Social behavior for epidemiological simulation: A preliminary model

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Motivation

The COVID-19 pandemic has highlighted the importance of two aspects for epidemic management: First, **simulation models** that help us understand dynamics of disease spread and support policy decisions (e.g, Chang et al., 2021). Second, the **interconnectedness of human behavior and epidemic progression.** Namely, the success of a public health measure (e.g., a mask mandate) depends on each individuals's behavior.

However, integrating models of behavior into simulations can be challenging. Among other things, introducing more complexity increases computational costs and decreases intelligibility, especially in agent-based models (ABMs) (Gilbert et al., 2021). The mechanisms driving behavior thus are often left out (Lorig et al., 2021). Given the evidence for the impact of behavior on epidemic spread (Jirsa et al., 2022), the consequences of such a simplification are hard to gauge. Our aim is therefore to **develop an empirically based model of social behavior in epidemics** that is usable for ABMs so that the implications of explicitly modeling behavior can be explored.

Figure 1: Behaviors like mask-wearing are central to managing an epidemic.

Method

To develop the model, we are drawing on **existing theory and evidence** from four major sources:

- Theories of **health behavior** and behavior change (e.g., Michie et al., 2011).
- Literature on **climate behavio**r (e.g., Klöckner, 2013), because we assume that there might be important parallels.
- Evidence on factors associated with **individual protective behavior in the COVID-19 pandemic** (Hanratty et al., 2022) as exemplified in figure 2.
- **Existing ABMs** that use socio-psychological theory to inform agent behavior .

To test the model's explanatory capacity, we plan to fit regression models using both meta-analysis and newly collected data. Lastly, we will examine the model's suitability for simulation by conducting sensitivity analyses and by integration in a large-scale ABM in the OptimAgent consortium.

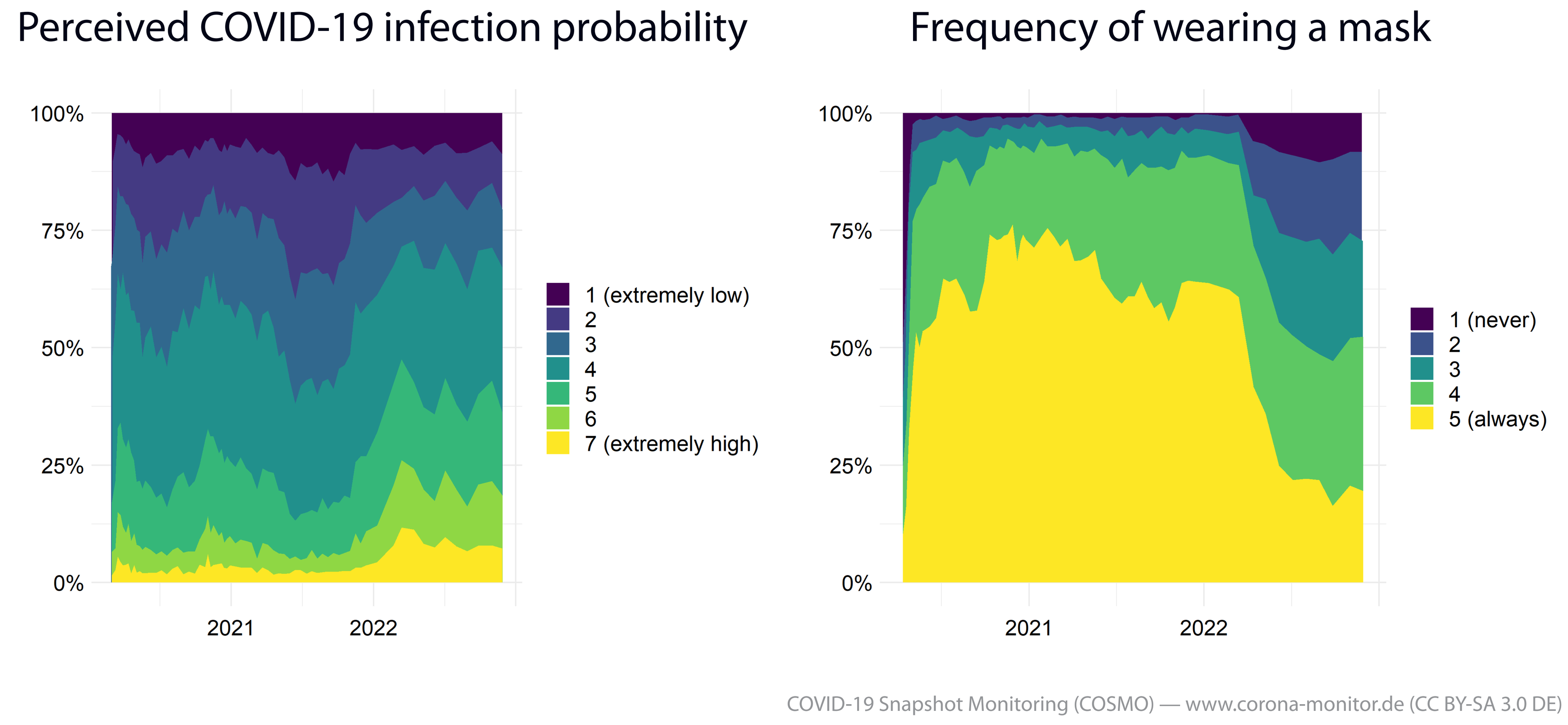

Figure 2: Answer percentages for perceived COVID-19 infection probability (7-point Likert scale) and frequency of wearing a mask (5-point-Likert scale) in a representative German sample from March 2020 to December 2022 (Betsch et al., 2020).

Proposed model

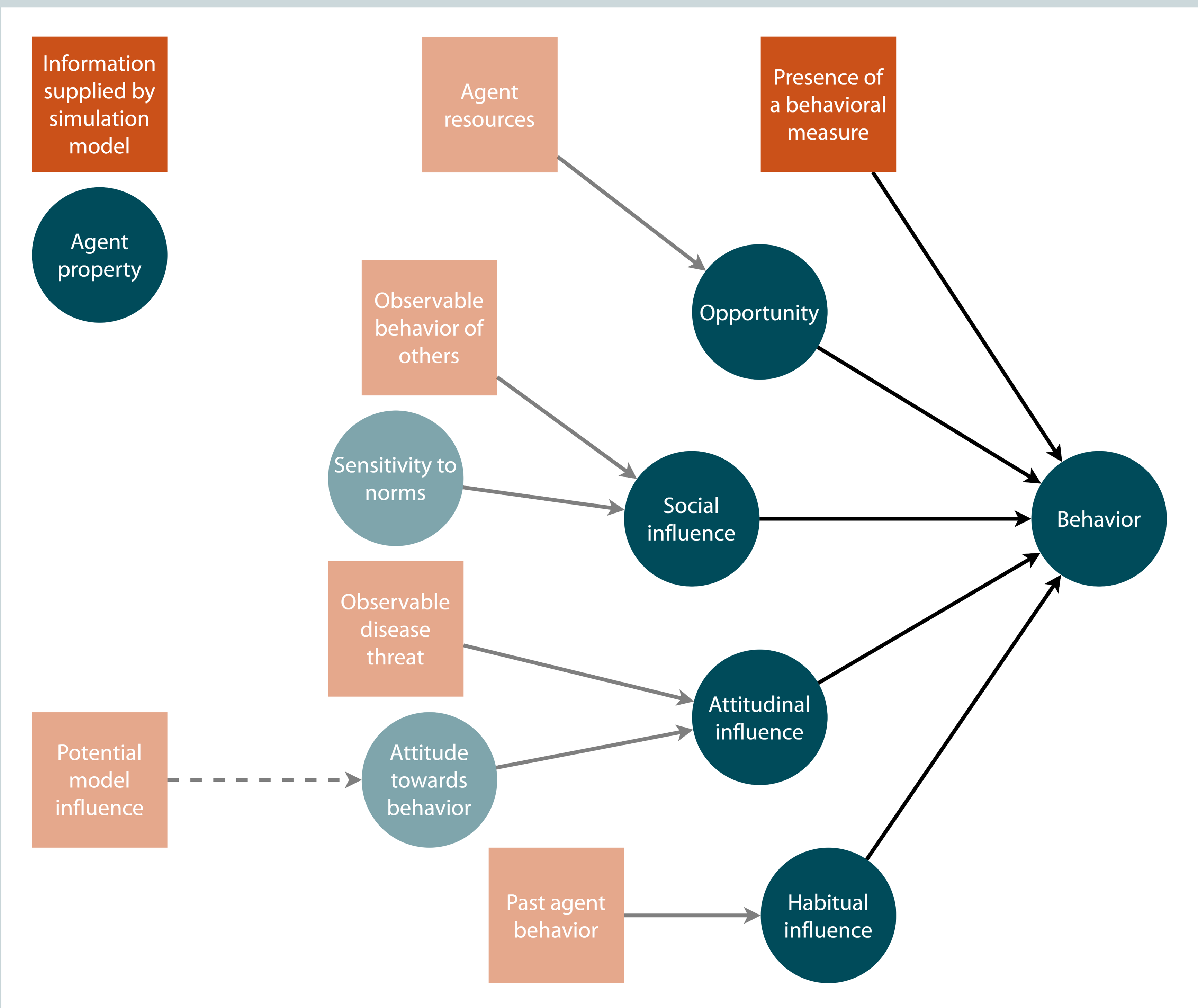

Figure 3: A proposed model for behavior in epidemiological modeling. Whether an agent complies with a public health measure depends on that agent's opportunity, as well as social, attitudinal, and habitual influences.

We propose a model based on the assumption that health behavior in epidemics is not purely a consequence of deliberate decision-making. As illustrated in figure 3, it incorporates five categories of influence:

- The **presence of a behavioral public health measure**, either as a mandate or as a recommendation.
- An individuals's **opportunity** to comply with that measure based on their resources.
- **Social influence** on behavior, which includes both situational and general normative influence; here, an individual's sensitivity to social norms might moderate the impact of others' observed behavior.
- **Attitudinal influence**, which comprises cognitive and affective drivers of behavioral decision-making; here, attitude might moderate the impact of the observed threat of the disease on behavior, with extreme attitudes weakening the impact.
- **Habitual influence**, which accounts for the automatic influences on health behavior and is informed by an individual's past behavior in similar situations.

A drawback of the proposed model is that a separate behavioral model has to be implemented for each behavior or public health measure, as the influences defined above differ drastically, e.g., between mask-wearing and self-isolation. A benefit is that for statistical modeling, more complexity can be introduced using a multi-level approach. This allows us to accommodate the diversity of existing evidence.

We will explore if the model is parsimonious enough for use in a simulation and whether the model assumptions are appropriate for prediction and explanation. If so, it will be possible to compare the performance of epidemiological simulations with and without explicit behavioral models.

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031L0299D