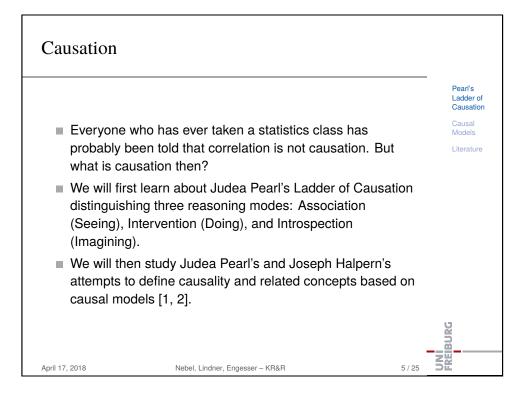
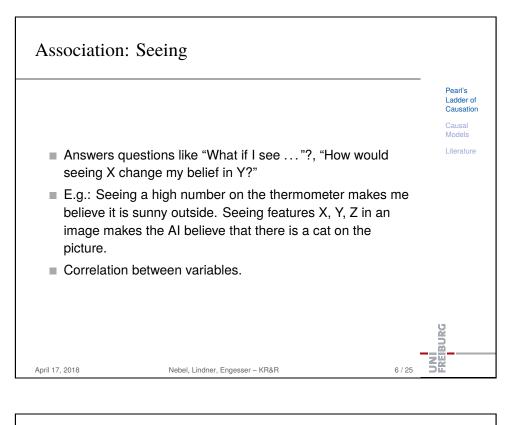
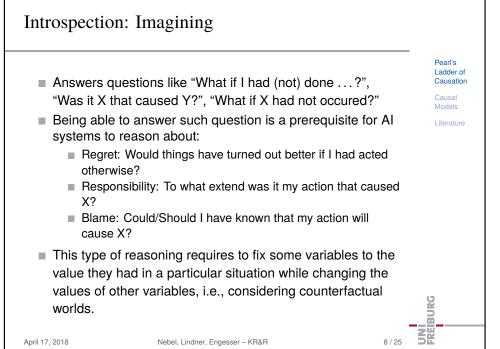
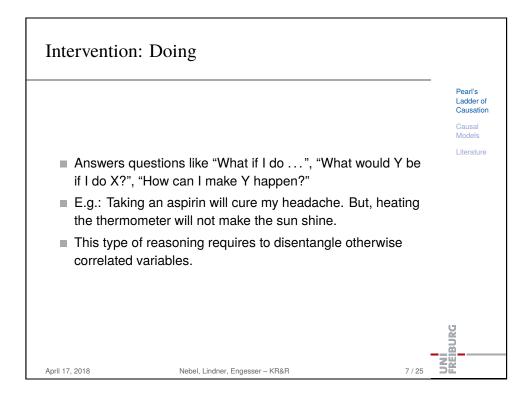


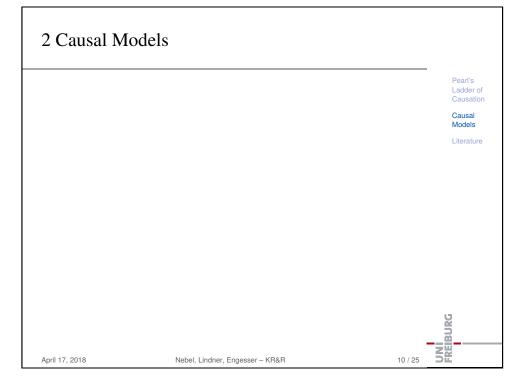
domains t	s are used or are about to be used in many hat potentially affect people's life significantly: _aw, Health etc.	Pearl's Ladder Causati Causal Models Literatur
Regulation	to The European Union General Data Protection n, everyone has the right to obtain an explanation ision reached [] and to challenge the decision.	
Explainab	e is currently a huge interest in so-called le AI (XAI), i.e., the design and analysis of nat are able to explain their decisions to humans.	
•	erfect reason (among others) to study causal as a means to come up with answers to	

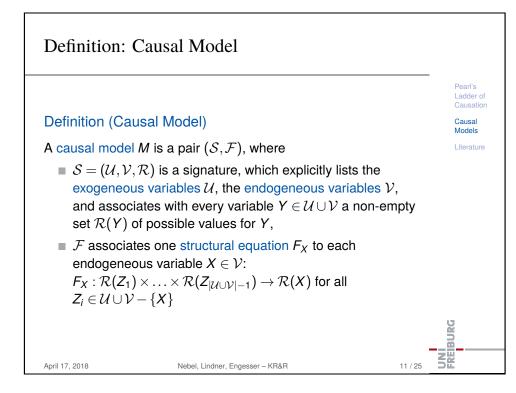












## Intervention

#### **Definition** (Intervention)

An intervention sets the value of some endogeneous variable *X* to a value *x* in a causal model M = (S, F) resulting in a new causal model  $M_{X \leftarrow x} = (S, F_{X \leftarrow x})$ , where  $F_{X \leftarrow x}$  results from replacing the structural equation for *X* in *F* by X = x and leaving the remaining equations untouched.

Interventions enable counterfactual reasoning by setting values different from actual values thereby overriding structural equations. Terminology Ladder of Causal Model M: Specification of the available variables Models (exogeneous and endogeneous) and their structural Literature relationships (via structural equations). Context  $\vec{u}$ : An assignment of values to the exogeneous variables. (From this assignment, the values of the endogeneous variables can be deterministically determined). Situation  $(M, \vec{u})$ : A pair of a model and a context determines a situation. In a situation, every variable in the model has got a value. BURG NE Nebel, Lindner, Engesser - KR&R April 17, 2018 12/25

# Independence and Recursiveness I

#### Definition (Independence)

Endogeneous variable *Y* is independent of endogeneous variable *X* in a setting  $(M, \vec{u})$  iff for all settings  $\vec{z}$  of the endogeneous variables other than *X* and *Y*, and all values x, x' of *X*,  $F_Y(x, \vec{z}, \vec{u}) = F_Y(x', \vec{z}, \vec{u})$  holds.

## Definition (Recursive Model)

A model *M* is recursive iff for each context  $\vec{u}$ , there is a partial order  $\leq_{\vec{u}}$  (reflexive, anti-symmetric, transitive) of the endogeneous variables, such that unless  $X \leq_{\vec{u}} Y$ , *Y* is independent of *X* in (*M*, $\vec{u}$ ).

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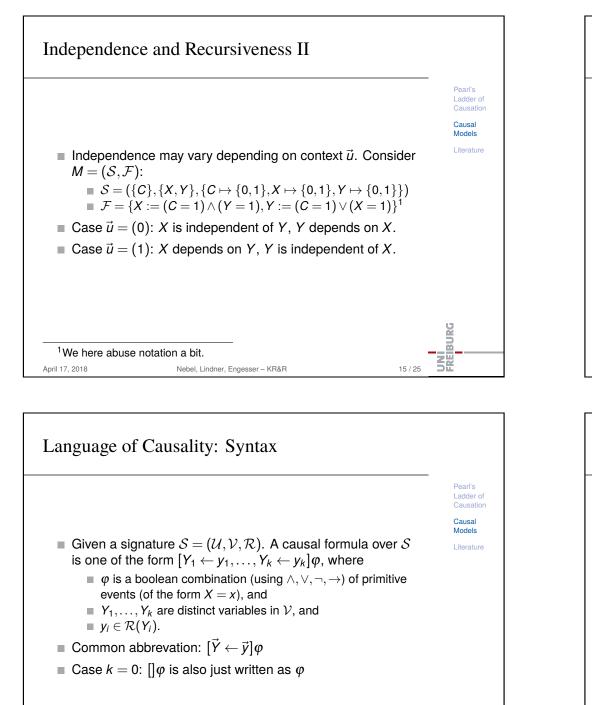
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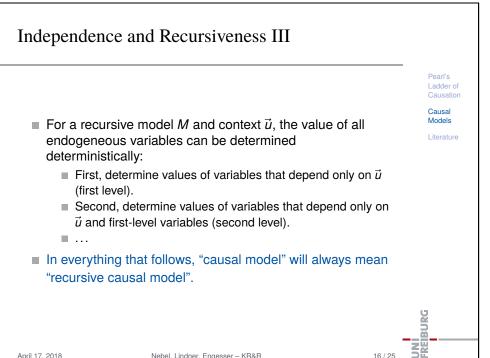
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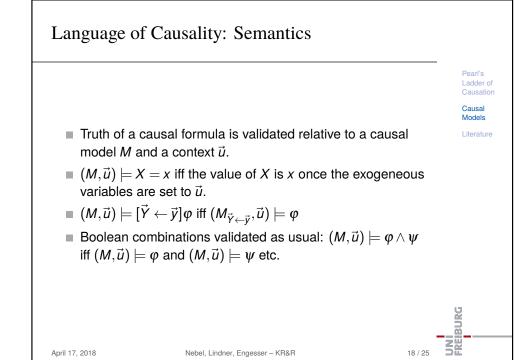
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# **But-For Cause**

### Definition (Cause according to Hume)

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"We may define a cause to be an object followed by another, and where all the objects, similar to the first, are followed by objects similar to the second. Or, in other words, where, if the first object had not been, the second never had existed."

### **Definition (But-For Cause)**

- X = x is a but-for cause of  $\varphi$  in  $(M, \vec{u})$  iff
  - $(M, \vec{u}) \models (X = x) \land \varphi$ , and
  - there exists some x', s.th.  $(M, \vec{u}) \models [X \leftarrow x'] \neg \phi$

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