Insights on Enacting Critical Statistical Literacy Habits of Mind

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but before we start,

but before we start,
thank you!

- How do you imagine that preservice secondary mathematics teachers (PSMTs) would make sense of this graph?
- What might PSMTs notice and wonder?
- How do you anticipate PSMTs will address (or not) issues of power and privilege?

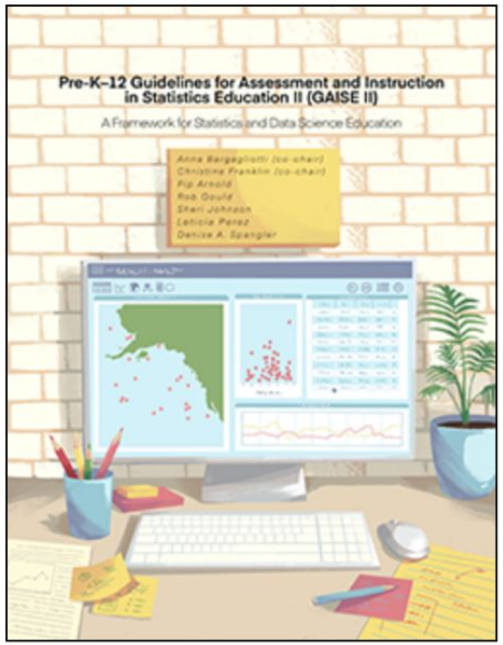

data

(Duckworth, n.d.)

Guidelines for Assessment and Instruction in Statistics Education (GAISE) Reports

Participants in the Guidelines for Assessment and Instruction in Statistics Education (GAISE) project have created two reports of recommendations for introductory statistics courses (college level) and statistics education in Pre-K–12 years.

Pre-K–12 Report



College Report

PUBLIC SCHOOLS OF NORTH CAROLINA
State Board of Education | Department of Public Instruction

North Carolina Standard Course of Study
North Carolina Math 4

Note on Numbering:
North Carolina Math 4 (NC.M4) Number and Quantity (N) Algebra & Functions (AF) Statistics and Probability (SP)

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Statistics and Probability

NC.M4.SP.1 Create statistical investigations to make sense of real-world phenomena.	
NC.M4.SP.1.1	Construct statistical questions to guide explorations of data in context.
NC.M4.SP.1.2	Design sample surveys and comparative experiments using sampling methods to collect and analyze data to answer a statistical question.
NC.M4.SP.1.3	Organize large datasets of real-world contexts (i.e. datasets that include 3 or more measures and have sample sizes >200) using technology (e.g., spreadsheets, dynamic data analysis tools) to determine: types of variables in the data set, possible outcomes for each variable, statistical questions that could be asked of the data, and types of numerical and graphical summaries could be used to make sense of the data.
NC.M4.SP.1.4	Interpret non-standard data visualizations from the media or scientific papers to make sense of real-world phenomena.

Catalyzing Change in High School Mathematics

Initiating Critical Conversations

NCTM®
NATIONAL COUNCIL OF TEACHERS OF MATHEMATICS

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"Students should become critical consumers of statistically-based results reported in popular media, recognizing whether reported results reasonably follow from the study and analysis conducted." (Carver et al., 2016)

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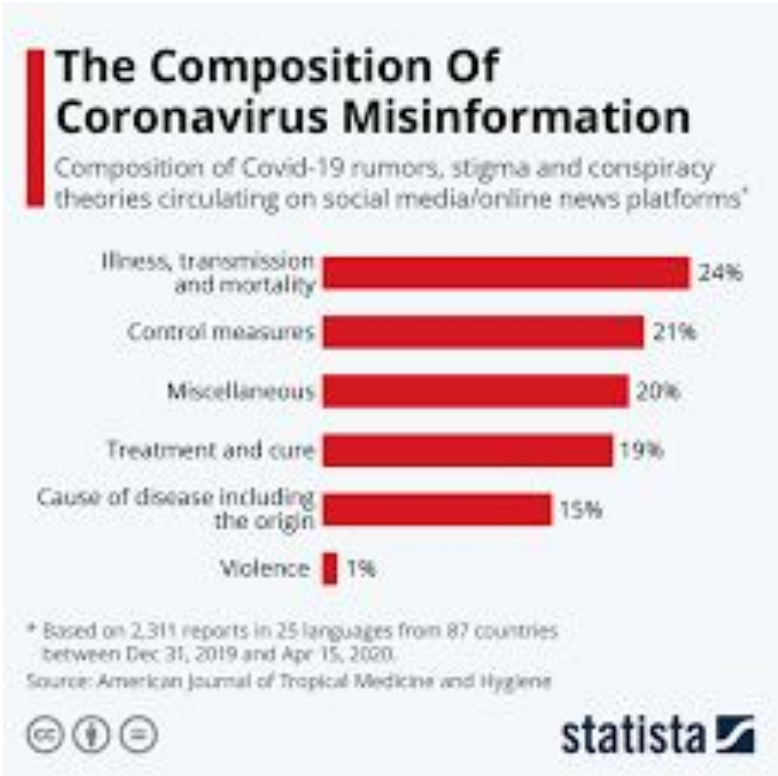
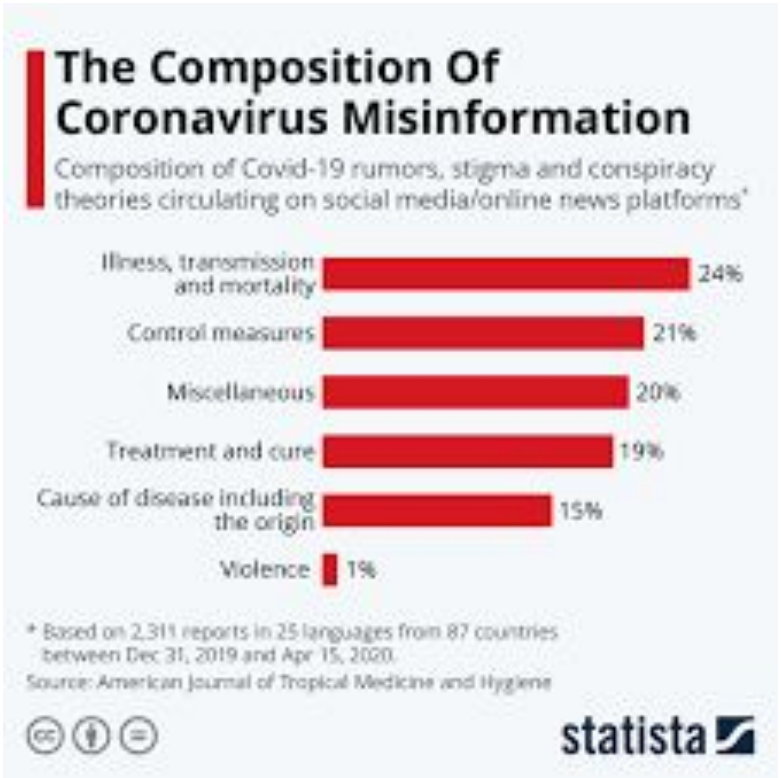

The Composition Of Coronavirus Misinformation
Composition of Covid-19 rumors, stigma and conspiracy theories circulating on social media/online news platforms*
Illness, transmission and mortality
24%
Control measures
21%
Miscellaneous
20%
Treatment and cure
19%
Cause of disease including the origin
15%
Violence
1%
* Based on 2,311 reports in 25 languages from 87 countries between Dec 31, 2019 and Apr 15, 2020.
Source: American Journal of Tropical Medicine and Hygiene
statista


Misinformation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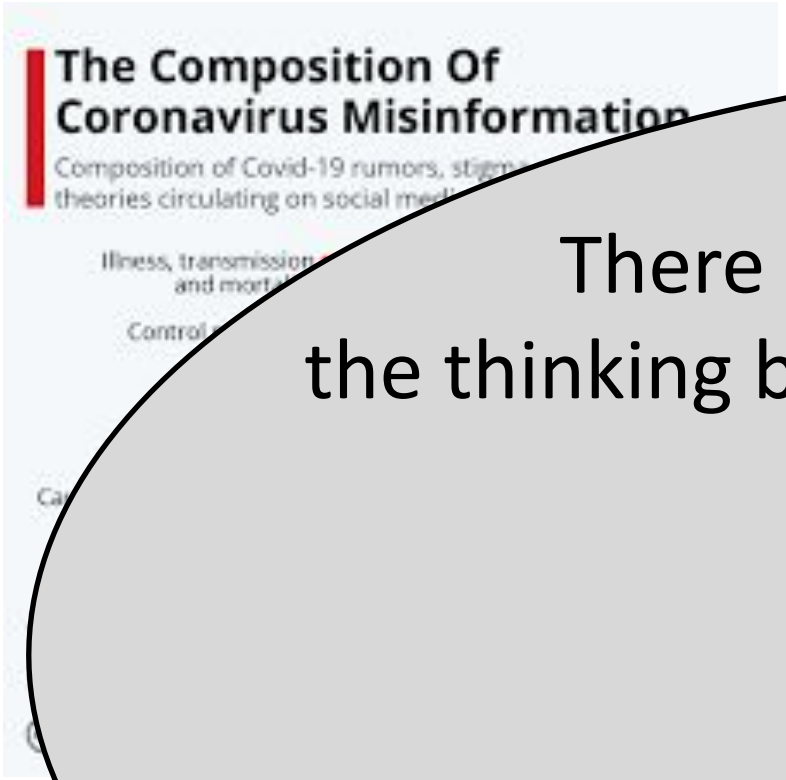
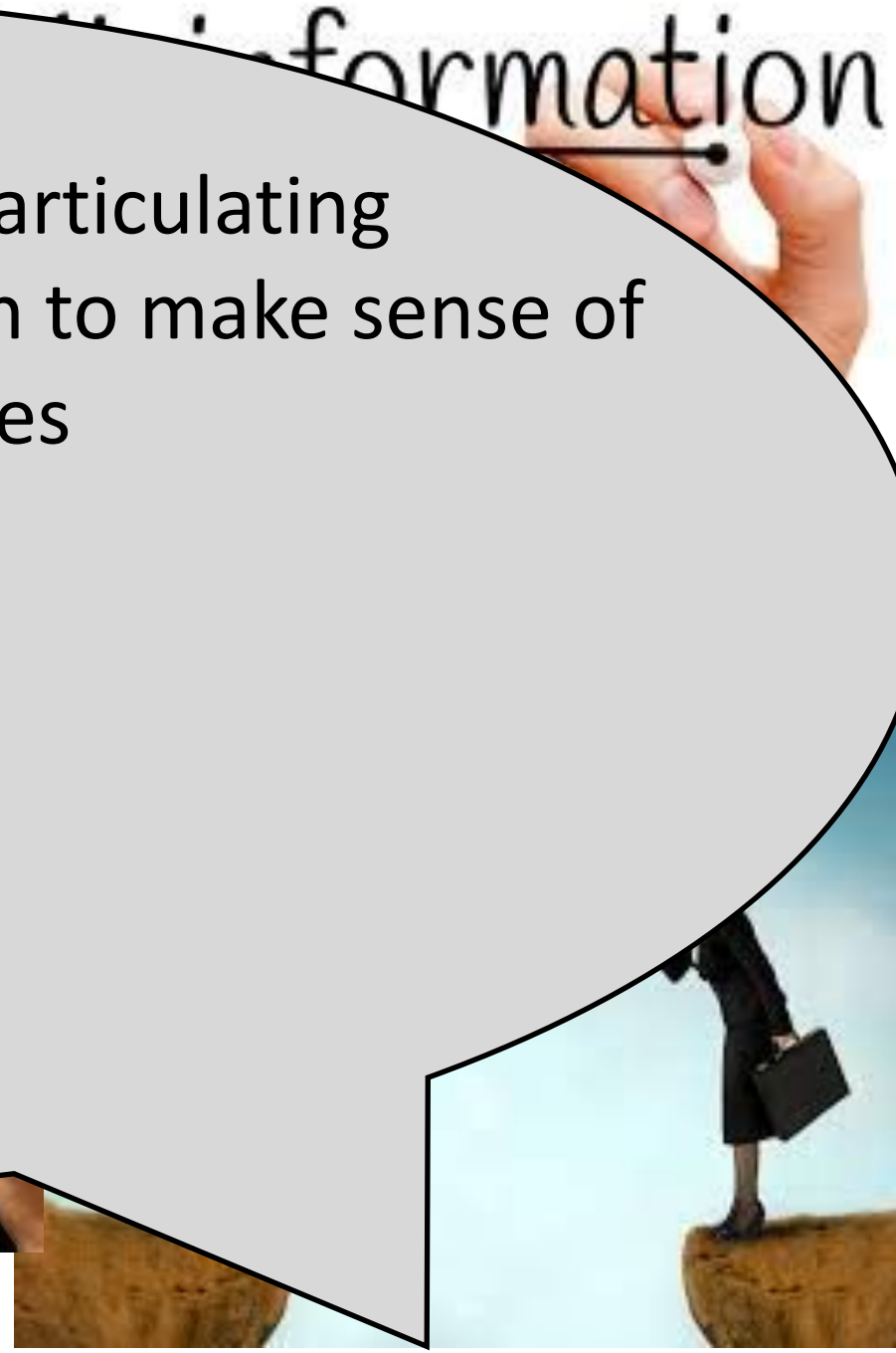
Misinformation
FAKE
FACT

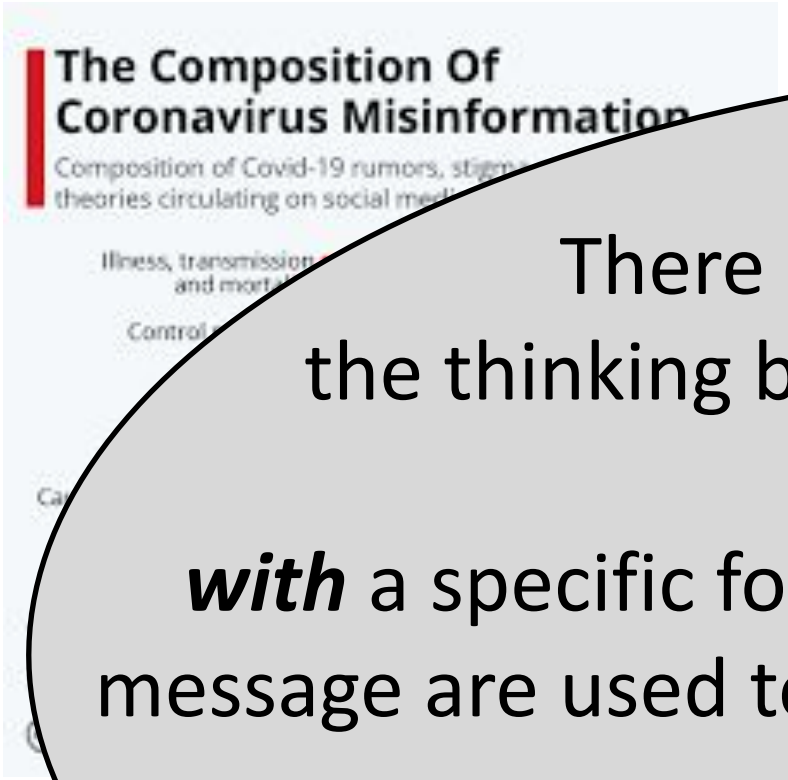

American Distrust
Deepens Divide

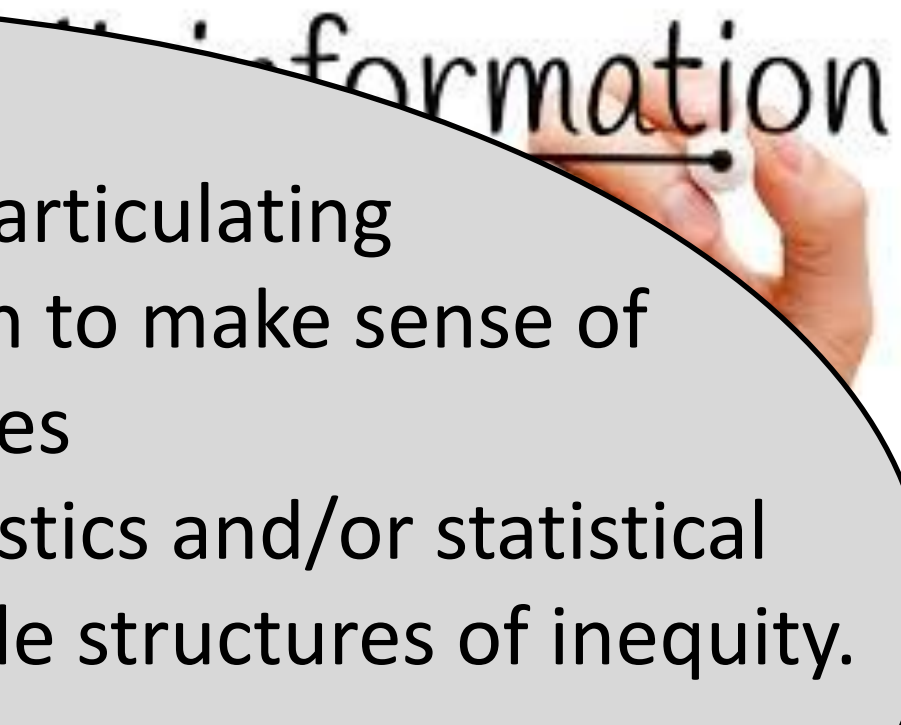

FAKE NEWS
FACTS





There is a need for clearly articulating
the thinking behaviors called upon to make sense of
statistical messages





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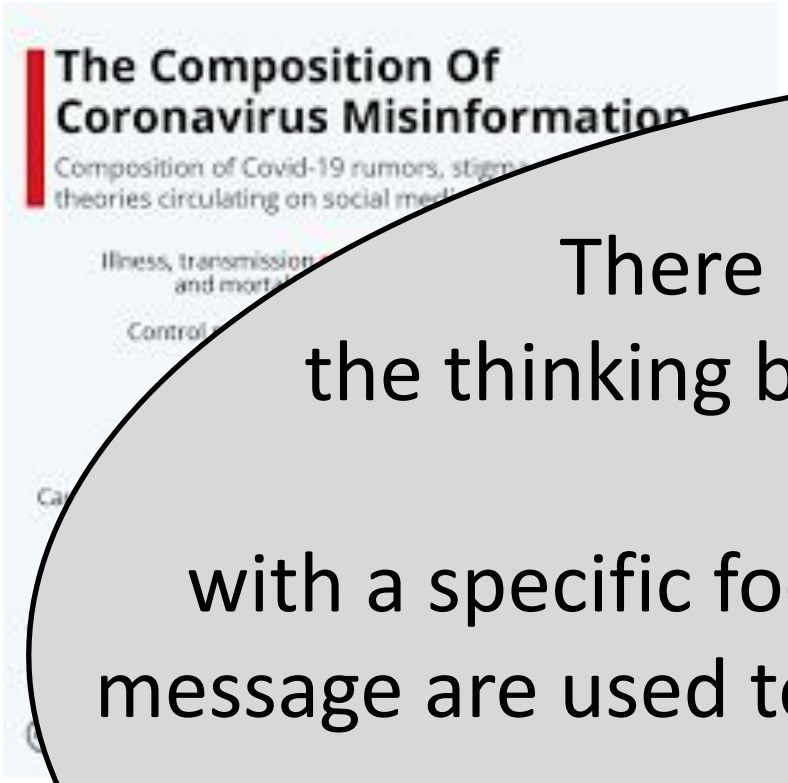

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also known as

Critical Statistical Literacy Habits of Mind (CSLHM)

Overview of some of my past and current CSLHM Work

3-Article Dissertation

- **The CSLHM Framework Article**
- **PSMT CSLHM Enactment Article**
- **PSMT Comparison Article**

Adult CSLHM Enactment - Dr. Karie Smucker, Montclair doctoral student Asja Alic, and I aim to explore how the general adult population enacts CSLHM.

Developing CSLHM among HS students

Brief Background on the Framework: Critical Statistical Literacy Habits of Mind

Creating the Framework:
Using Interview Data to Refine the Framework

Semi-structured task-based interviews

(Goldin, 2000)

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- asked to share what they would discuss with a confidant with similar beliefs if they were talking about this tweet

Creating the Framework:
Using Interview Data to Refine the Framework

Semi-structured task based interviews

(Goldin, 2000)

- presented with a tweet and data representation
- directed to think aloud
- asked to share what they would discuss with a confidant with similar beliefs if they were talking about this tweet
- asked the same question but with a confidant with dissimilar beliefs

The Tasks: 6 Tweets

- Perception of police (Purcell 2017)
- BLM (JordanUhl 2021)
- Gender wage gap (Butwell, 2020)
- Systemic racism (Mobley, 2020)
- Hate crimes (Krugman, 2020)
- Covid and education (DeSantis, 2021)

Creating the Framework:
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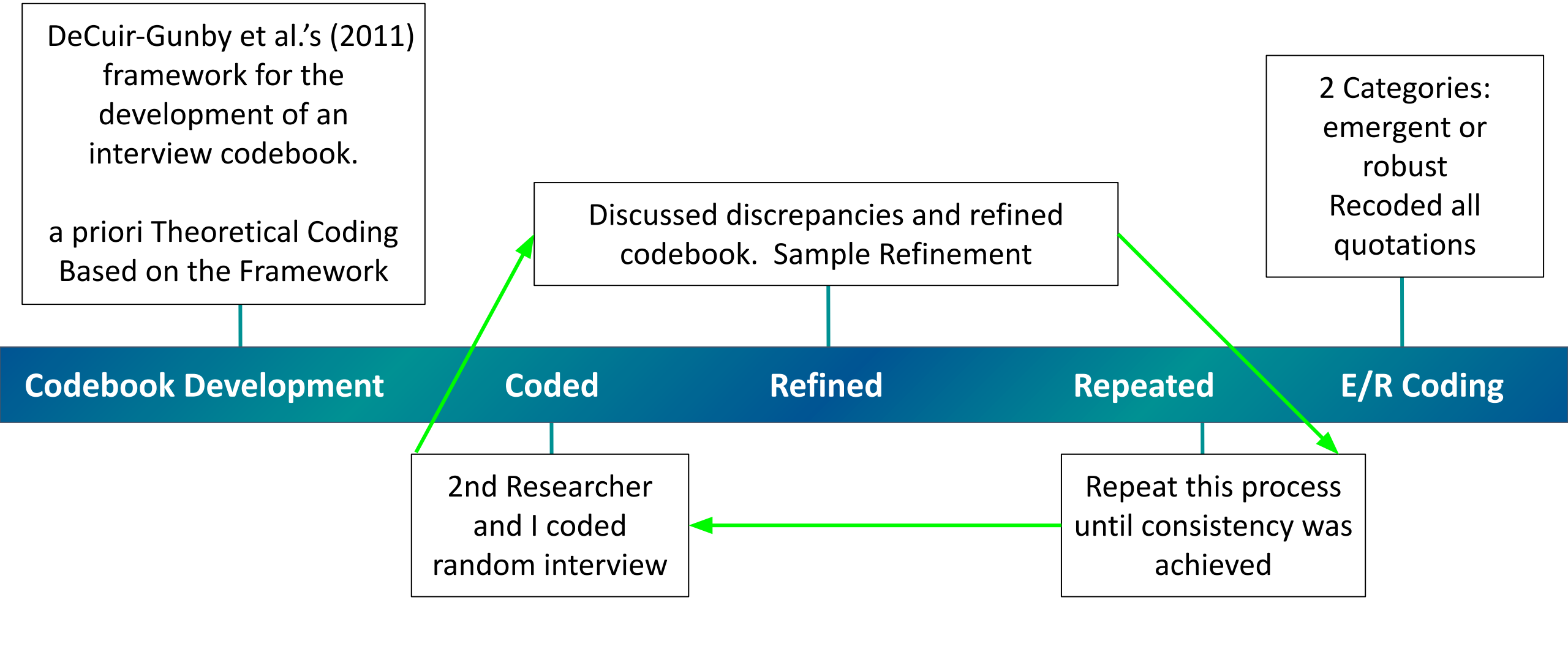

CSLHM

(1) questioning sample size and methods

(2) recognizing appropriate statistics and appropriate representations

(3) desiring additional information

(4) acknowledging alternate explanations

(5) recognition of one's own sociopolitical/critical consciousness

(6) employing active citizenry

CSLHM

Questioning Sample Size/Methods		
Description	**Emergent Guiding Questions**	**Robust Guiding Questions**
Individual demonstrates healthy skepticism regarding the sample, sample size, sampling technique, sampling bias, or lack of information regarding sampling that may lead to invalid inference on a target population. This includes considering who is missing, why, and how that influences the statistical message and the generalizability of the results, and the potential power of the message.	1. Were the sampling methods discussed? 2. Who was sampled and why? 3. How many were sampled? 4. The sample feels biased. 5. Were measures taken to reduce bias? 6. The sample was too small/ /large/convenient? 7. Discuss "cherry picking" without explicitly considering representation within the sample. 8. Where are the people in the sample from?	1. Were the sampling methods discussed? AND if not, why? 2. Who was sampled and why? AND Who is missing and why? Does that influence the results? 3. Could non-response or other sampling issues influence this data or the generalizability of the results? 4. How many were sampled AND why? 5. Were measures taken to reduce bias? 6. Was the sample too small? Too large? Convenient? AND why this matters? 7. Is the sample representative of the population? AND/OR was the sample intentionally selected to create a statistical message that misleads or deceives? 8. Where are the people in the sample from? Where is the data from? Who is the source, and do I trust them? (*Note*: questioning the data and source in these questions refers to the people/sample being studied)

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Very Brief Example
Desiring Additional Information

Emergent Quotation	
What time period was this? And so, before I can, we can have a real conversation. You would have to know certain things.	

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What time period was this? And so, before I can, we can have a real conversation. You would have to know certain things.	

general wonderment, such as

“why did they do this?”

“when did this happen?”

Very Brief Example
Desiring Additional Information

Emergent Quotation	**Robust Quotation**
What time period was this? And so, before I can, we can have a real conversation. You would have to know certain things.	I'm not sure what timespan it's for, because it would have to be some sort of time series data to go from, grew up rich to what they are as an adult. And all I see down here is “adult outcomes reflect household incomes in 2014 and 15”. **I would imagine they would have had to have traced back to, to make sense of that. So, I'm not sure like how far back they went**. Um, so that starts to **raise questions of methodology of where this came from**.

Very Brief Example
Desiring Additional Information

wonderment about the timeline with respect to how far back the data went since the representation lacked specific information about the time points

	Robust Quotation
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PSMT Enactment

Research Question

- How do PSMTs enact CSLHM when presented with data representations from the media?

Participants

- All 17 preservice secondary (middle and high) mathematics teachers
- Recruited from 4-year universities in the southeast
- Taking senior math methods at time

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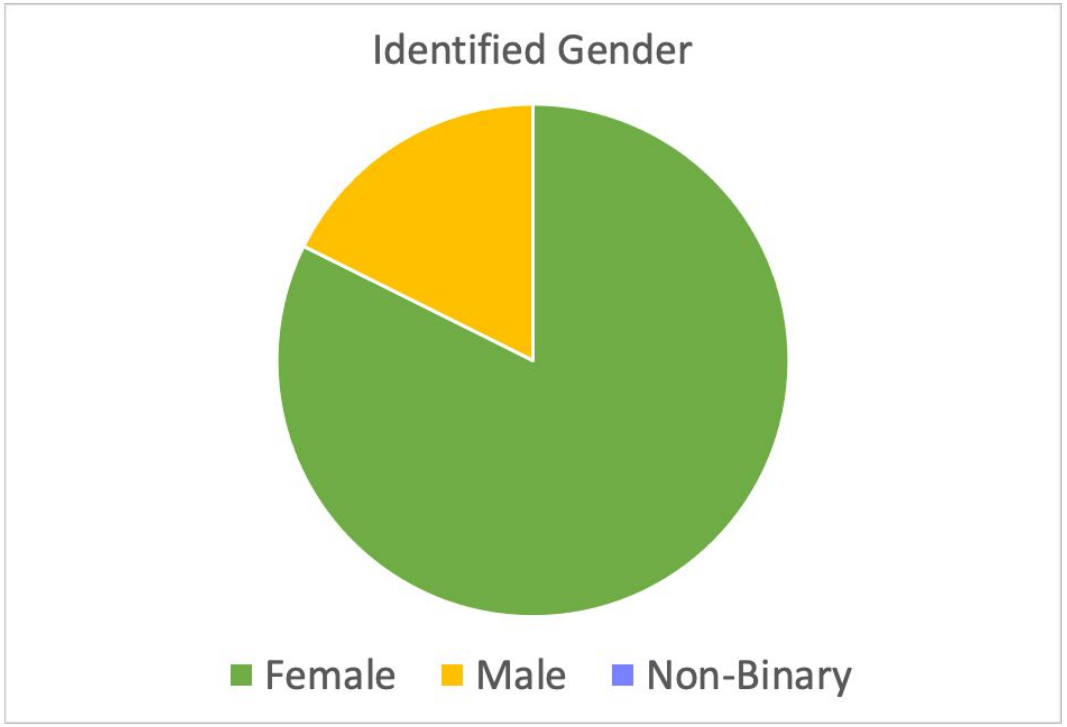
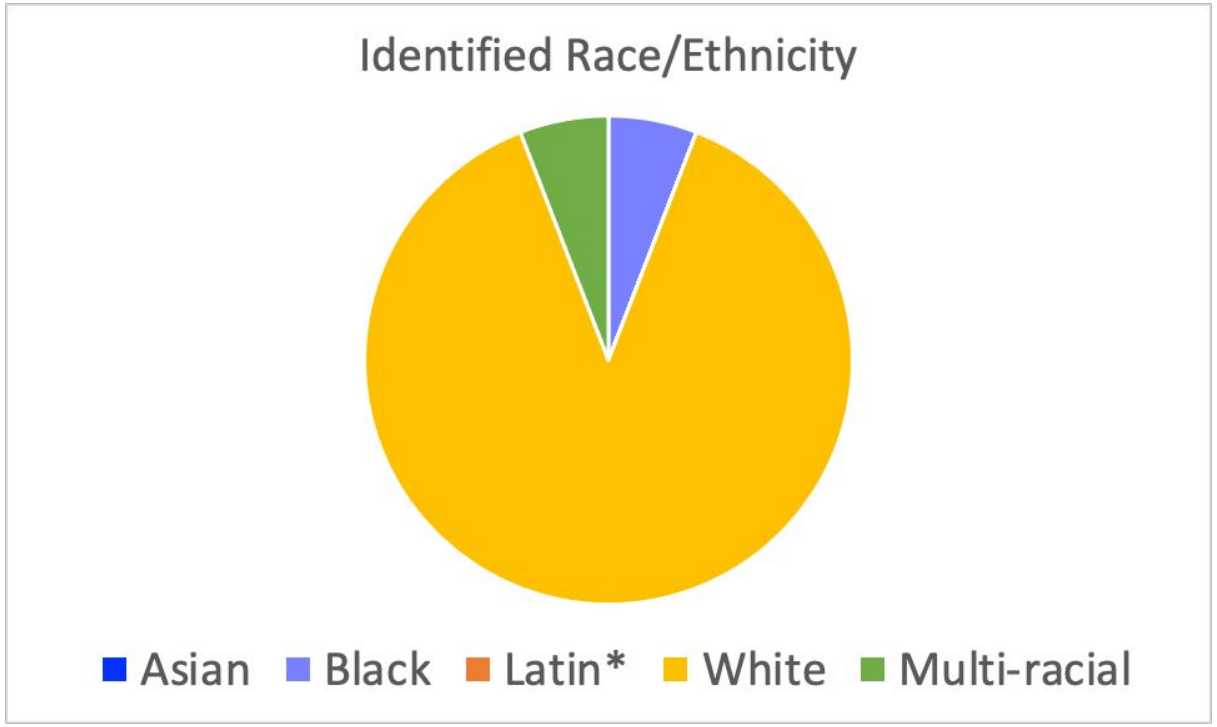
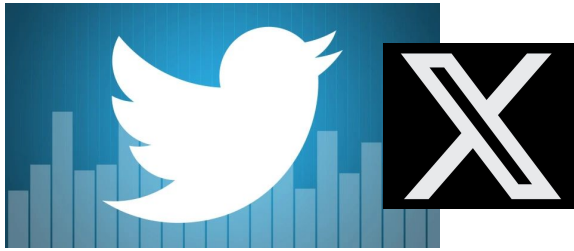




Data Collection



Recruited PSTs → Initial Survey → LOCUS Assessment → Semi-Structured Interview (Goldin, 2000) → 6 Tasks/Tweets (Order Randomized)

Stage 1 Analysis

a priori theoretical coding using CSLHM descriptions(DeCuir-Gunby et al., 2011)

a priori Theoretical Coding

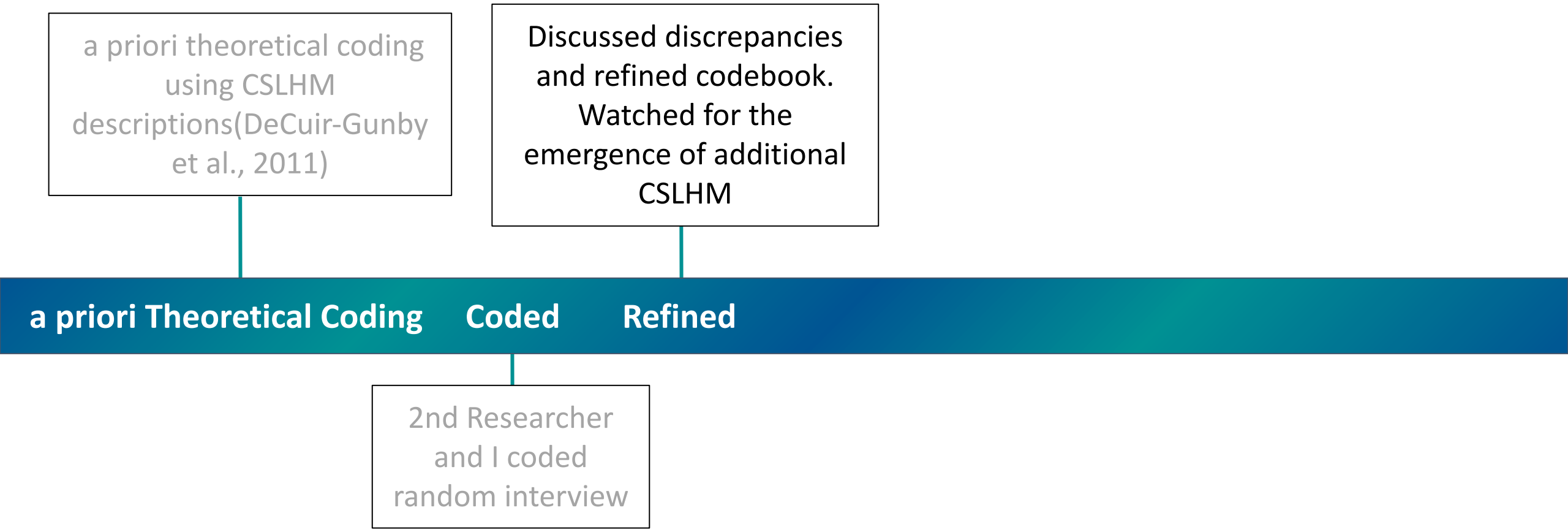
Stage 1 Analysis

a priori theoretical coding using CSLHM descriptions(DeCuir-Gunby et al., 2011)

a priori Theoretical Coding **Coded**

2nd Researcher and I coded random interview

Stage 1 Analysis



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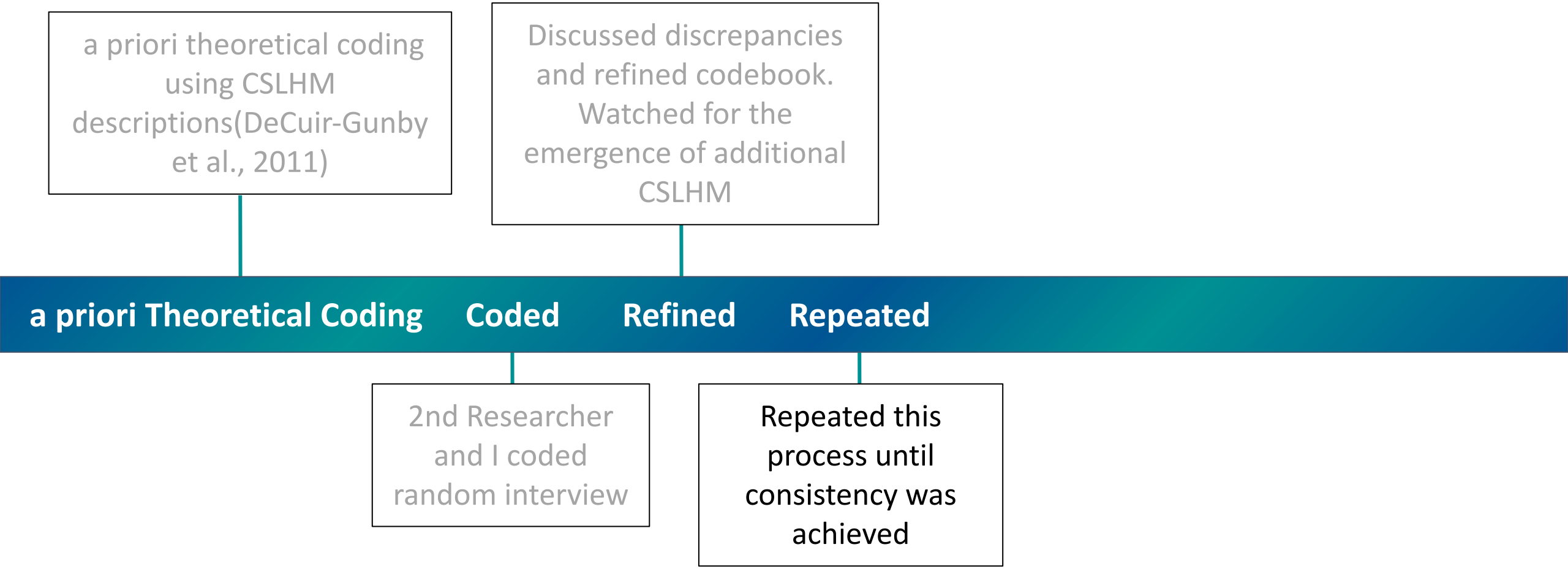

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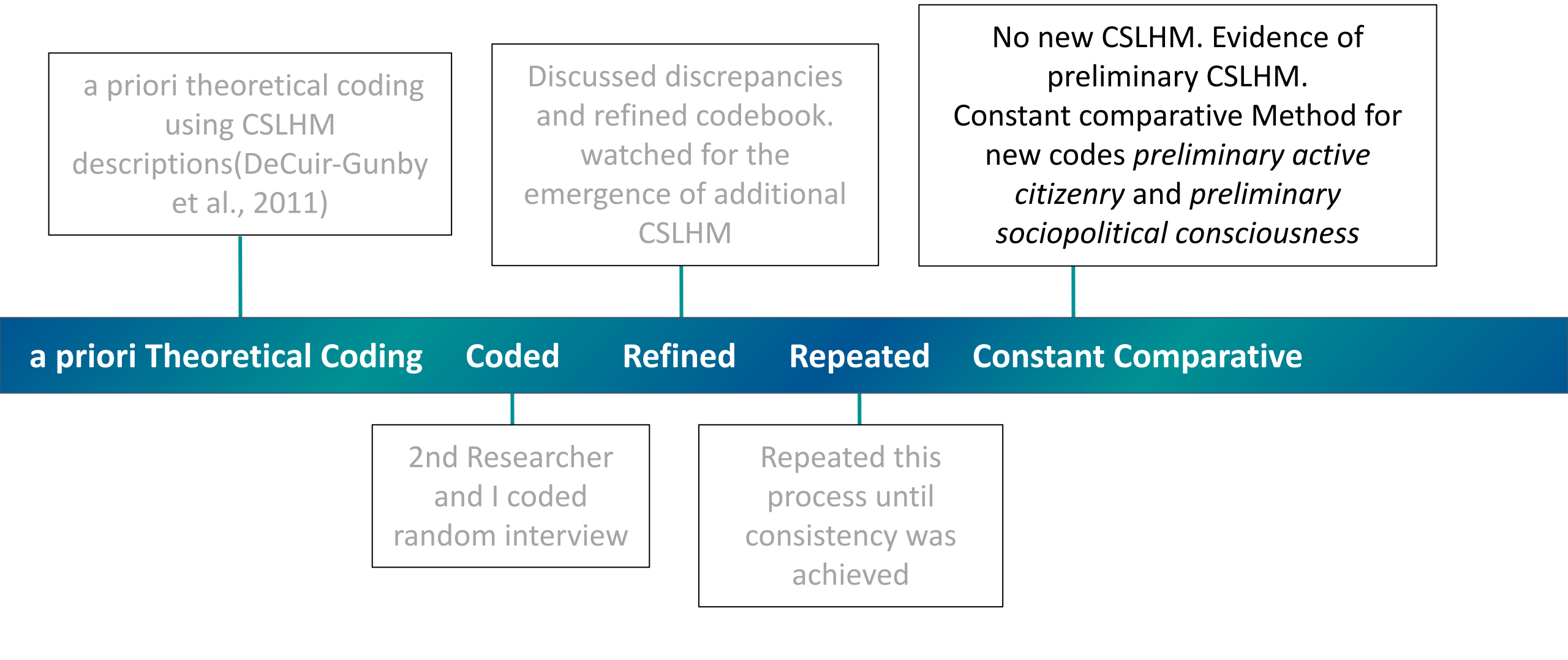

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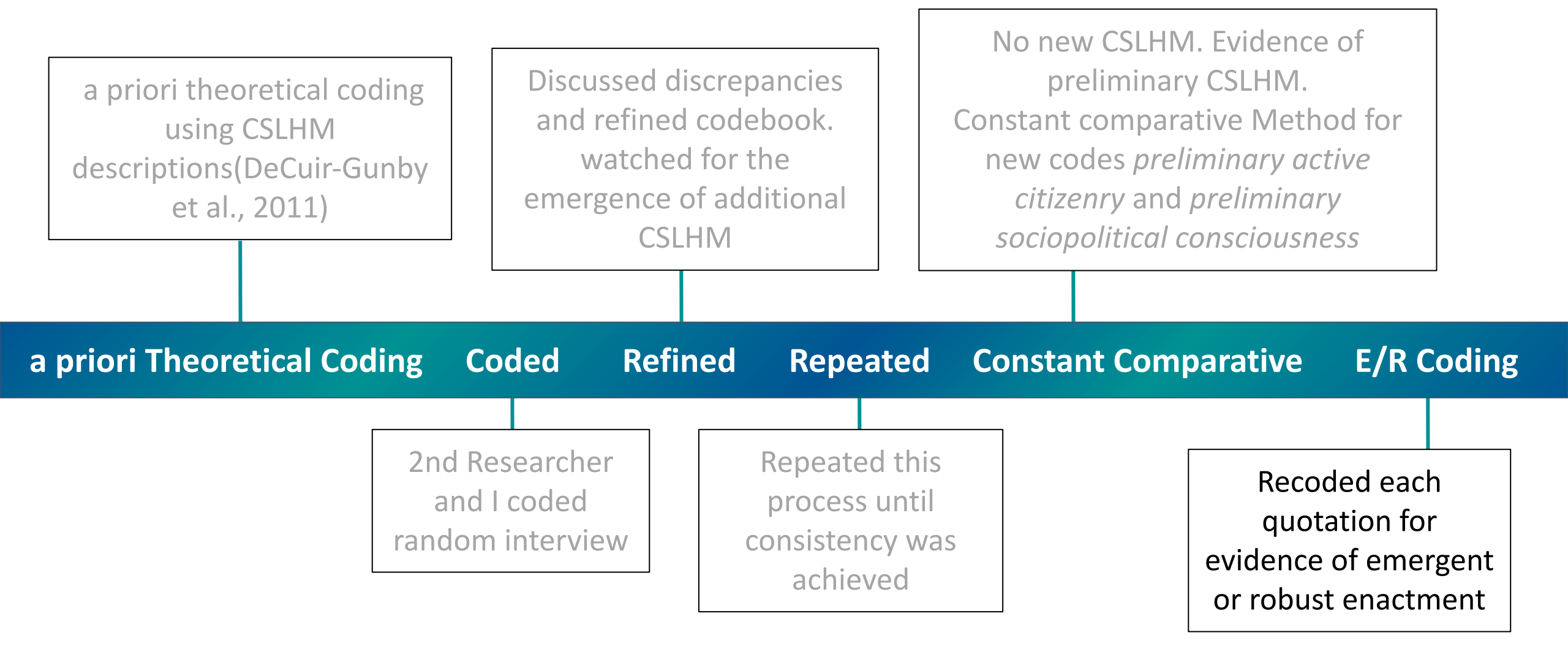

Stage 1 Findings

PSMT	CSLHM					
	Questioning Sample Size/ Methods	Appropriate Stats & Representations	Additional Information	Alternate Explanations	Sociopolitical/ Critical Consciousness	Active Citizenry
1	E		E	R		E
2	R	R	E	E		E
3	E	E	E	E	E	E
4			E	E		R
5	R	E	R	E	E	
6		E	E	E		
7	R	R	E	E	E	
8	E			E		
9	R	E	E	E	E	
10	E	E	E	E	E	
11				E		
12						R
13	E		E	R	E	E
14	R	E	E	E		E
15	E	E	E	E		
16	E	E		E		
17	R	R	R	E	R	R

Stage 1 Findings

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3	E	E	E	E	E	E
4			E	E		R
5	R	E	R	E	E	
6		E	E	E		
7	R	R	E	E	E	
8	E			E		
9	R	E	E	E	E	
10	E	E	E	E	E	
11				E		
12						R
13	E		E	R	E	E
14	R	E	E	E		E
15	E	E	E	E		
16	E	E		E		
17	R	R	R	E	R	R

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4			E	E		R
5	R	E	R	E	E	
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7	R	R	E	E	E	
8	E			E		
9	R	E	E	E	E	
10	E	E	E	E	E	
11				E		
12						R
13	E		E	R	E	E
14	R	E	E	E		E
15	E	E	E	E		
16	E	E		E		
17	R	R	R	E	R	R

Big Takeaway: Mostly Emergent CSLHM Enactment

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11				E		
12						R
13	E		E	R	E	E
14	R	E	E	E		E
15	E	E	E	E		
16	E	E		E		
17	R	R	R	E	R	R

Big Takeaway: PSMT 17 looks different

PSMT	CSLHM					
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1	E		E	R		E
2	R	R	E	E		E
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4			E	E		R
5	R	E	R	E	E	
6		E	E	E		
7	R	R	E	E	E	
8	E			E		
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10	E	E	E	E	E	
11				E		
12						R
13	E		E	R	E	E
14	R	E	E	E		E
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Participants for this Study

	CSLHM					
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1	E		E	R		E
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4			E	E		R
5	R	E	R	E	E	
6		E	E	E		
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Common Case: Carrie

Unusual Case: Kate

17	R	R	R	E	R	R

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1	E		E	R		E

Common Case: Carrie

Chosen because they also had similar statistical backgrounds

Unusual Case: Kate

17	R	R	R	E	R	R

Additional Analysis

Summaries

summary table of all PSTs CSLHM enactment → Case Selection

Additional Analysis

Focused on the 2 Tasks that highlight the difference between cases

Summaries **2 Focus Tasks**

summary table of all PSTs CSLHM enactment → Case Selection

Additional Analysis

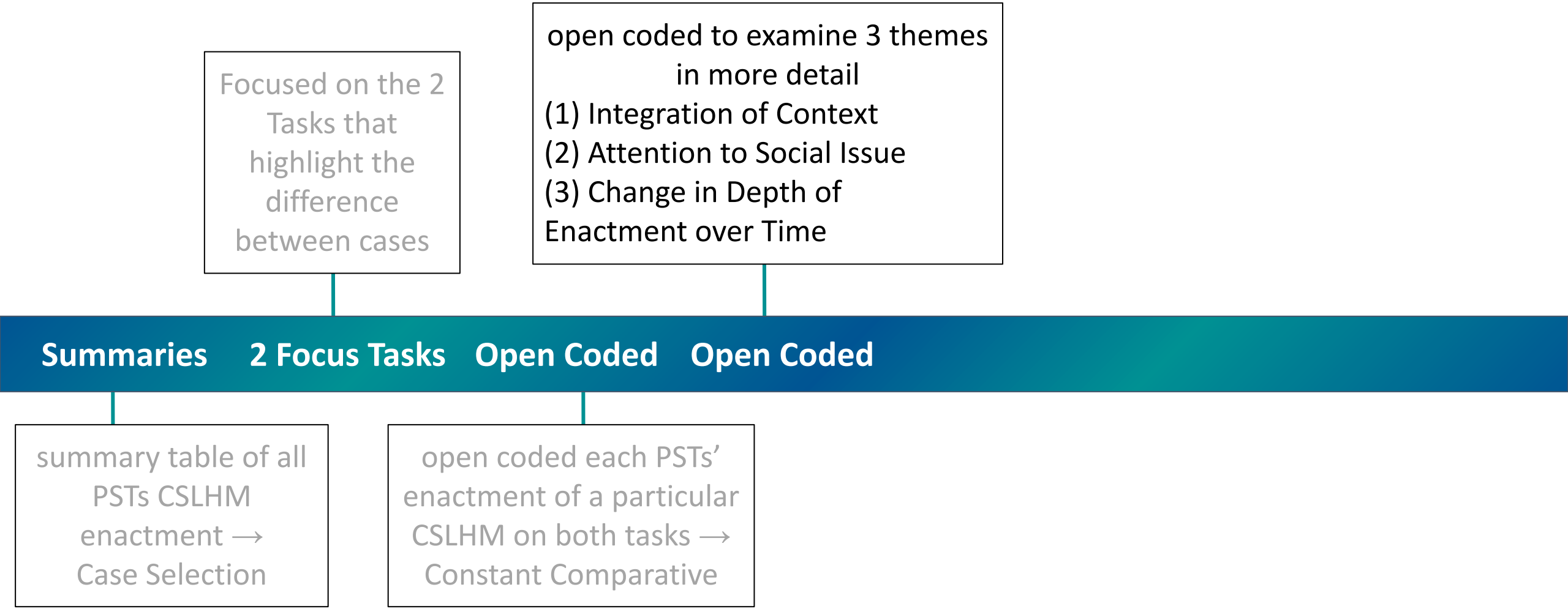
Focused on the 2 Tasks that highlight the difference between cases

Summaries **2 Focus Tasks** **Open Coded**

summary table of all PSTs CSLHM enactment → Case Selection

open coded each PSTs' enactment of a particular CSLHM on both tasks → Constant Comparative

Additional Analysis



Additional Analysis

Focused on the 2 Tasks that highlight the difference between cases

open coded to examine 3 themes in more detail
(1) Integration of Context
(2) Attention to Social Issue
(3) Change in Depth of Enactment over Time

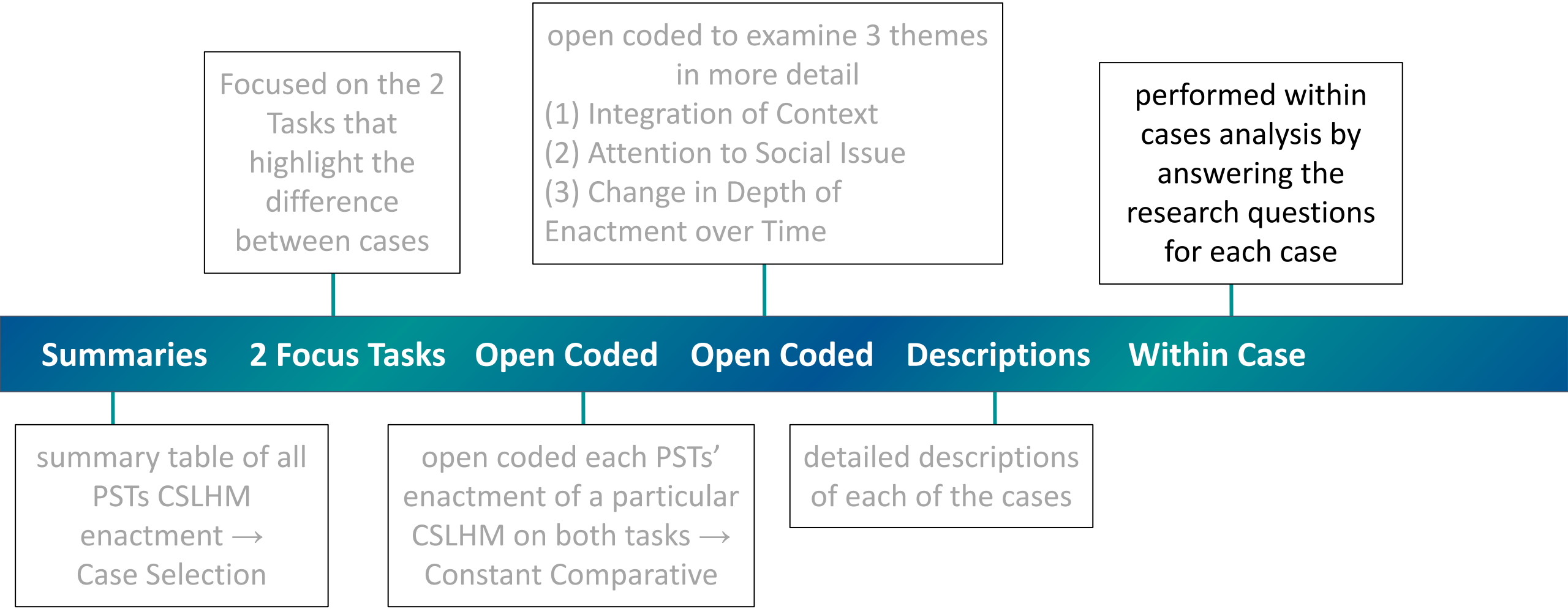
Summaries **2 Focus Tasks** **Open Coded** **Open Coded** **Descriptions**

summary table of all PSTs CSLHM enactment → Case Selection

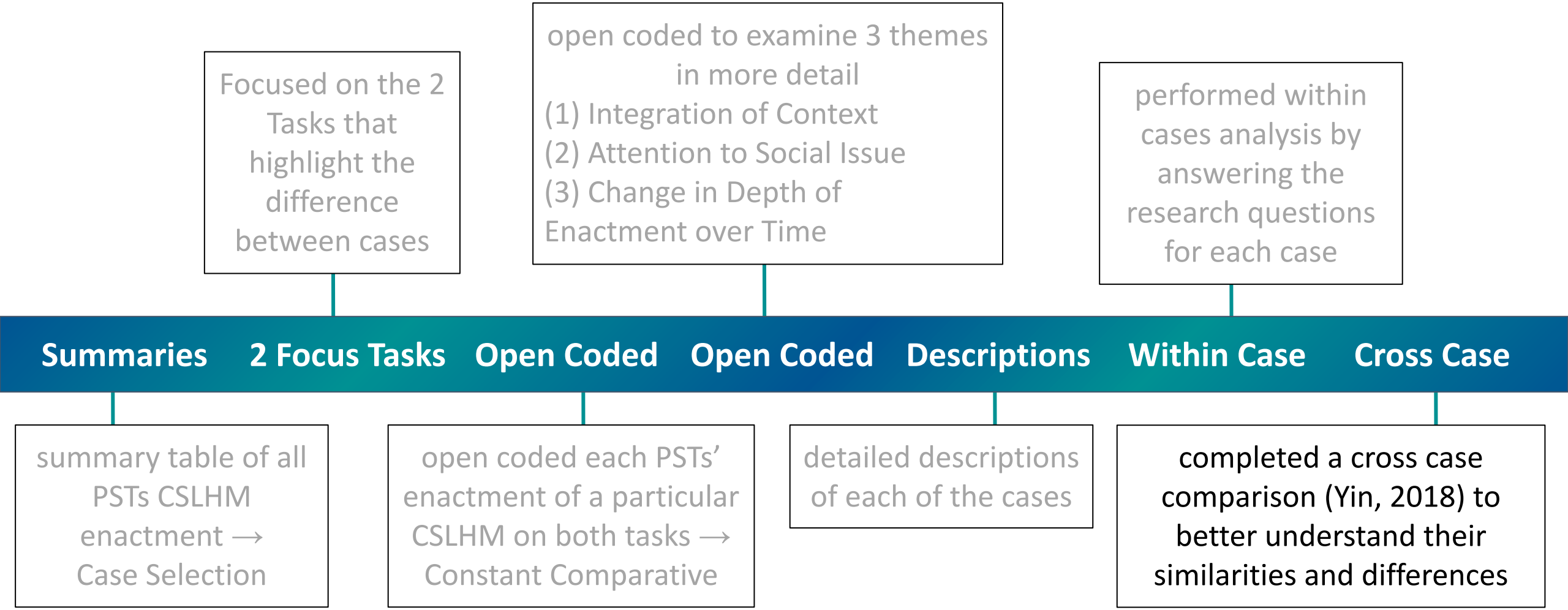
open coded each PSTs' enactment of a particular CSLHM on both tasks → Constant Comparative

detailed descriptions of each of the cases

Additional Analysis



Additional Analysis



Findings: Attention to Context

Common Case: Carrie

- Inconsistent and surface level integration of the context
- Often wondered vaguely without explicitly making connections to the context (e.g., mentioned educational testing on COVID and Education Task, did not discuss risks and benefits of in-person schooling during a pandemic)
- Sometimes ignored context

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Unusual Case: Kate

- Explicitly integrated the context

  e.g., on the COVID and Education Task: talked about living conditions, population density, whether or not the data is an appropriate slice from a broader report (i.e., taken out of context), mask mandates, the implications on students and covid tracing emails etc.

Findings: Attention to Social Issue

Common Case: Carrie

- Danced around the social issues: “makes me wonder what that was about”
- Consistently used the language from the data representation, but often did not consider the broader implications of the issue or the connections to society

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Unusual Case: Kate

- Consistently attended to the broader social issues: intertwined political ideas and considered broader human impact
- Not shy to share beliefs, political stance, and feelings on these issues
  - why and how her beliefs and feelings influenced her sense making of the data representation

Findings: Change in Depth over Time

Common Case: Carrie

- Consistently emergent
- Did not change with respect to depth of enactment when making sense of the data representations in either task

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Common Case: Carrie

- Consistently emergent
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Unusual Case: Kate

- Change from emergent to robust enactment as she continued to make sense of the data representations

Discussion

Limitations

- Not random sample of PSMTs
    - May have been motivated to participate

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    - May have been motivated to participate
- Recruited from universities in the southeast United States → could be different with wider PSMT population
- Focused on tweets → CSLHM enactment with different types of statistical messages could be different

Implications

If taking statistics courses at the university level ***does not***

- help prepare PSTs to teach high school statistics content (Lovett, 2017, 2018)

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- appear to help develop CSLHM enactment (Bailey, 2023)

mathematics educators and teacher educators need to carefully consider how to integrate CSLHM into education preparation programs

Implications

- PSTs are often uncomfortable discussing or teaching social justice topics (e.g., Simic-Muller et al., 2015)
- PSTs struggle to integrate context into sense making & sometimes ignore it (e.g., Guven et al., 2021; Tak et al., 2017)

This work corroborates these findings

Implications

- Kate → talked about her program's emphasis on anti-racist pedagogy
- Carrie → program that met 4 times a semester to dig into social justice topics

Implications

- Kate → talked about her program's continual emphasis on anti-racist pedagogy
- Carrie → program that met 4 times a semester to dig into social justice topics

Difference in Carrie's and Kate's CSLHM enactment → intermittent support/discussion on social justice topics + critical pedagogies is *not* enough

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Difference in Carrie's and Kate's CSLHM enactment → intermittent support/discussion on social justice topics + critical pedagogies is *not* enough

Social justice, anti-racists pedagogies, and critical consciousness need to be intentionally integrated throughout a teacher preparation program to influence CSLHM enactment→ further research.

How do we even navigate this work in the current US?
There are broader implications
What we know students need to be able to make sense of statistical messages in the real world faces many obstacles for how we help them develop those skills

- Kate →
  pedago
- Carrie –
  justice t

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support/di
enough

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PSMT Enactment

Implications

Scholars have advocated for explicit attention to critical consciousness
(e.g., Frankenstein 1983, Gutiérrez, 2002;Gutstein, 2003;
Kokka, 2020; Skovsmose, 1994; Weiland, 2017)

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Kate's experience points to importance of developing critical consciousness among PSMTs

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Kate's experience points to importance of developing critical consciousness among PSMTs

so they can help their students develop an understanding of mathematics and statistics as a tool that can be wielded to further privilege or marginalize OR as a tool that can work to dismantle unjust systems

What does this mean for us?

- How can PSMTs gain exposure to CSLHM?
- What instructional routines support the use of the CSLHM?
- How can teacher preparation programs support the development of CSLHM within existing courses?
    - We know that there is not much room to add curriculum in already packed programs, so coming up with creative ways to integrate CSLHM into existing courses is key to answering the aforementioned calls for Critical Statistical Literacy
- How can we advocate for CSLHM amidst the current political climate?

Preliminary Findings: Adult Enactment

Dr. Nina Bailey, Dr. Karie Smucker, & Asja Alic

Multiple Case Study

Four Cases:

		Critical Consciousness	
		Emergent	**Strong**
Statistical Knowledge and Self Efficacy	**Emergent**	Case 1	Case 3
	Strong / Confident	Case 2	Case 4

Validated Scales to Determine Cases

- **Statistical Self Efficacy Knowledge**
  - Current Statistical Self-Efficacy Scale (Finney & Schraw, 2003)
  - Instrument designed to assess ‘‘confidence in one’s abilities to solve specific tasks related to statistics’’ (Finney & Schraw, 2003, p. 164).
- **+ Statistical Knowledge**
  - Since confidence is not necessarily correlated with statistical knowledge, included four knowledge check items
  - Pulled from the Intermediate/Advanced Statistical Literacy form of the Levels of Conceptual Understanding in Statistics (LOCUS) assessment (Jacobbe et al., 2014) online (locus.statisticseducation.org)

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- **Critical Consciousness**
  - Short Critical Consciousness Scale (S-CCS; Diemer et al., 2020; Rapa et al., 2020)

Cut-Offs

		Critical Consciousness	
		Emergent (S-CCS sum<50)	**Strong** (S-CCS sum=50+)
Statistical Knowledge and Self Efficacy	**Emergent** (CSSS sum<56; LOCUS 0-2)	Case 1	Case 3
	Strong / Confident (CSSS sum=56+; LOCUS 3-4)	Case 2	Case 4

We are Currently in Data Analysis

- We have coded 8 of 20 interviews so far (random order for coding)
- Some intriguing *very* preliminary noticings that have emerged from our coding

		Critical Consciousness	
		Emergent	**Strong**
Statistical Knowledge and Self Efficacy	**Emergent**	Case 1 - Coded 3 of 5	Case 3 - Coded 3 of 5
	Strong / Confident	Case 2 - Coded 1 of 5	Case 4 - Coded 1 of 5

Our noticings (so far)

Not everyone… but so far a few folks in Cases 1 and 2

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Our noticings (so far)

Not everyone… but so far a few folks in Cases 1 and 2

- Questioning or critiquing the graph so much that they miss the broader message or issue
- Quickly dismissing or believing the statistical message because of their beliefs (little to no CSLHM enactment or graphical analysis)
- Refusal to engage on the topic with someone with different beliefs

Our noticings (so far)

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which makes me wonder why I didn't see similar behavior with the PSMTs!

Also seems to strengthen the call for Critical Consciousness in teacher prep courses


All the Questions Now
(that’s how we grow)