

Understanding the Data Needs for Developing a Computational Model of Team Dynamics



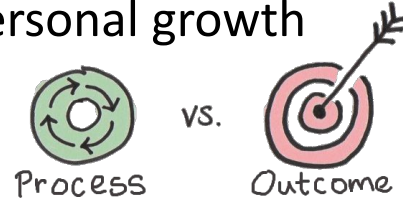
Novia Fan and Dr. Bowen Hui



Computer Science
University of British Columbia

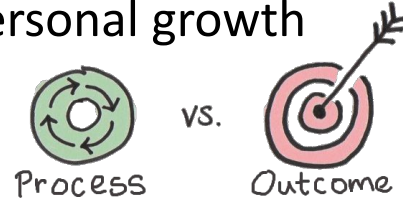
Motivation

- Effective teamwork enhances performance, collaboration, personal growth
 - Model **process variables** that explain underlying team dynamics [Kozlowski & Klein 2000]
 - Beyond outcome variables, e.g. team performance
 - Most team models are descriptive or derived through small empirical samples

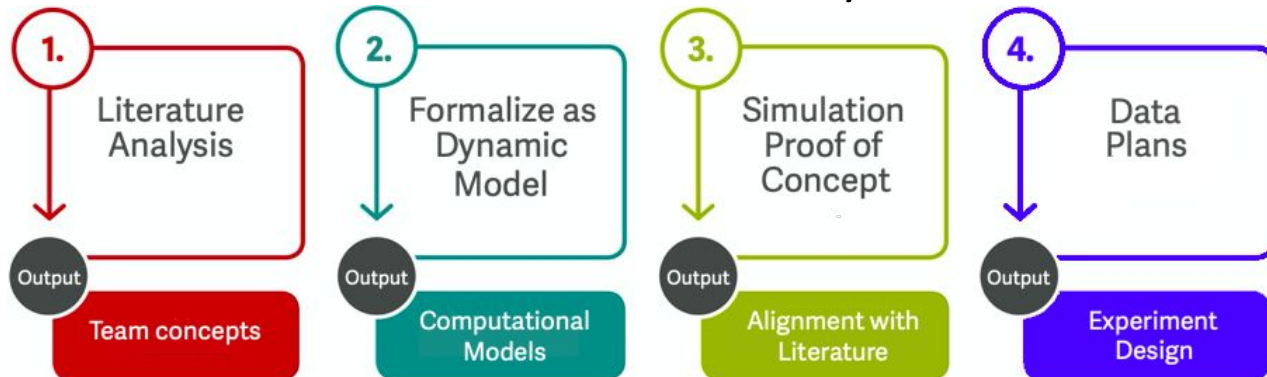


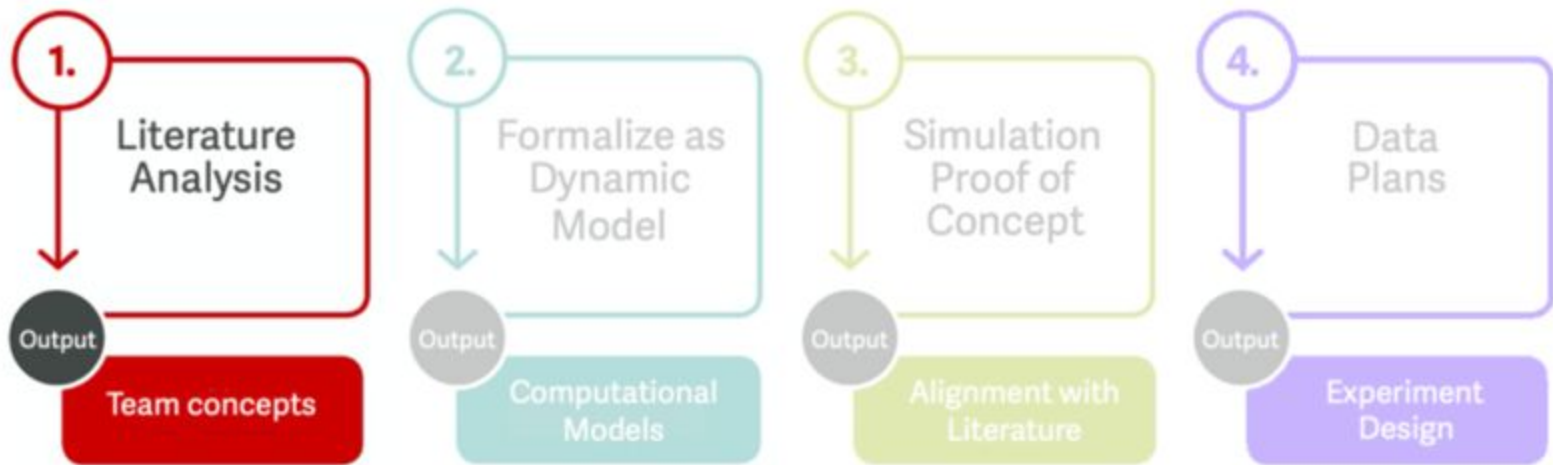
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- Our vision: Support management process with alerts of problematic behaviors so to take interventions early





Related Literature



Team Stages

**Quantitative
Team Diagnosis**

Team Characteristics

**Our Synthesis of
Team Concepts**

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Team Stages

- Stages of Development
[Tuckman 1965; Tuckman & Jensen 1977]
- Two-Stage Group Development
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Team Characteristics

- GRIP shared mental model [Raue et al. 2013]
- skills, accountability, commitment [Katzenback & Smith 1993]
- safety, structure, meaning [Google 2023]
- interdependence, conflict res, safety, structure [Adams 2002]
- 7 org structure, 4 indiv, 7 team processes [Mickan & Rodger 2000]
- social loafing, interdependence, trust, shared mental model [Borrego et al. 2013]
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Our Synthesis of Team Concepts

- shared mental model
- trust
 - safety, belonging, commitment, ...
- interdependence
- motivation
- diversity of skills
- external factors

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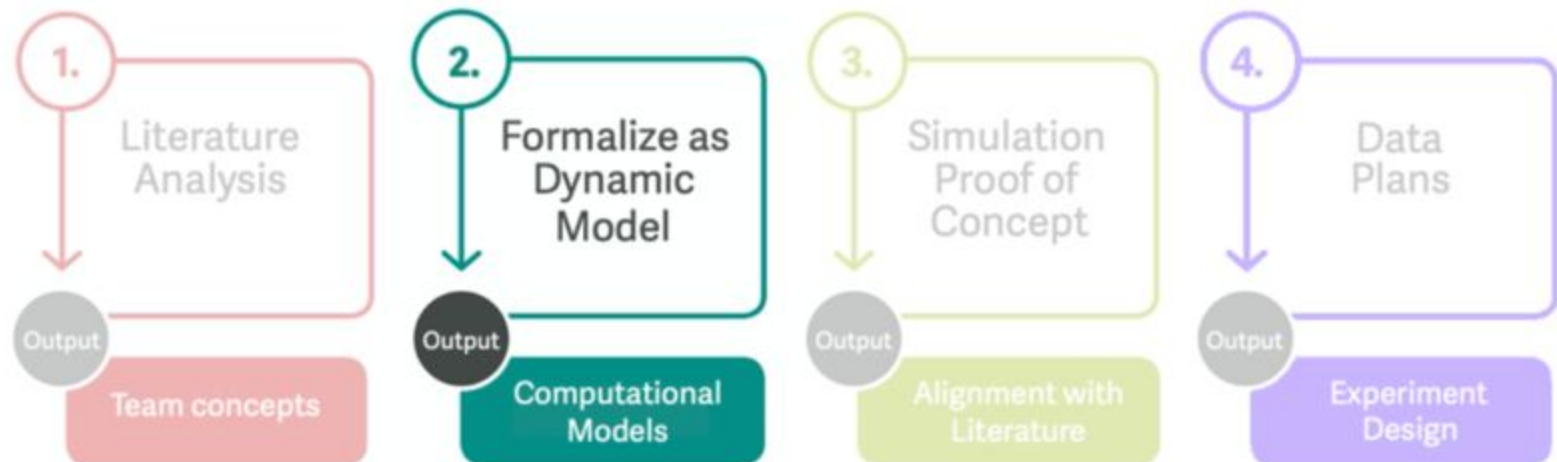
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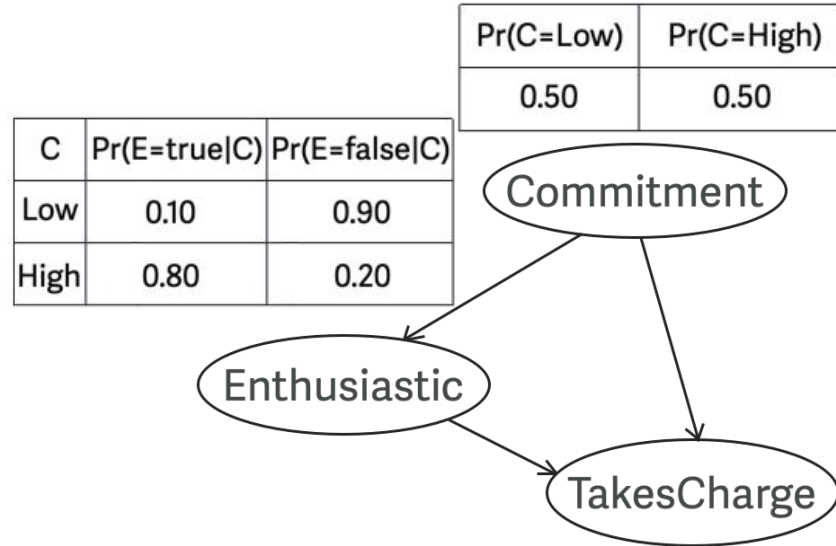
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Bayesian Network (BN)

- A BN is a directed acyclic graph of variables X_1, X_2, \dots, X_n
 - Nodes represent random variables
 - Edges represent **causal** relationships
 - Each node X_i has a **conditional probability table** (CPT) in the form $\Pr(X_i | \text{Parents}(X_i))$



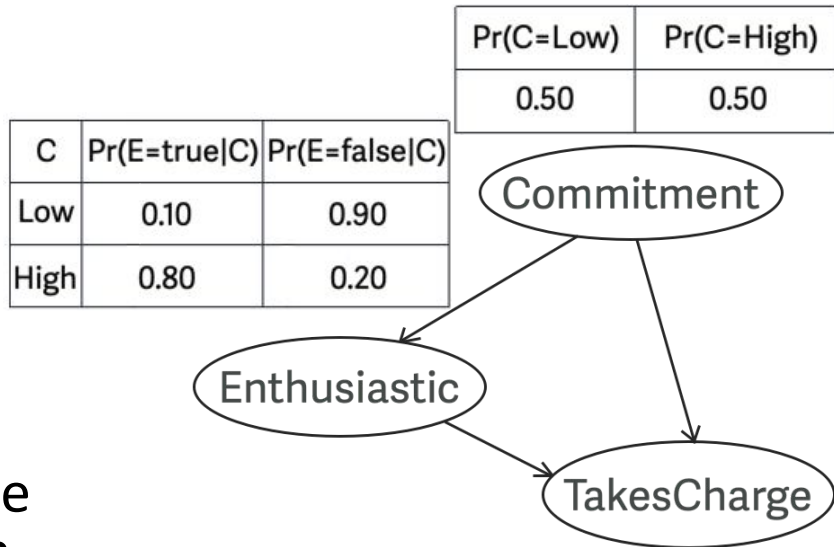
Model feature:

*BNs can represent uncertain world
knowledge intuitively
to support causal reasoning*

C	E	Pr(TC=true C,E)	Pr(TC=false C,E)
Low	true	0.45	0.55
Low	false	0.01	0.99
High	true	0.90	0.10
High	false	0.60	0.40

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 - Each node X_i has a **conditional probability table** (CPT) in the form $\Pr(X_i | \text{Parents}(X_i))$
- **Inference** allows us to estimate the likelihood of a variable value given observed variable outcomes
 - *"If the student is highly committed, how likely are they to take charge?"*
 - Represents system's current **belief** about the student



C	Pr(E=true C)	Pr(E=false C)
Low	0.10	0.90
High	0.80	0.20

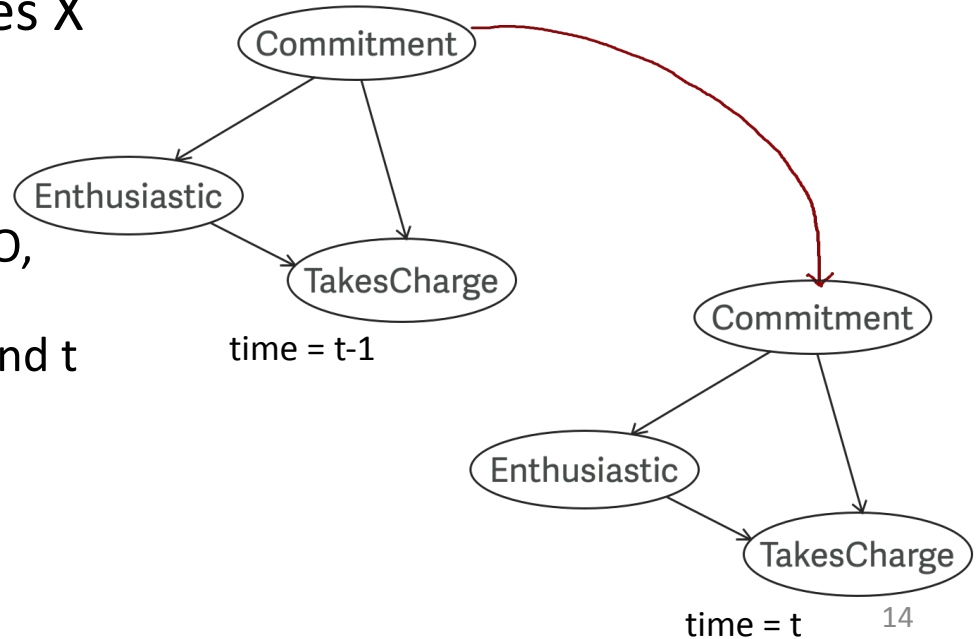
Pr(C=Low)	Pr(C=High)
0.50	0.50

C	E	Pr(TC=true C,E)	Pr(TC=false C,E)
Low	true	0.45	0.55
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Dynamic Bayesian Network (DBN)

- An extension of a BN that describes causal dependencies **over time**
- A 2-stage DBN over variables X consists of:
 - A set of **hidden variables** S , where $S \subset X$
 - A set of **observable variables** O , where $O \subset X$
 - Two discrete time slices: $t-1$ and t

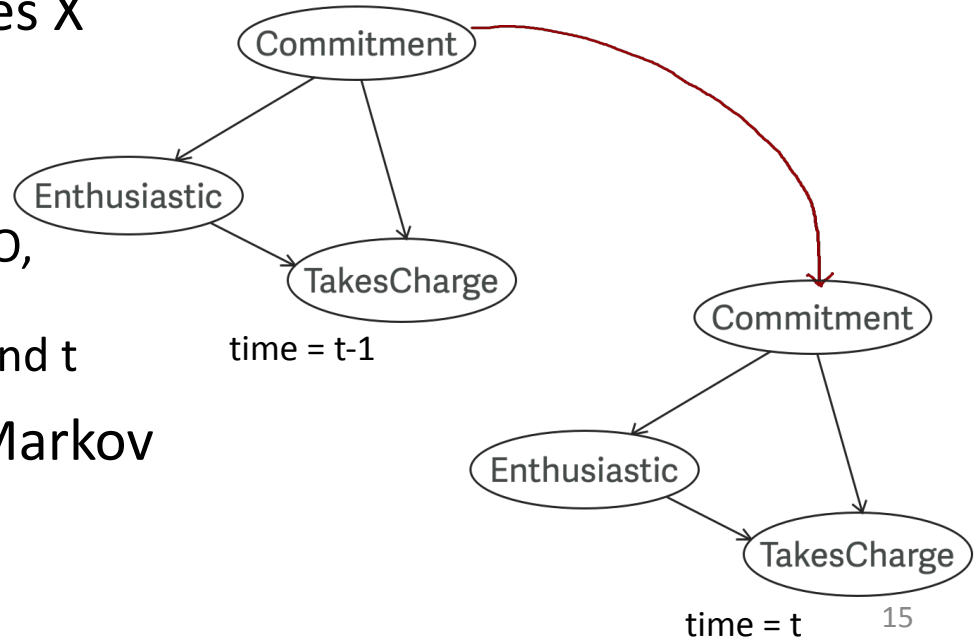
C_{t-1}	$\Pr(C_t = \text{Low} C_{t-1})$	$\Pr(C_t = \text{High} C_{t-1})$
Low	0.30	0.70
High	0.15	0.85



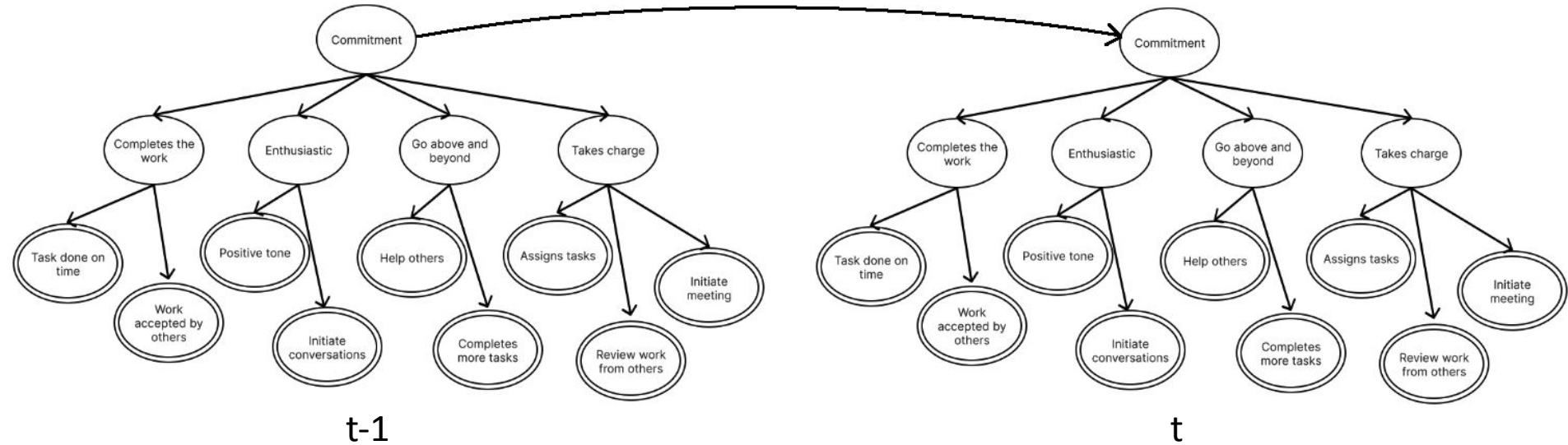
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- This model is a first order Markov process:
$$\Pr(U_t | U_{1:t-1}) = \Pr(U_t | U_{t-1})$$

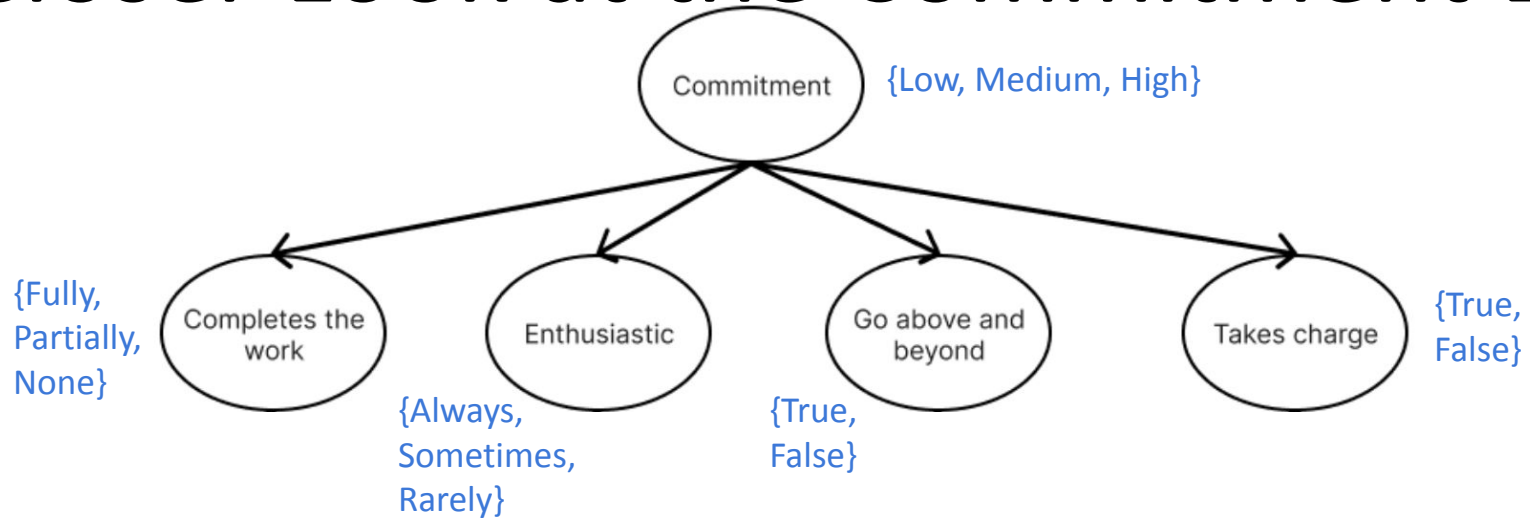
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A DBN Model of Commitment

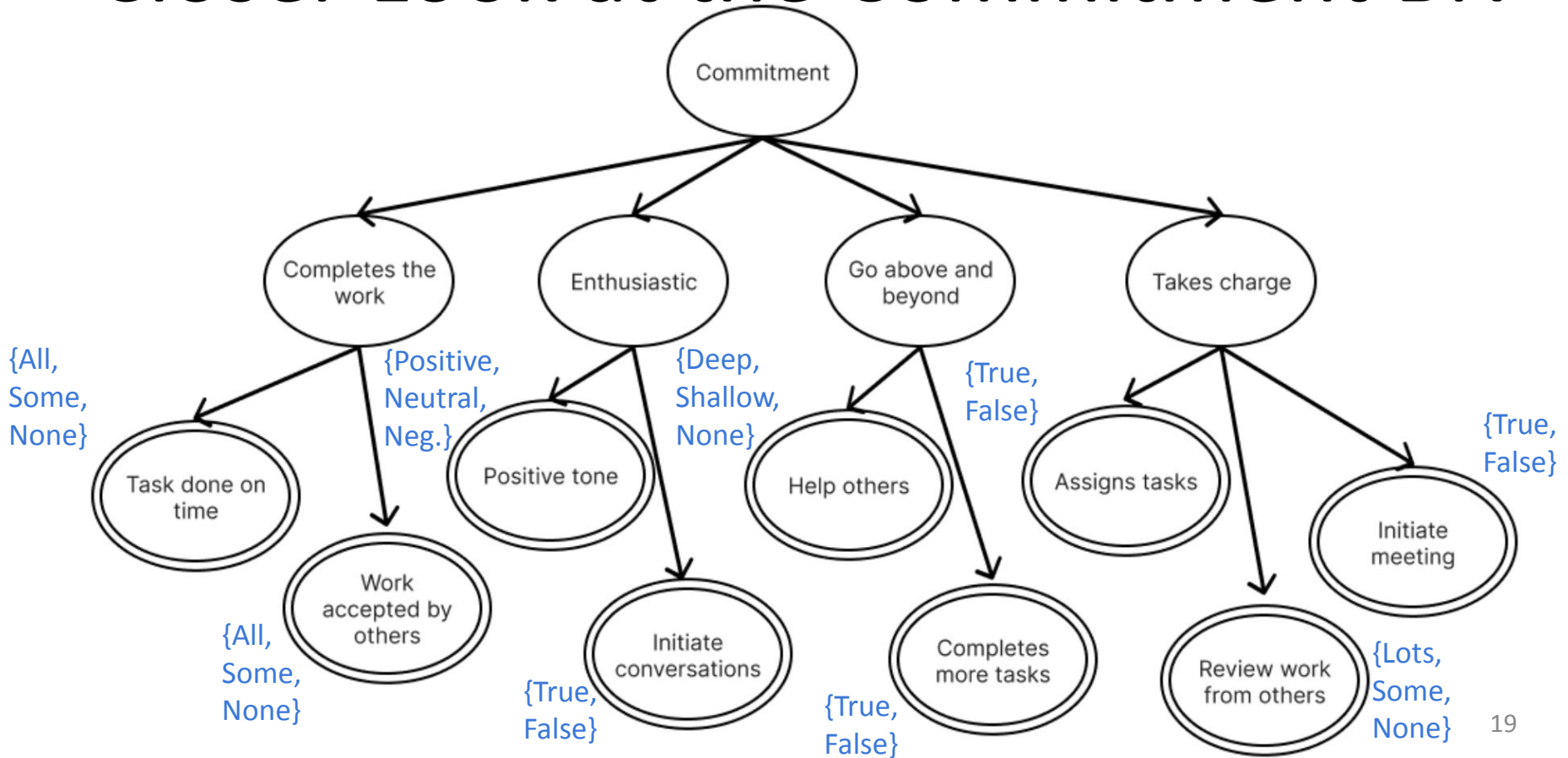


Closer Look at the Commitment BN



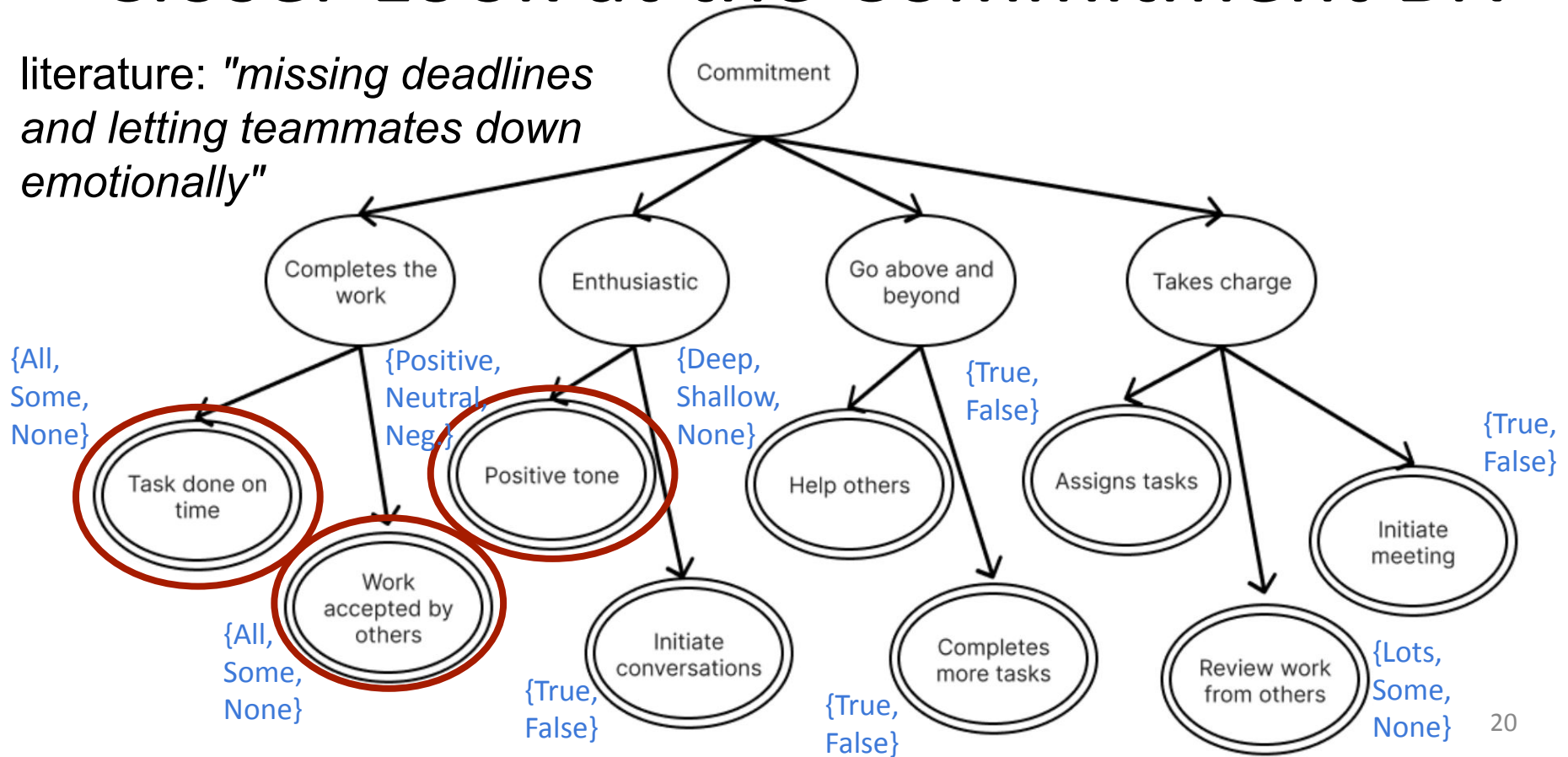
literature: *"feeling of responsibility for the team's work"*

Closer Look at the Commitment BN

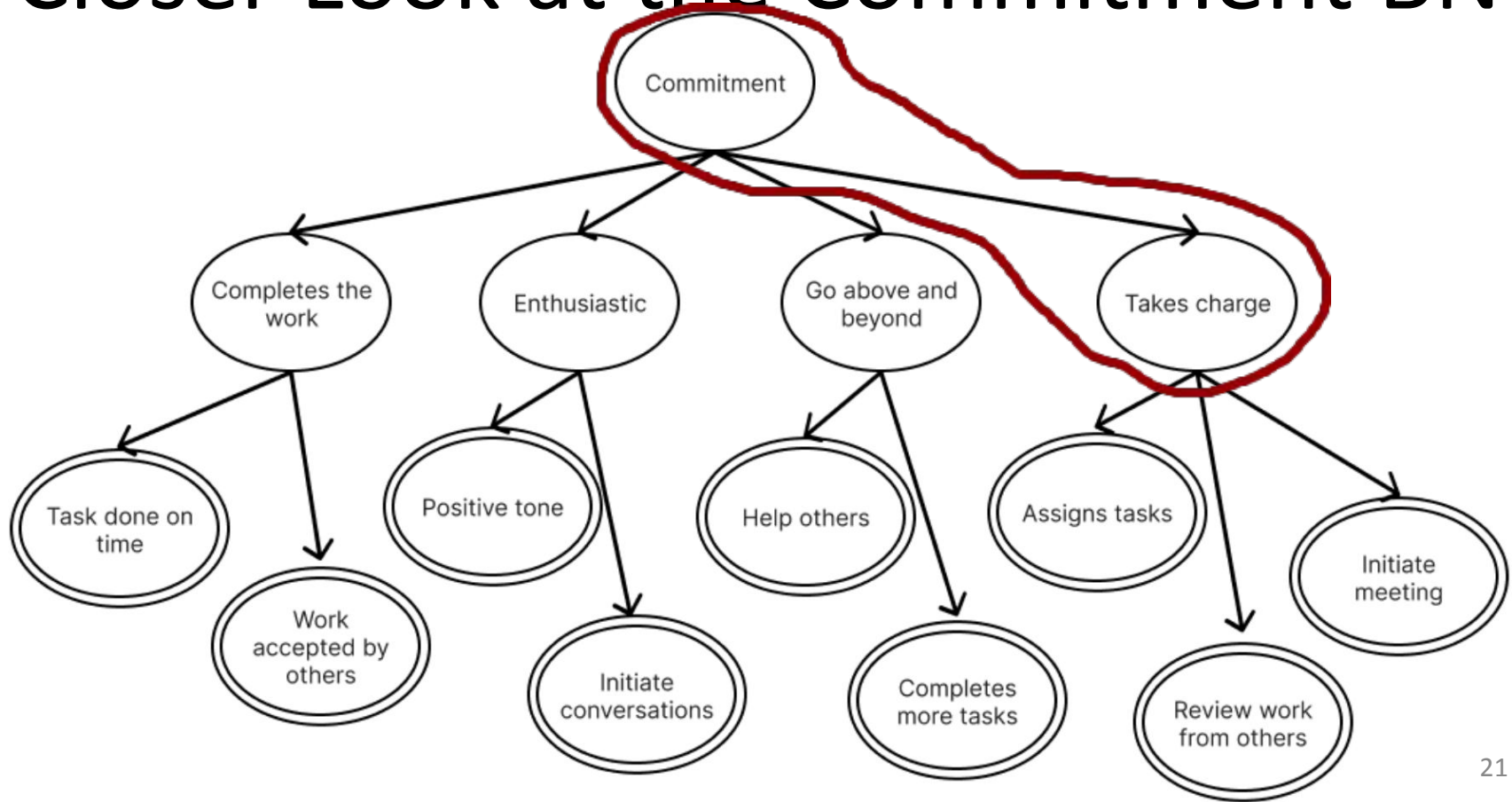


Closer Look at the Commitment BN

literature: *"missing deadlines and letting teammates down emotionally"*



Closer Look at the Commitment BN

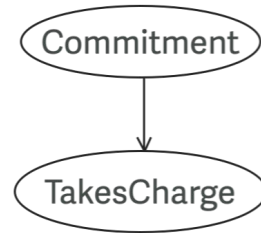


Example CPTs for Commitment

- Each row is a probability distribution
 - When parent value is known, what is the child distribution?

Pr(TakesCharge_t|Commitment_t):

	TakesCharge_t = true	TakesCharge_t = false
Commitment_t = low	0.01	0.99
Commitment_t = medium	0.20	0.80
Commitment_t = high	0.90	0.10

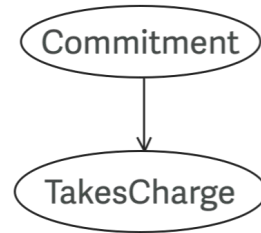


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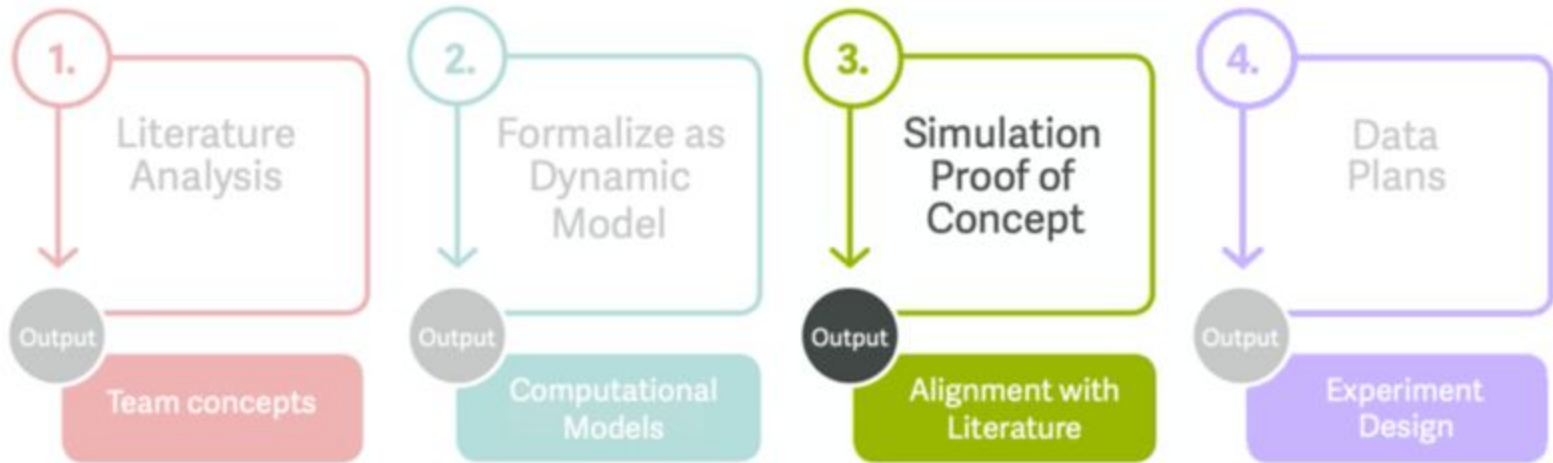
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- Parameters are currently handcrafted
 - Define user types and replicate descriptive theoretical behavior



Simulation Setup

- Python implementation with pgmpy package
 - Spans over 13-weeks
 - Results averaged over 100 trials
- Experiments:
 - #1: Evaluate inference accuracy
 - Create fixed behaviors of "prototypes"
 - Fed behaviors into DBN to infer commitment level
 - Check alignment with expectations of prototypes
 - #2: "Sensitivity analysis" of behavior distributions
 - Generated a series of behaviors from DBN
 - Check alignment to High vs. Low commitment individuals

Student Prototypes

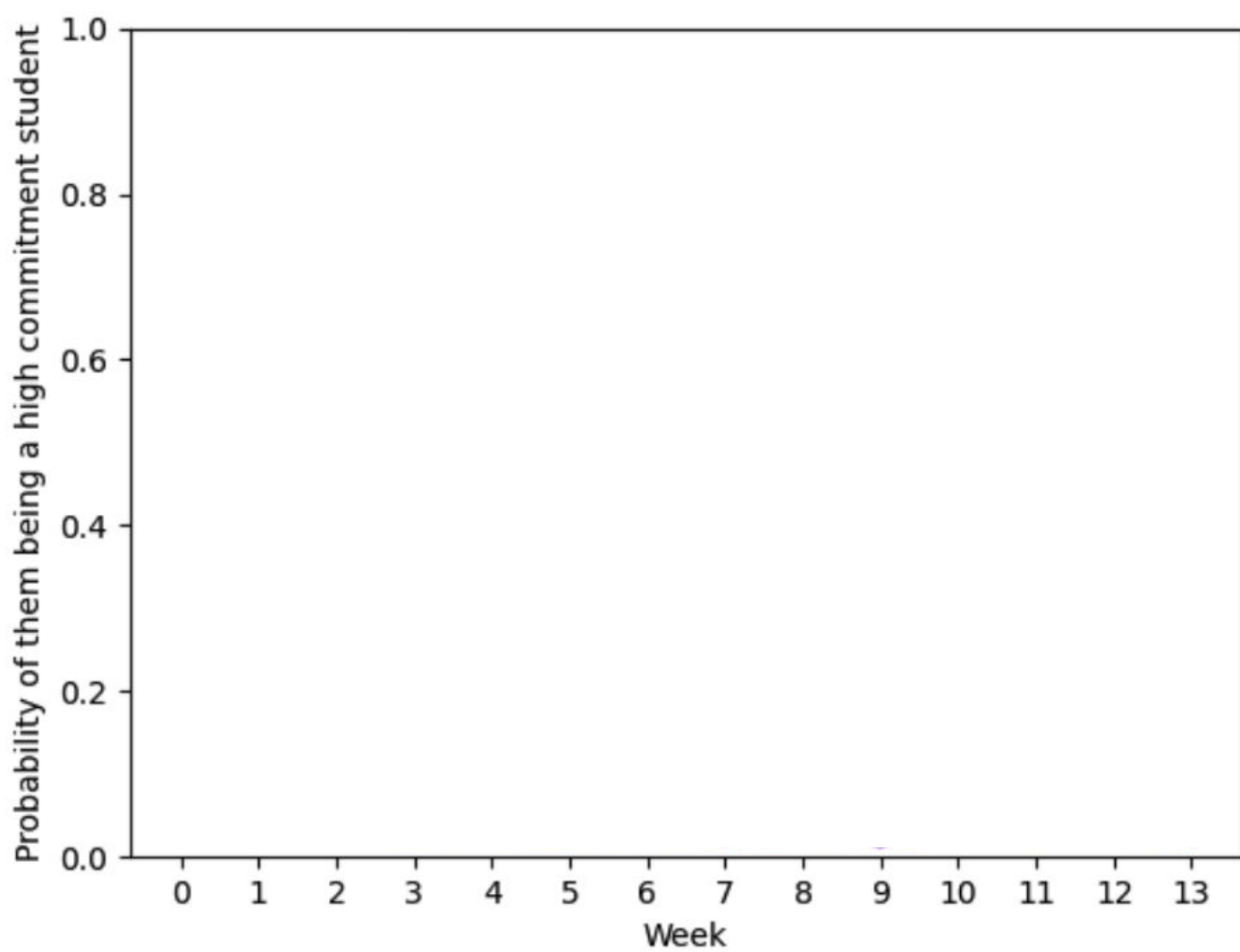
- **Student A:**
 - Gets all tasks done on time and helps others
- **Student B:**
 - Always positive, initiates conversations (~2 wks), initiates meetings (~3 wks)

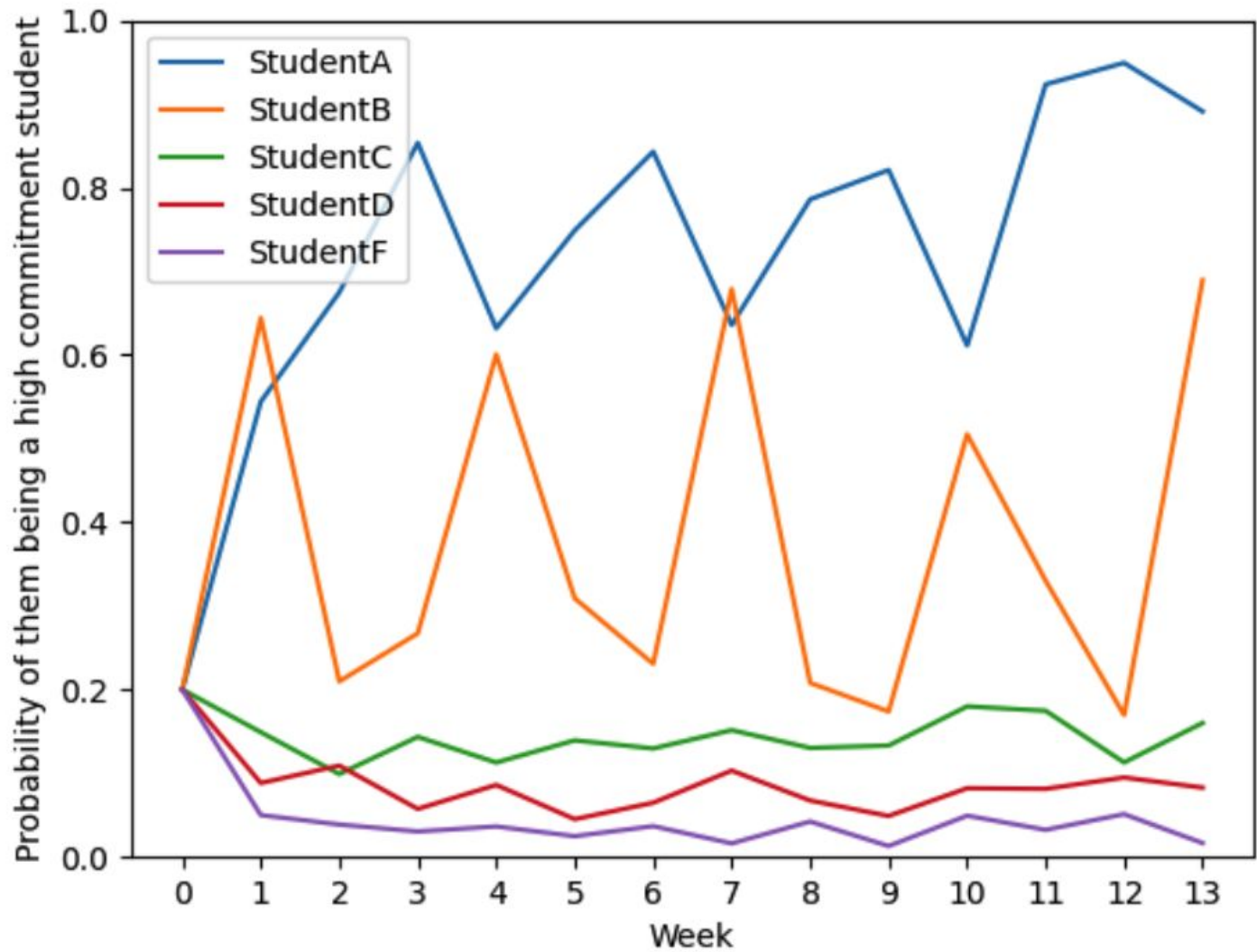
Student Prototypes

- **Student A:**
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- **Student C:**
 - Gets some tasks done, helps others superficially (~3 wks)
- **Student D:**
 - Gets some/no tasks done, work only partially accepted by others

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- **Student F:**
 - Never gets work done, always negative





strong
commitment

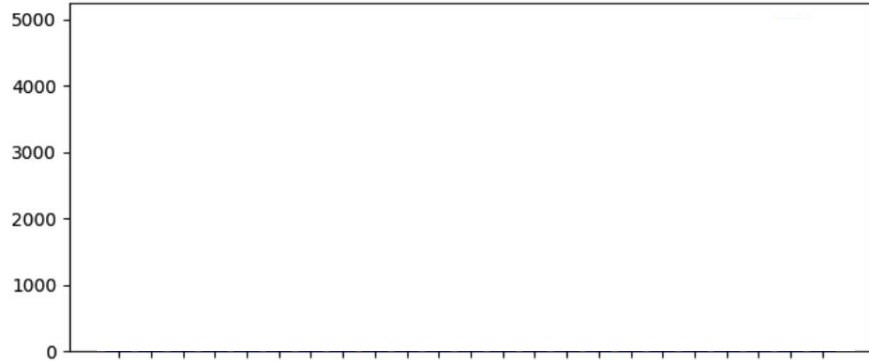
reasonable
commitment

low
commitment

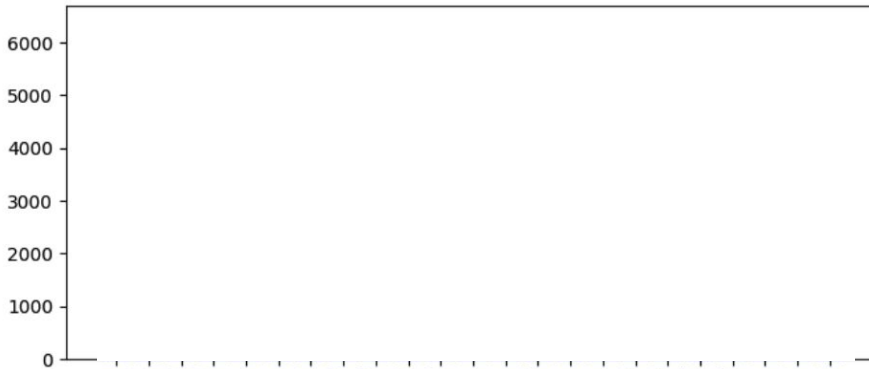
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Commitment
= High



Commitment
= Low

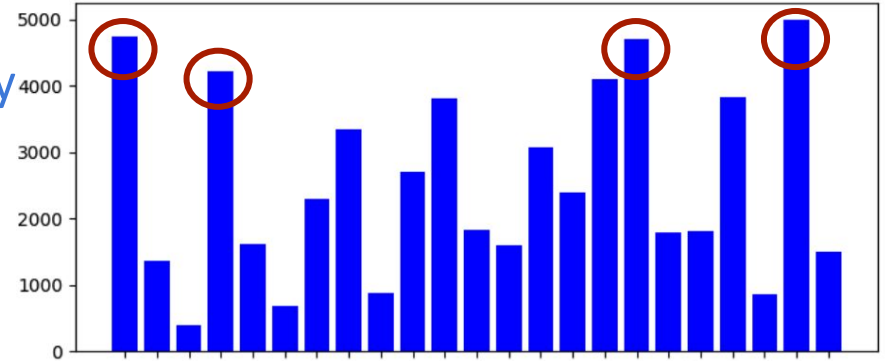


- Task done on time=all
- Task done on time=partial
- Task done on time=none
- Work accepted by others=all
- Work accepted by others=partial
- Work accepted by others=none
- Mostly Positive tone
- Mostly Neutral tone
- Mostly Negative tone
- Initiate conversations=true
- Initiate conversations=false
- Help others=deep
- Help others=shallow
- Help others=none
- Completes more tasks=true
- Completes more tasks=false
- Assigns tasks=true
- Assigns tasks=false
- Review work from others=alot
- Review work from others=some
- Review work from others=none
- Initiate meeting=true
- Initiate meeting=false

responsible:

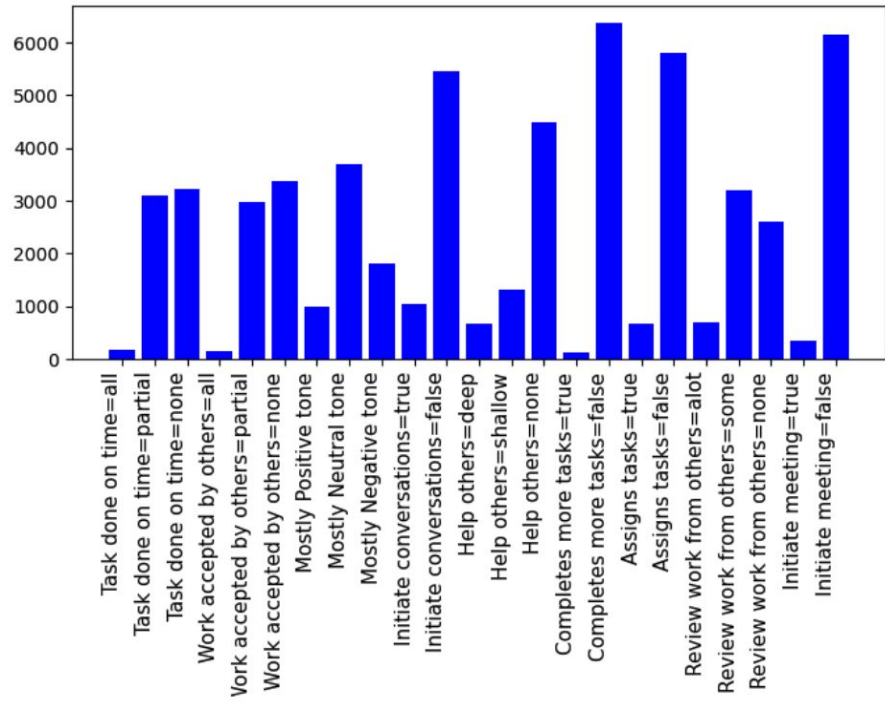
work on time, good quality

Commitment = High

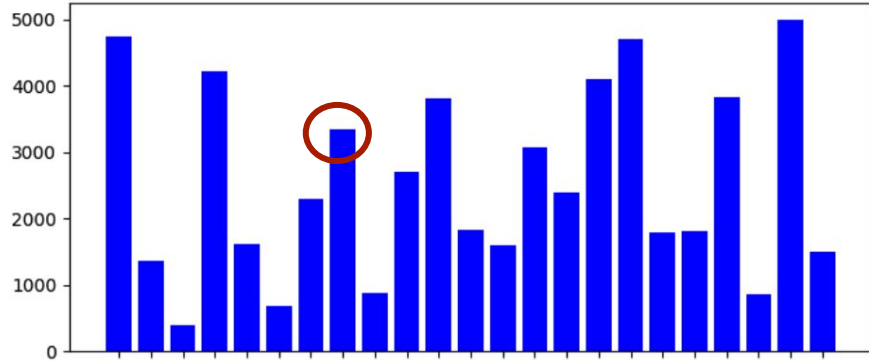


leadership:
assigns tasks,
initiate meetings

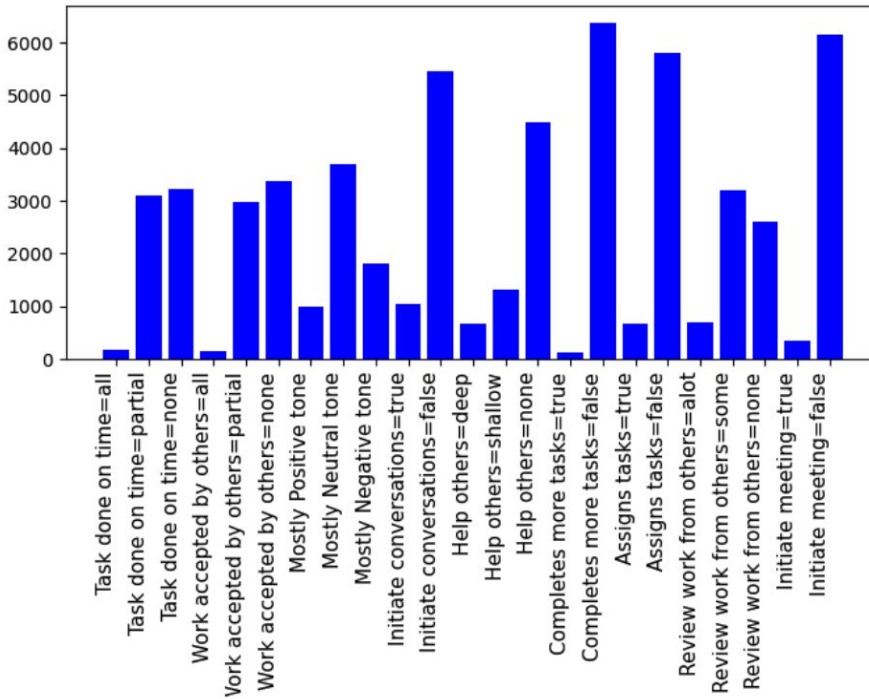
Commitment = Low



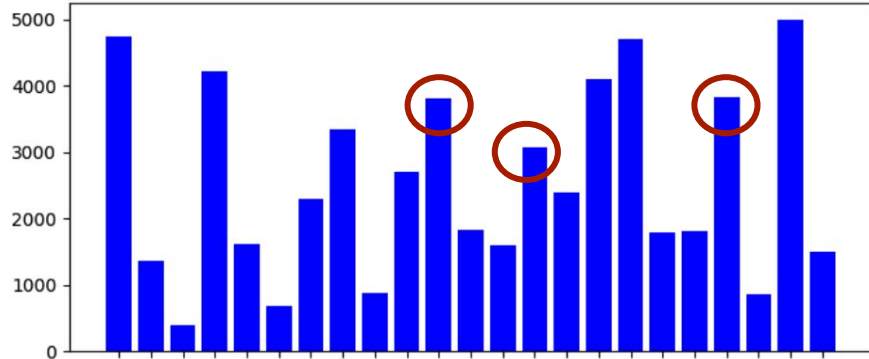
neutral > positive, negative
tone tone
Commitment
= High



Commitment
= Low

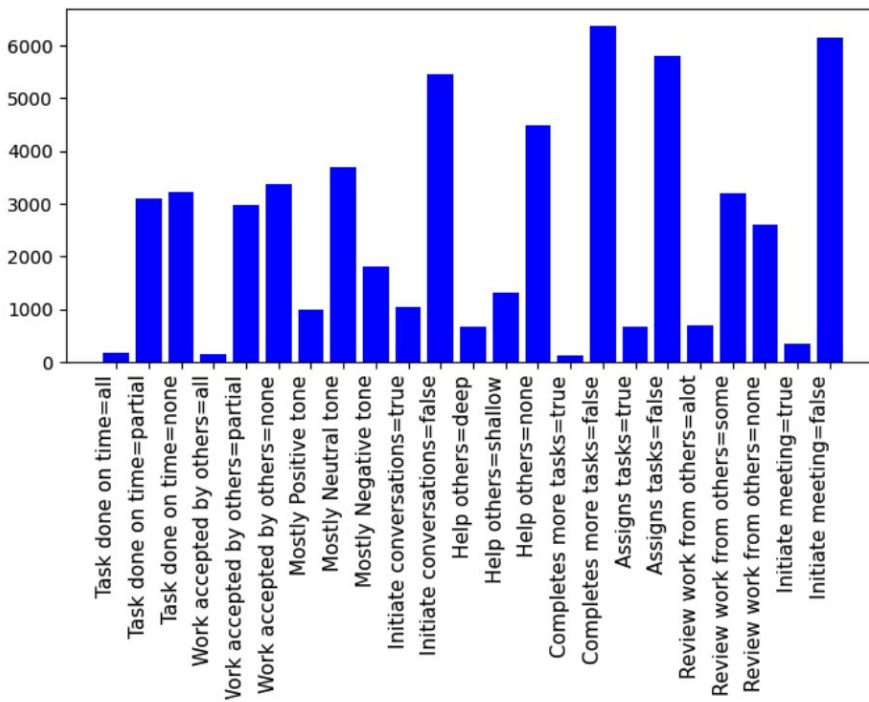


Commitment
= High

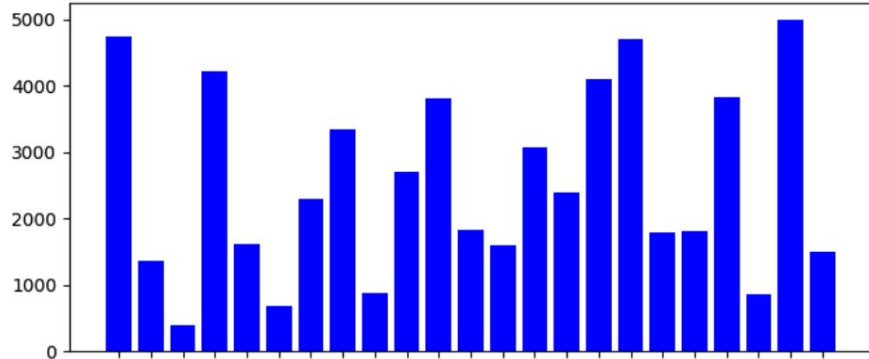


relation with
others plays a
less important
role

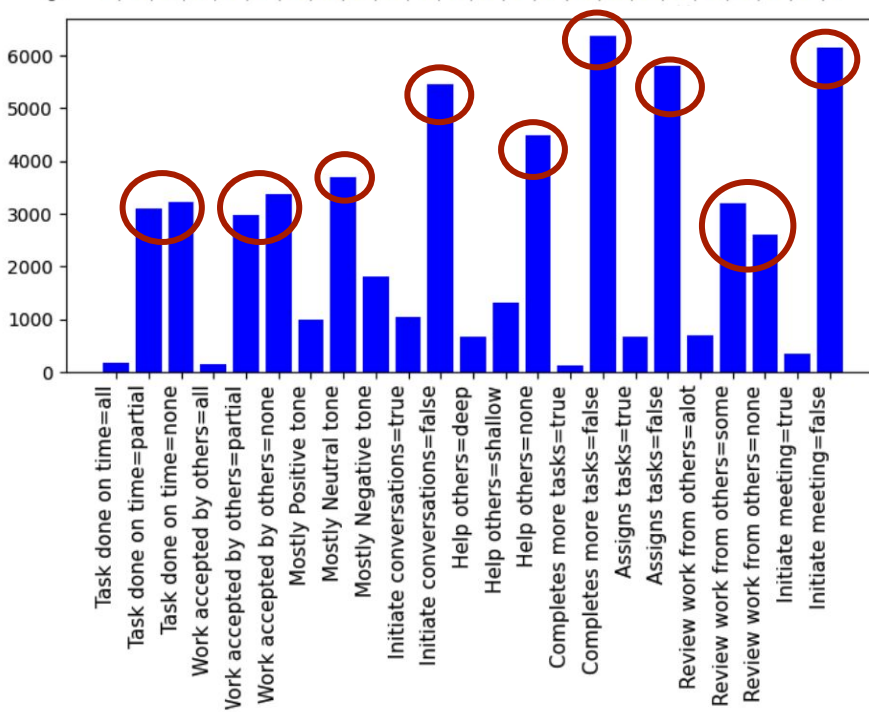
Commitment
= Low



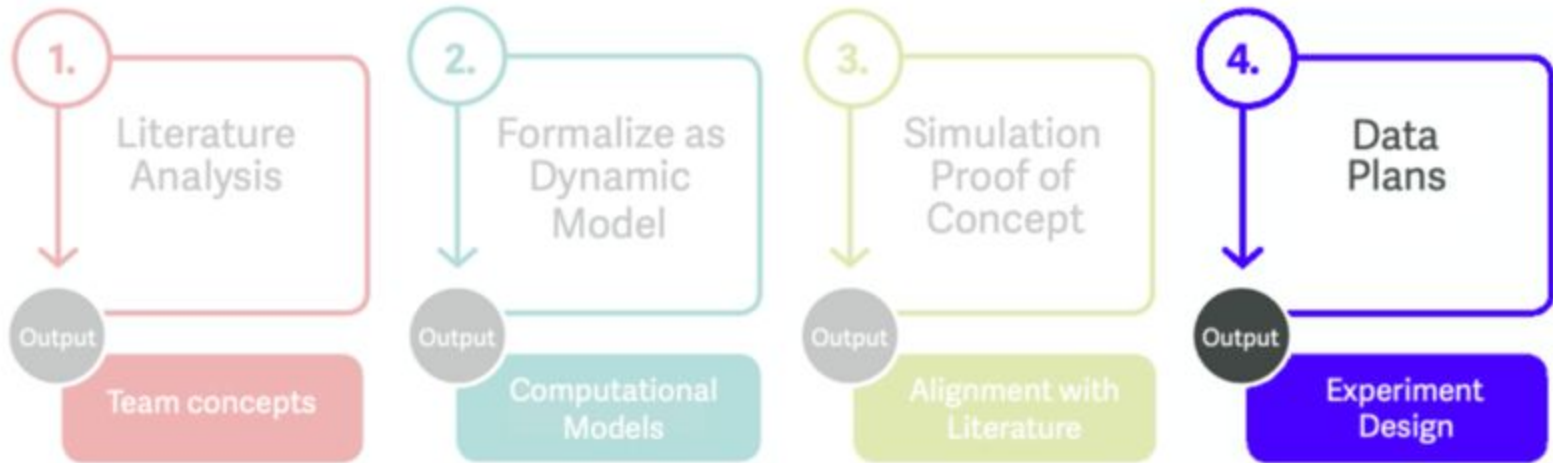
Commitment
= High



Commitment
= Low

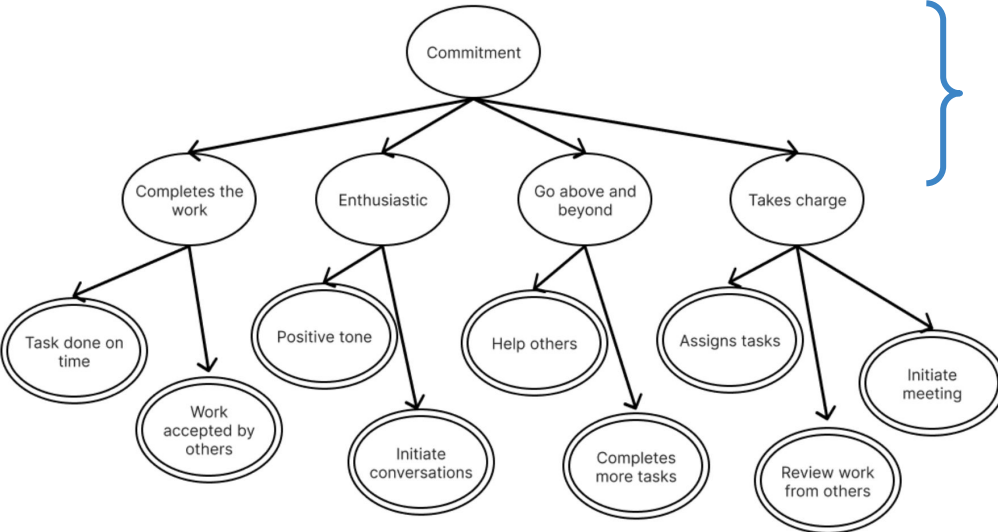


more neutral
or negative
behaviors



Data Needs

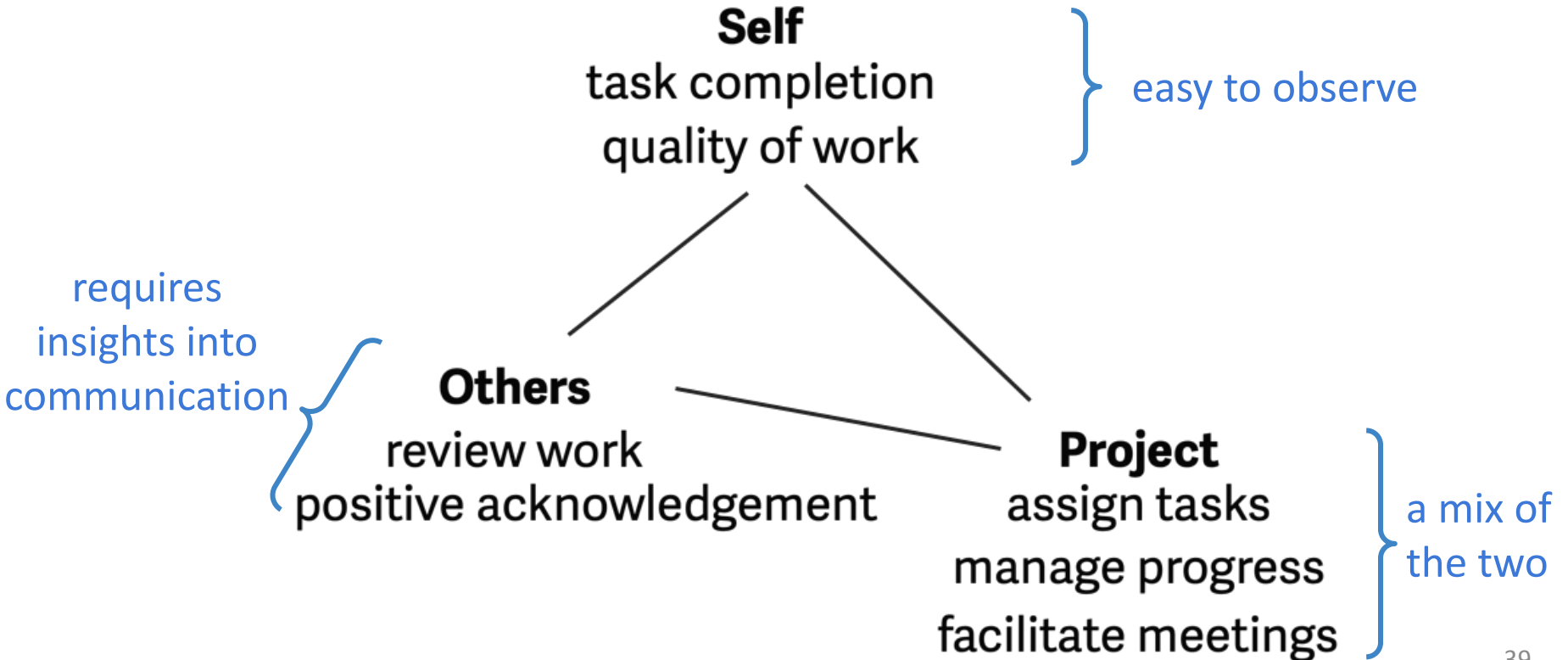
- Design controlled experiments or collect field data to populate CPTs
 - Every CPT is a quantitative relationship between two or more variables



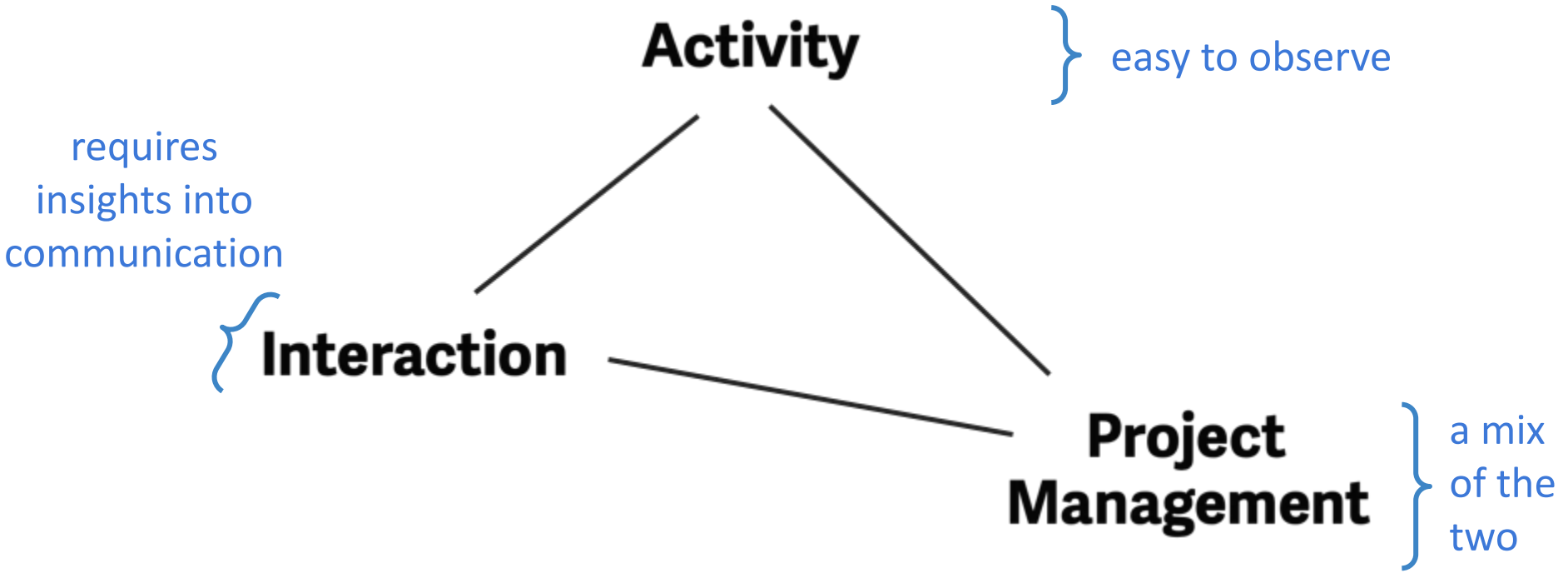
Survey: State your commitment level.
How likely are you to [type]

Survey: When you want to [type],
how likely are you to [action]
Empirical: Knowing you are [type],
count instances of each action

Insights on Data Needs



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Future Work

- Conducting data collection experiments on building **Activity** and observable **Project Management** relationships



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- Further investigation on observing natural behaviors for **Interaction**
 - Most teamwork interactions do not happen in class
 - Studies that work on this are conducted in controlled, short settings



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- Conducting data collection experiments on building **Activity** and observable **Project Management** relationships
- Further investigation on observing natural behaviors for **Interaction**
 - Most teamwork interactions do not happen in class
 - Studies that work on this are conducted in controlled, short settings
- Long-term goal: ongoing team monitoring
 - Recall our vision: Support management process with alerts of problematic behaviors so to take interventions early