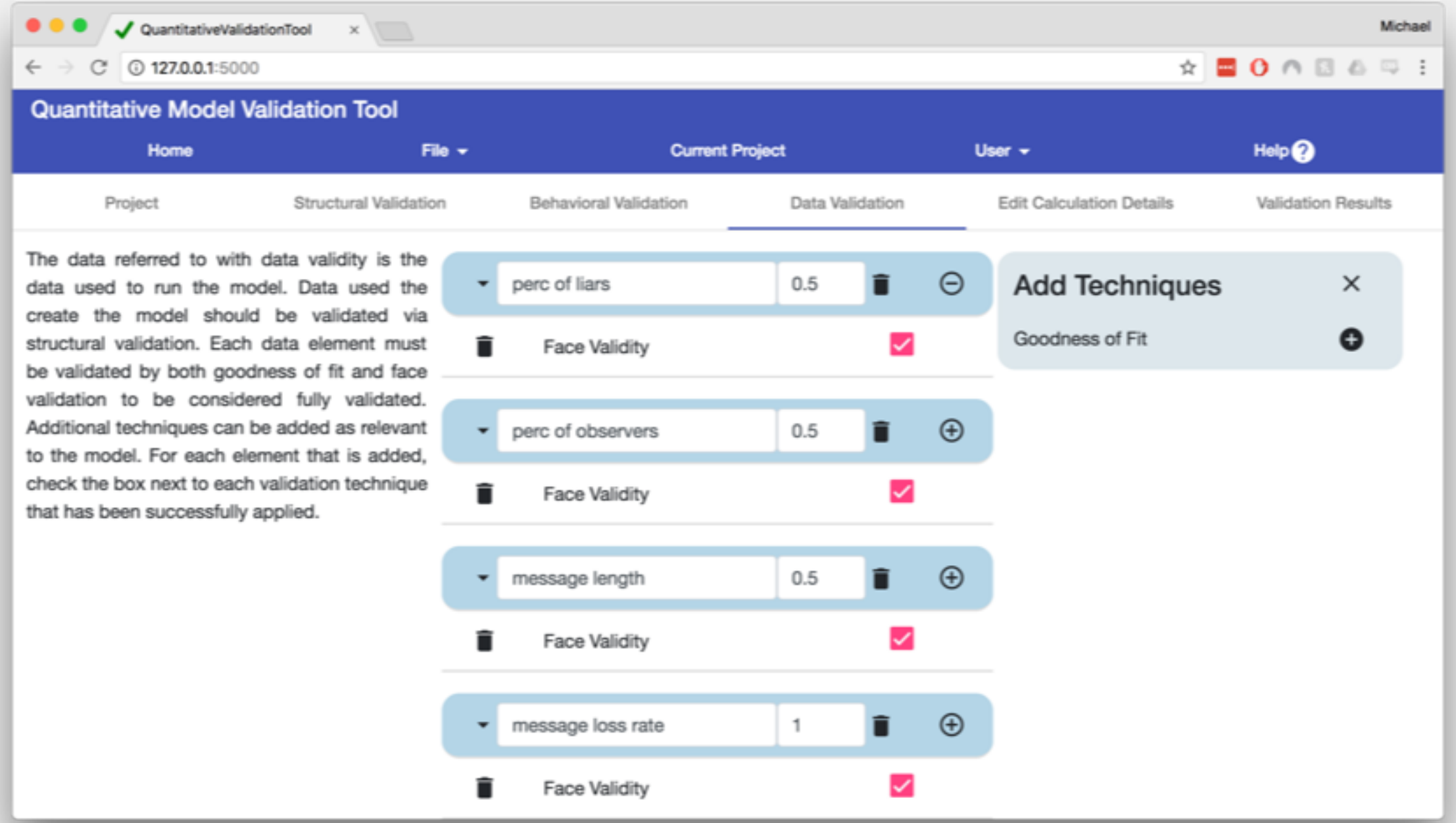
All relevant validation techniques should be selected. The maximum confidence level described is the highest impact that validation technique can have on a single behavioral element. If a single application of a validation technique is applied to more than one element, it should be added to both elements. Validation techniques can be added at any time to any element.
gossip fidelity decrease
1
Animation
3
Sensitivity Analysis
7
Face Validation
7
agent belief change
1
Add Techniques
Technique Name
Potential Confidence
Degenerate Tests
4
Internal Validity
5
Turing Tests
5
Metamorphic Validation
8
Model Comparison
8
Trace Data
10
Results Validation
10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Current Project
User
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Project
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The data referred to with data validity is the data used to run the model. Data used the create the model should be validated via structural validation. Each data element must be validated by both goodness of fit and face validation to be considered fully validated. Additional techniques can be added as relevant to the model. For each element that is added, check the box next to each validation technique that has been successfully applied.
perc of liars
0.5
Face Validity
perc of observers
0.5
Face Validity
message length
0.5
Face Validity
message loss rate
1
Face Validity
Add Techniques
Goodness of Fit

Print Validation Results Table

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Gossip Model

Loyola University Maryland

Describes gossip propagation in a social network.

By: Dr. Olsen , Dr. Raunak

Structural Validation (weight = 0.3)

Element	PV 2	DC 2	SV 3	EC 3	BA 4
agent network			1	1	1
messaging structure			0.75	0	1
heterogeneity of agents			0.75	1	1
gossip spread process			1	0	1
agent memory			1	1	1
choice strategy			1	1	1
sharing strategy			0.75	1	1
distortion approach			1	0	1
number of agents	1	1			1
Structural Confidence:	89.96%				

PV: Parameter Verification; **DC:** Dimensional Consistency; **SV:** Structure Verification; **EC:** Extreme Condition; **BA:** Boundary Adequacy;

Behavioral Validation (weight = 0.5)

Element	Weight	A 3	DT 4	IV 5	TT 5	FV 7	SA 7	MV 8	MC 8	TD 10	RV 10
gossip fidelity decrease	1	☑				☑	☑				
agent belief change	1	☑				☑	☑				☐
neighbor sharing	1	☑				☑	☑	☑			
liar impact propagation	1	☑				☑	☑	☑			
gossip propagation ends	1	☑					☑				
observer placement impact	1	☑					☑	☑			
Behavioral Confidence:	91.80%										

A: Animation; **DT:** Degenerate Tests; **IV:** Internal Validity; **TT:** Turing Tests; **FV:** Face Validation; **SA:** Sensitivity Analysis; **MV:** Metamorphic Validation; **MC:** Model Comparison; **TD:** Trace Data; **RV:** Results Validation;

Data Validation (weight = 0.2)

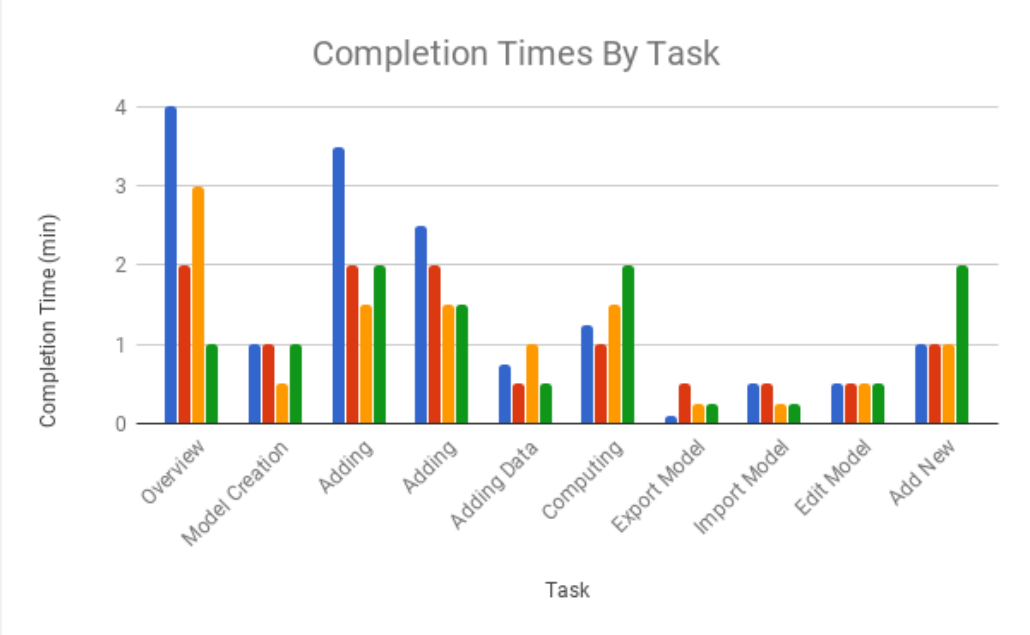
Element	Weight	GF	FV
perc of liars	0.5		☑
perc of observers	0.5		☑
message length	0.5		☑
message loss rate	1	☐	☑
heterogeneity of agents	1	☐	☑
Data Confidence:	71.43%		

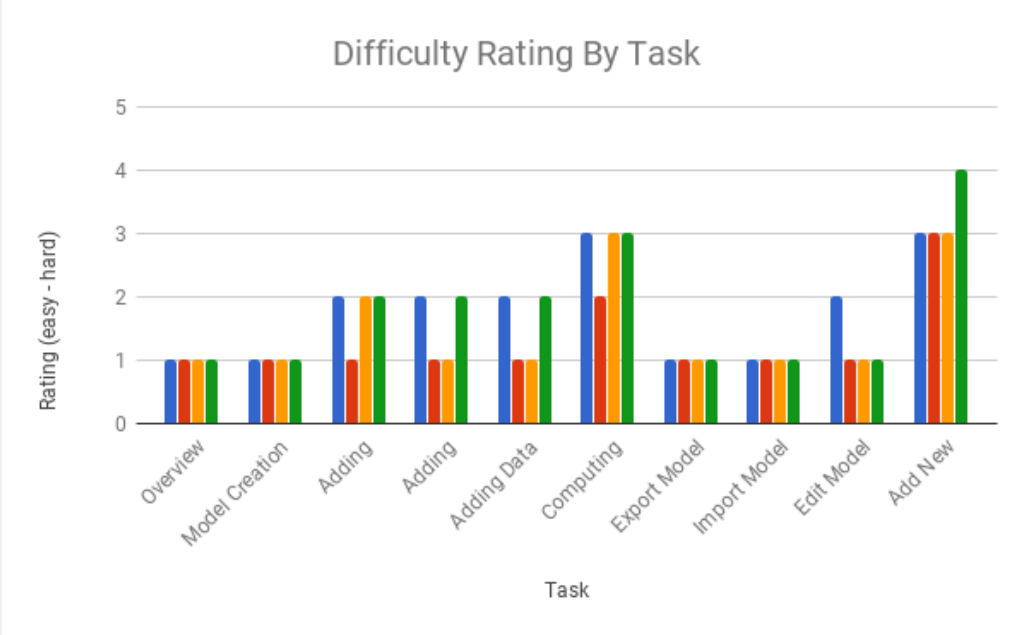
GF: Goodness of Fit; **FV:** Face Validity;

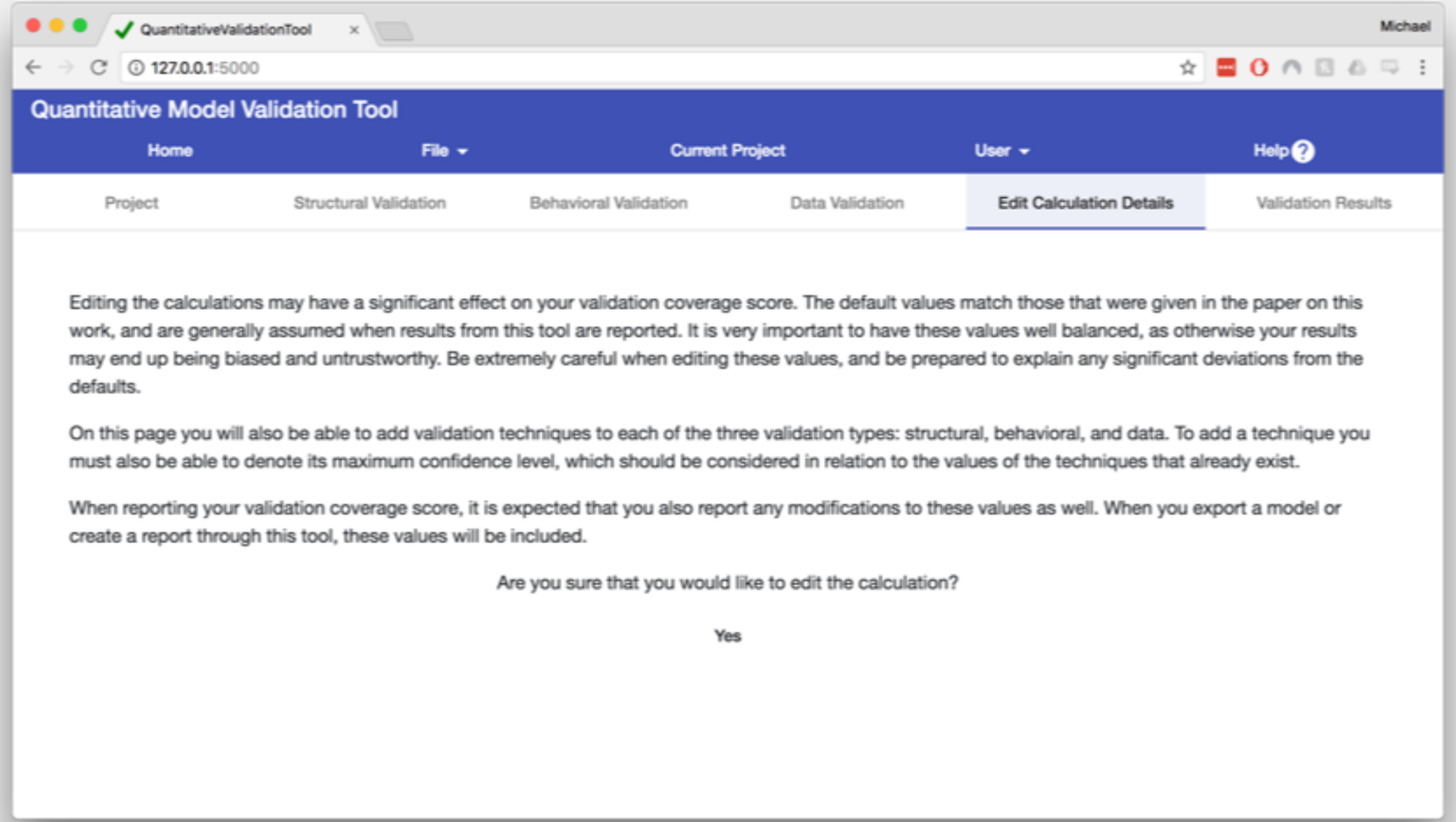
Overall Model Confidence:	**87.17%**

Waiting for extension AdBlock...

USER STUDY


Completion Times By Task
Completion Time (min)
4
3
2
1
0
Overview
Model Creation
Adding
Adding
Adding Data
Computing
Export Model
Import Model
Edit Model
Add New
Task


Difficulty Rating By Task
Rating (easy - hard)
5
4
3
2
1
0
Overview
Model Creation
Adding
Adding
Adding Data
Computing
Export Model
Import Model
Edit Model
Add New
Task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File
Current Project
User
Help
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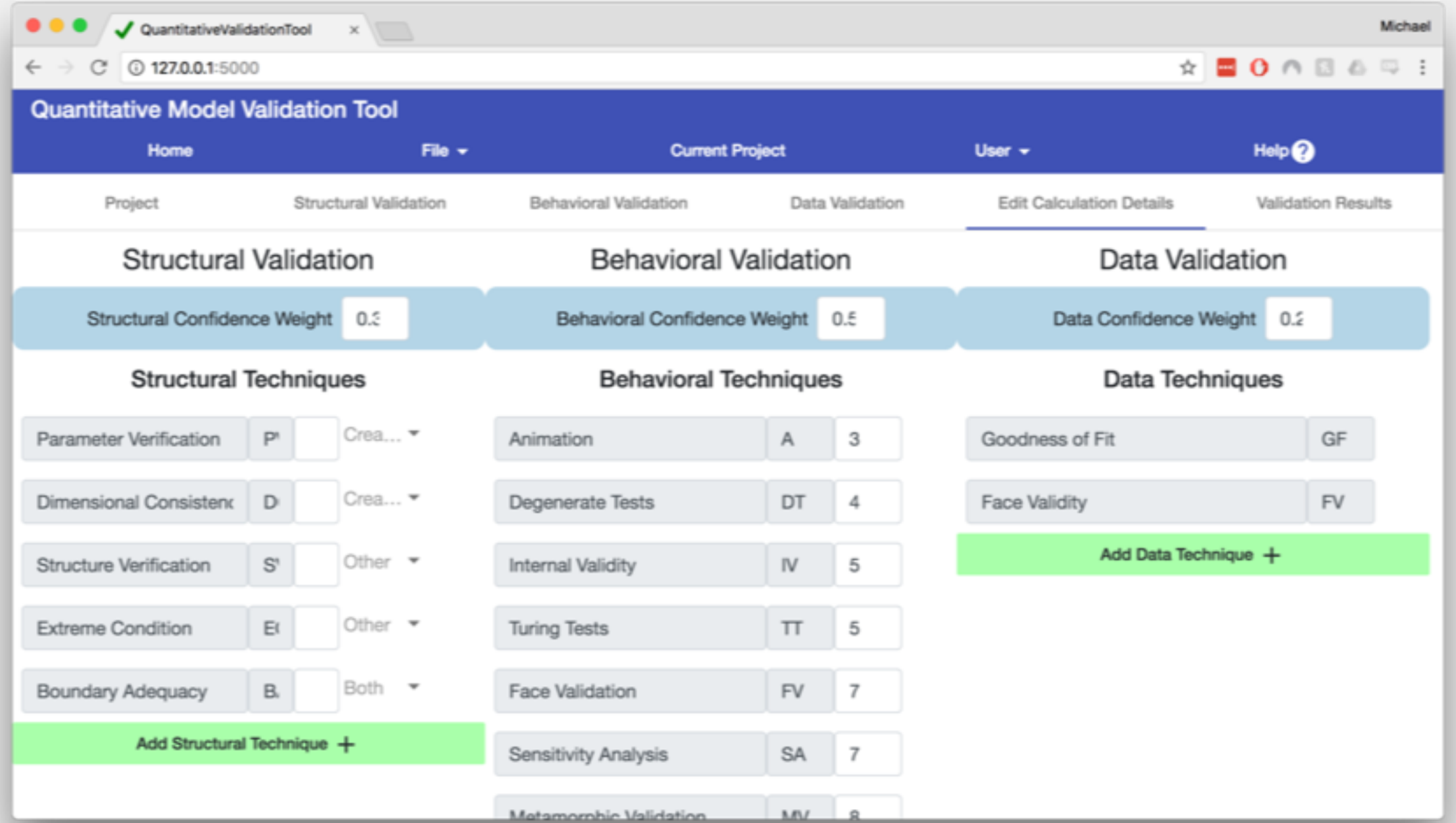
Editing the calculations may have a significant effect on your validation coverage score. The default values match those that were given in the paper on this work, and are generally assumed when results from this tool are reported. It is very important to have these values well balanced, as otherwise your results may end up being biased and untrustworthy. Be extremely careful when editing these values, and be prepared to explain any significant deviations from the defaults.
On this page you will also be able to add validation techniques to each of the three validation types: structural, behavioral, and data. To add a technique you must also be able to denote its maximum confidence level, which should be considered in relation to the values of the techniques that already exist.
When reporting your validation coverage score, it is expected that you also report any modifications to these values as well. When you export a model or create a report through this tool, these values will be included.
Are you sure that you would like to edit the calculation?
Yes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File
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User
Help
Project
Structural Validation
Behavioral Validation
Data Validation
Edit Calculation Details
Validation Results
Structural Validation
Behavioral Validation
Data Validation
Structural Confidence Weight
0.3
Behavioral Confidence Weight
0.5
Data Confidence Weight
0.2
Structural Techniques
Behavioral Techniques
Data Techniques
Parameter Verification
P
Crea...
Dimensional Consisten
D
Crea...
Structure Verification
S
Other
Extreme Condition
E
Other
Boundary Adequacy
B
Both
Add Structural Technique +
Animation
A
3
Degenerate Tests
DT
4
Internal Validity
IV
5
Turing Tests
TT
5
Face Validation
FV
7
Sensitivity Analysis
SA
7
Goodness of Fit
GF
Face Validity
FV
Add Data Technique +

IMPACT


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REFLECTION

- Application development
- User Study and Case Study
- Full stack development takes a long time

QUESTIONS?

SOFTWARE TESTS

- Quantitative Framework Algorithm
  - Unit tests that validate models used as examples in Dr. Olsen and Dr. Raunak's paper
- Front-end Angular Tests
  - Jasmine testing framework
- Back-end API Tests
  - Unit tests for endpoint functions
  - Authentication tests

FUNCTIONAL REQUIREMENTS

- The system shall allow users to input validated elements of the model.
- The system shall allow users to input validation techniques performed on elements of the model.
- The system shall allow users to modify the weights of the validation categories (structural, behavioral, and data) that are used to calculate the overall confidence.
- The system shall allow users to store the model being tested in a JSON file.
- The system shall allow logged-in users to retrieve and update previously created models that are stored on the server.