

# Cognitive security and resilience: A social-ecological model of disinformation and other harms with applications to COVID-19 vaccine information behaviors

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# Common ground terminology

- **Information-based harms:** misinformation, disinformation, conspiracy theories, and a variety of other types of potentially harmful information
- **Sociotechnical systems view of mis- and disinformation,** considers people, process, technology, interactions. Based on information security tools and processes
- **Cognitive security:** ability to detect, characterize, and counter misinformation, disinformation, and other information-based harms and forms of malign influence among people
- **Resilience:** as part of cognitive security, includes the structural context that protects humans from exposure to disinformation in the first place, as well as the ability to identify it, limit its spread, and mitigate its effects once exposed

# The Problem Space

- Fundamental change in how people communicate, and how information is disseminated and accessed
  - Contributed to the viral spread of misinformation, disinformation, targeted propaganda and influence campaigns
  - Change in the 3 V's: volume, velocity, and variety
- Complex and multifaceted causes of and contributors to information disorder
  - Spanning numerous fields
- Studies have examined:
  - Characteristics that make individuals susceptible to information disorder,
  - Characteristics of the information itself,
  - Networks in which it spreads,
  - Platforms and technologies that enable individuals to form networks and engage with information.

# The Gap

- Problem scale and its far-reaching effects have created an urgent need to:
  - Develop effective strategies to counter information disorder and
  - Facilitate better access to and engagement with credible information
- Fundamental challenges include:
  - Inconsistent terminology,
  - Not enough integration of research from different disciplines,
  - Underuse of theory
- Lack of foundational, theory-based research examining how agents, processes, and environments:
  - Interact with each other and
  - Respond to change

# SEM as Opportunity to fill Gap

- **Social Ecological Model (SEM)** (Broffenbrenner, 1979)
  - Framework for understanding human development,
  - With emphasis on dynamic interactions between individuals and their environments
- Recognizes **individuals as embedded within multiple levels of interacting systems**
  - Within each of these systems there are myriad factors that directly and indirectly influence the individual, and
  - Are influenced by the individual
- **Reciprocal causation is a core assumption**
  - Individuals can influence their environment and
  - The environment can influence the individual
- Used here to conceptualize cognitive security and resilience in the context of information disorder and information-based harms

# Where and How You Retrieve Information Matters

- Tripodi: Information seekers:
  - Analyze retrieved information
  - Co-create the information search terms that they use with different levels of their personal SEMs, leading to term-based information silos (Tripodi, 2018)
- Self: Credibility of retrieved information is based on factors:
  - *"(i) the source of information,*
  - *(ii) the information that is diffused, i.e., the message, considering both its structure and its content,*
  - *(iii) the media used to diffuse information"* – Self (2014) quoted by Pasi (2021)
- UK Admiralty Code: separately rates information contents and sources, - UK MoD 2011
  - Widely used to assess credibility in information retrieval and open source intelligence (OSINT) by
  - But scant research on the effects of the type of source, their relationship to the information seeker, the credibility they assign to information retrieved through personal communication, online search, networking, and OSINT
- This SEM:
  - Extends information retrieval to give ways to consider the source and the effects of source assessment on retrieved information credibility

# SEM Levels

## Individual

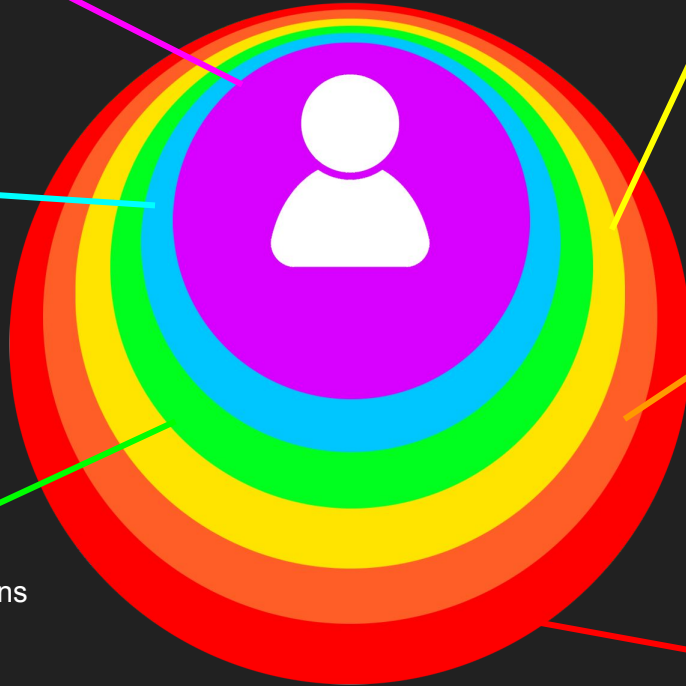
- Demographics
- Psycho-social factors
- Digital literacy and numeracy
- Information related factors
- Identity / Online identity

## Interpersonal

- Family, peers, and other social connections
- Fact checkers and validators
- Quality of interpersonal relationship matters
- Homophily / Echo chamber
- Social roles
- Overloading

## Organizations

- Narrative- and activity-based mitigations
- Boundary problems
- Information monitoring
- Response resources
- Access to collaboration resources
- Subcommunity visibility
- Organization structure



## Community

- Influential actors
- Locations / Meeting points
- Community structure
- Trust levels
- Shared beliefs, norms, myths
- Access to information
- Access to resources
- Responsiveness
- Intervention policies

## Policy

- Legislative and executive policy
- Coordinated planning documents
- Stakeholder involvement
- Policy hesitancy or resistance
- Funding and resources
- Research and reporting endeavors

## Society

- Media and free press
- Social media
- Economy
- Discrimination and marginalization

# Individual

- Demographic factors
  - ◆ Disparities in access & use of technology
  - ◆ Language (vocabulary mismatch problem)
- Psychosocial factors
  - ◆ Attitudes & beliefs about technology
  - ◆ Trust in information, sources
  - ◆ Cognitive biases
- Digital literacy & digital numeracy
- Information needs, evaluation, and behavior
  - ◆ Where do people go for information? How do they find it? How do they engage with it once they find it?
  - ◆ How people interact w/ search engines
  - ◆ Relevance & credibility judgments

# Interpersonal

- Family & peers
  - ◆ Potential source of & filter for information.
- Social network (online & offline)
- Norms
  - ◆ Individuals influence & are influenced by behavior of others w/in a group or network.
- Homophily
  - ◆ Groups w/ high homophily are more likely to become echo chambers.
    - Malicious actors recognize & exploit this
- Social roles
  - ◆ Social exchanges (sharing information & correcting disinformation).
  - ◆ Corrections may require use of social capital.

*Individual factors are often the easiest to access & modify,  
but change at the individual level has limited impact.*



# Organizations

- Levels of cognitive security
  - ◆ Organization as a whole, plus all of the members/employees/subgroups.
- Organizational policies & practices
  - ◆ Cognitive security plans
- Coordination between branches of organization or levels of government
- Communication w/ public
  - ◆ Balancing security vs. transparency.
- Boundary issues
  - ◆ Unlike other areas of security, organizations need to monitor & act on not just its own systems, but systems controlled by others (e.g., social media).

# Communities

- Types of communities
  - ◆ E.g., scientific community, medical community, religious community, local community, etc.
- Online vs. physical communities
  - ◆ Unique vulnerabilities of online communities.
- Cognitive security response origins
  - ◆ Pro-community: Outside but on behalf of community.
  - ◆ Para-community: Working alongside w/ community.
  - ◆ Per-community: Occurs w/in & by communities.
- Community myths
  - ◆ May have a prosocial purpose – e.g., can signal belonging & cooperation.

# Policy

- Legislation & executive policy
  - ◆ Proactive vs. reactive approaches
  - ◆ Advertising & election transparency laws
  - ◆ Educational & training priorities
- Platform policies & enforcement
  - ◆ TOS, misinformation labels
- Stakeholder involvement
- Competing interests, priorities
  - ◆ Public vs private
  - ◆ Free speech/censorship
- Funding, timing, & resource allocation
  - ◆ Also affects future cognitive security efforts
- Research & reporting endeavors
  - ◆ Can be a barrier or accelerant for innovation and talent

# Society

- Culture & ideology
  - ◆ Low levels of trust in scientific institutions
  - ◆ Prioritizing individual freedom over security and protection of vulnerable populations
  - ◆ Political polarization and identity politics as strong predictors of vaccine hesitancy
- Media & free press
  - ◆ Increase fear, mistrust, and stress
  - ◆ Too little info → More rumors
  - ◆ Too much info → Overload and trust uncertainty
- Social media
  - ◆ Platforms as avenues for “alternative” new sources
  - ◆ Prevalence of foreign media outlets and bots
- Economy
  - ◆ Inequality drives mistrust
- Discrimination & marginalization
  - ◆ Attribution and Anti-Asian sentiment
  - ◆ Historically negative views of healthcare systems in the Black community

*Change at these levels can be harder to achieve, but is often more impactful.*

# Use case: Microchips in Covid-19 Vaccines

*“Millions will line up to take the vaccine, and boom, microchips for all of y’all, right in time for goddamn Thanksgiving.” – Charlamagne Tha God, while on The Breakfast Club radio show (October 2, 2020)*

- Individual
  - Personal engagement through public awareness and online activity
- Interpersonal
  - Individual user creation & sharing engagement online
  - School teachers as vaccine ambassadors in communication with parents of school children
- Organizational
  - Publicly available ingredient lists
  - Mythbusting by prominent institutions, e.g. CDC and FactCheck.org
  - Televised Q&A with public health administrators
- Communities
  - Faith-based groups endorsement of COVID-19 vaccine ingredient lists, e.g., Islam and Latter Day Saints
  - Celebrities and online influencers helping spread the debunked microchips rumor, reaching key hesitant groups and bridging communities
- Policy
  - Facebook Twitter & YouTube, as social media platforms, misinformation policies (also Org level)
- Society
  - Public media coverage of mythbusting, e.g., WFLA in Tampa and NBC

# Reflection Toward Application

- Expanding analysis to include not just the individual,
  - But also the effect of family and friends, communities, etc.,
  - And considering the **interactions between SEM levels**, potentially increases the reach and scalability of cognitive security
- Vaccination related information-based harms continue to pervade while the COVID-19 pandemic continues to affect individuals and societies around the world, creating and reinforcing vaccination hesitancy
- Our SEM analysis extended previous information disorder and COVID-19 related research to identify contributing factors and complex relationships to vaccine uptake
- Practitioners can **develop interventions that span interdependent relationships** for greater efficacy using our SEM factors
- Academics may leverage this adaptation of the SEM to link research across traditional disciplinary boundaries and **encourage future work on the causal relationships** within COVID-19 information behaviors
- Assess coverage of responses, the implications of actions, and barriers that could diminish the effectiveness of interventions at each SEM level

# ZOO RESIDENTS ASSN. MEETING



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## Quantification & Generalizability

# Quantifying the SEM & IR Research

- Political violence in Northern Ireland: Indexed variable and **structural equation modeling** (Cummings *et al.*, 2010)
- Alcohol use behaviors: logistic multilevel random effects models and censored **regression** (TOBIT) random effects models (Gruenewald *et al.*, 2014)
- **ABM for HCI research** on HIV prevention used a simplified SEM for interaction strategies based on the environment's **information landscapes** (Brown *et al.*, 2013)
  - “ABM may include quantitative, equation-based approaches, but the rules that characterize this approach are qualitative” (Rounsevell *et al.*, 2012)
- **SEMs as theoretical foundation** to inform **machine learning** approaches to impute missing data on information environments (Saha *et al.*, 2018)

# SEMs & Generalizability

- SEMs have a **situated context**
  - Current study findings would not be expected to be applicable to other subject matter issues
  - Model and its underlying assumptions and relationships should be expected to remain stable across many different settings
- Limitation yes, but expected
  - “By the very act of installing an information system, one is changing the situation into which it is installed” (Antil, 1985)
- Qualitative validity mechanisms
  - **Face validity**: conveys whether the results were viewed as credible, recognizable, and trustworthy by others
  - **Transferability / External validity**: results, assumptions, relationships, and models that can be generalized to other research studies (Kaplan & Maxwell, 2005)

# Large Potential for Future Work

- Explore additional factors and interdependencies within and between each level of the SEM
- Improve the model validity: more use cases of this approach for COVID-19 info disorder
- Looking at algorithms (e.g., social media recommendation) via SEM for cognitive security lens
  - Neighbors of individual algorithms would be models and model instantiations sharing training datasets and results, and communities could form around the pre-trained models used in e.g., text and image understanding, with model poisoning and other machine information harms being shared across those communities and so on
- Extends this SEM for cognitive security adaptation as a theoretical contribution alongside to other prominent theories of information behavior within an environment:
  - Small worlds micro view (Chatman, 1999), Lifeworld theory macro view (Habermas via Burnett & Jaeger, 2008), Information Worlds multilevel view (Jaeger & Burnett, 2014)
- Evolve this SEM adaptation to consider
  - Theory of local information landscapes on the materiality of information within the environment as a capacity-based construct (Lee & Butler, 2019)
  - Directionality of information seeking through information horizons (Sonnenwald, 2005) or chance discovery via incidental information acquisition (Williamson, 1998) or information serendipity (Agarwal, 2015)



# Thank you!

# Questions?

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# Bonus Slides

# Other SEM Examples Across Disciplines

- Public health [6, 36, 37, 38]
- Health literacy [7]
- Media and communications [8]
- Risk management [9]
- Organizational change [10]

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