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Eastern Switzerland
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Combining Causal Loop Diagrams, Behavior-Over-Time Graphs, and Domain-Specific Languages to Structure and Explore Complex Decision-Making Situations

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Problem Statement

- **Structuring and exploring complex problems** is **still one of the most significant challenges** in strategic decision-making and management.
- On the one hand, we **strive to add as much rigor as possible** to the analyses made, for example, through simulation models or data analyses.
- While, on the other hand, we **need to stay connected with all kinds of stakeholders** - an **essential precondition for implementation**.

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Proposed Solution

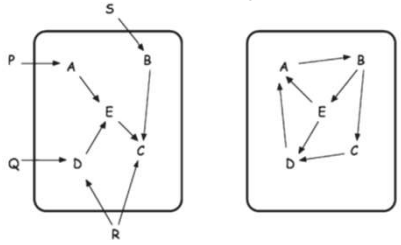
- We present an approach that **combines narratives, Causal Loop Diagrams, and Behavior-Over-Time Graphs**.
- The approach allows to **illustrate the structure, dynamic patterns and quantitative scale** of complex problems step-by-step.
- Thus, the approach is **accessible to a broad audience** and **allows exploration and reflection by all kinds of stakeholders**.

Complex problems, System Dynamics and Causal Loop Diagrams

Methodology

System Dynamics (SD)

- Method for **modeling and simulation of complex systems** that adapts control theory to a broader set of problems (Forrester1961)
- Two key elements differentiate SD from other methods in Operations Research:
  i. SD models *generate dynamics endogenously*. Many classical SD models show how flawed internal policies of industries or cities generate decay without external limiting factors (Richardson 2011).



  ii. SD *makes mental models explicit* by modeling them as CLDs. Making the models explicit is the basis for a deeper understanding of a messy situation, for revising mental models, for allowing double-loop learning to occur and for taking strategic decisions (Torres2017 [1],Lane1992 [1],Vennix1999, Paich1993 [2])

[1)] published in *"European Journal of Operational Research"*, [2)] published in *"Management Science"*

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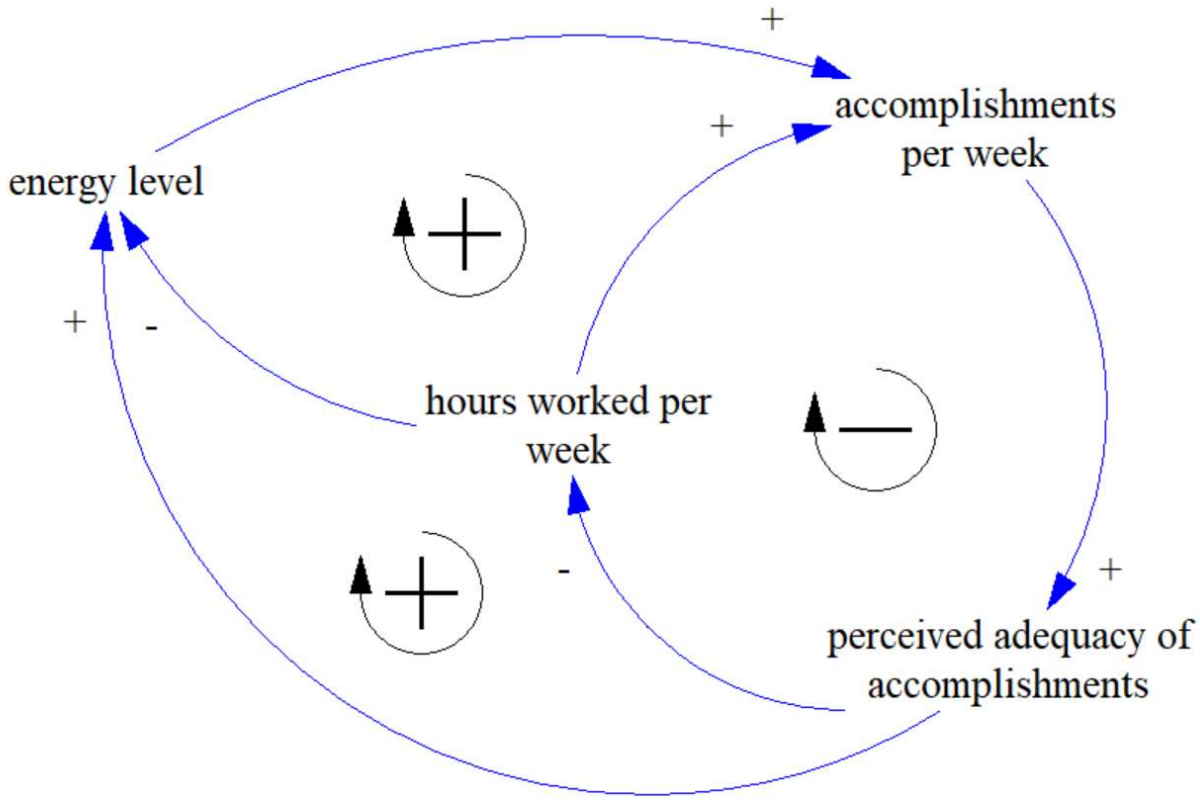
Methodology

Causal Loop Diagrams – What they are



Slightly simplified "Worker burnout model" by Jack B. Homer (Homer 1985)

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Usage of Causal Loop Diagrams

We use CLDs

i. to structure complex problems;

ii. to explore complex decision-making situations in participatory modeling processes;

iii. to foster learning among stakeholders involved in the modeling process;

iv. as a basis for simulation models, and

v. to communicate results of simulation studies

SD & CLDs: General Findings

- System Dynamics is best applied to relatively complex and unstructured problems where endogenous dynamics generate (unwanted) dynamics (Hovmand 2014, Lane 1999, Vennix 1999)
- Stakeholder involvement is crucial in such problems: Confidence in models and simulation results is necessary for implementation to happen (Black 2013, Wolstenholme 1999, Hovmand 2014)
- While CLDs and BOTGs are valuable *in* such projects, their dissemination *out* of the project is unlikely (Wolstenholme 1999, Hovmand 2014)
- Relevant stakeholders (senior decision-makers) generally don't have the knowledge to interpret CLDs (Wolstenholme 1999). They don't like being "taught" (Wolstenholme 1999).

So the question is: How can we strengthen the dissemination of CLDs outside the project team?

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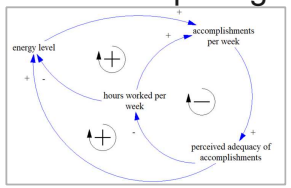
Solution

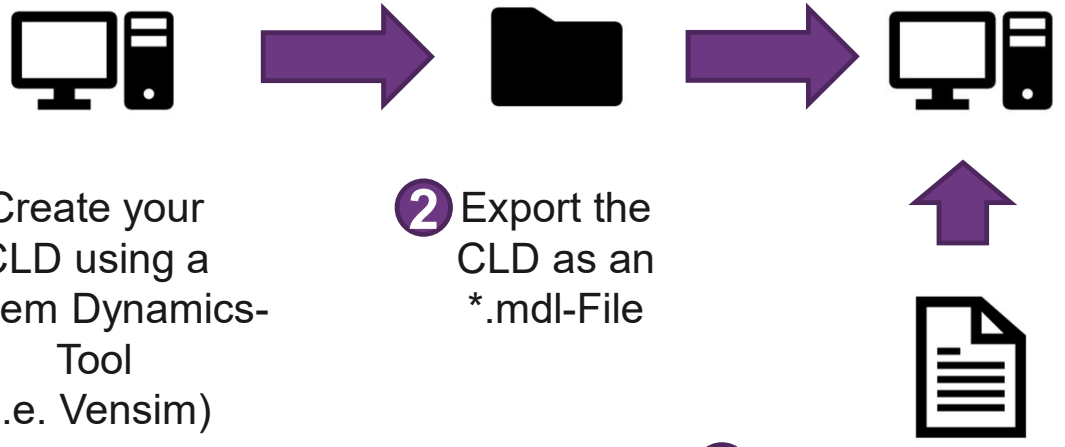
Solution

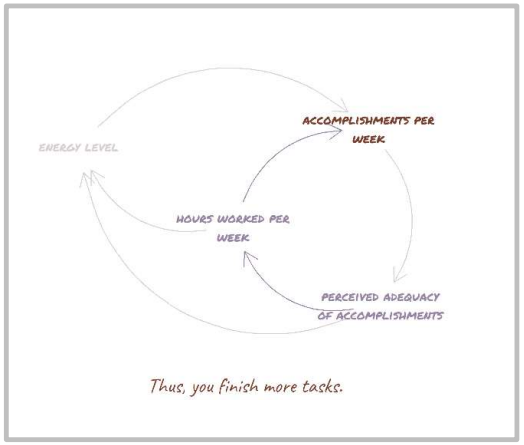
An embedded Domain-Specific Language in R

R-Package with Fuctionality for CLD-Visualization (the DSL)

Causal Loop Diagram







1. Create your CLD using a System Dynamics-Tool (i.e. Vensim)

2. Export the CLD as an *.mdl-File

3. Write a small R Script to explain the CLD to your Audience using new DSL Commands

4. Get a new set of representations of your CLD which are easier to grasp

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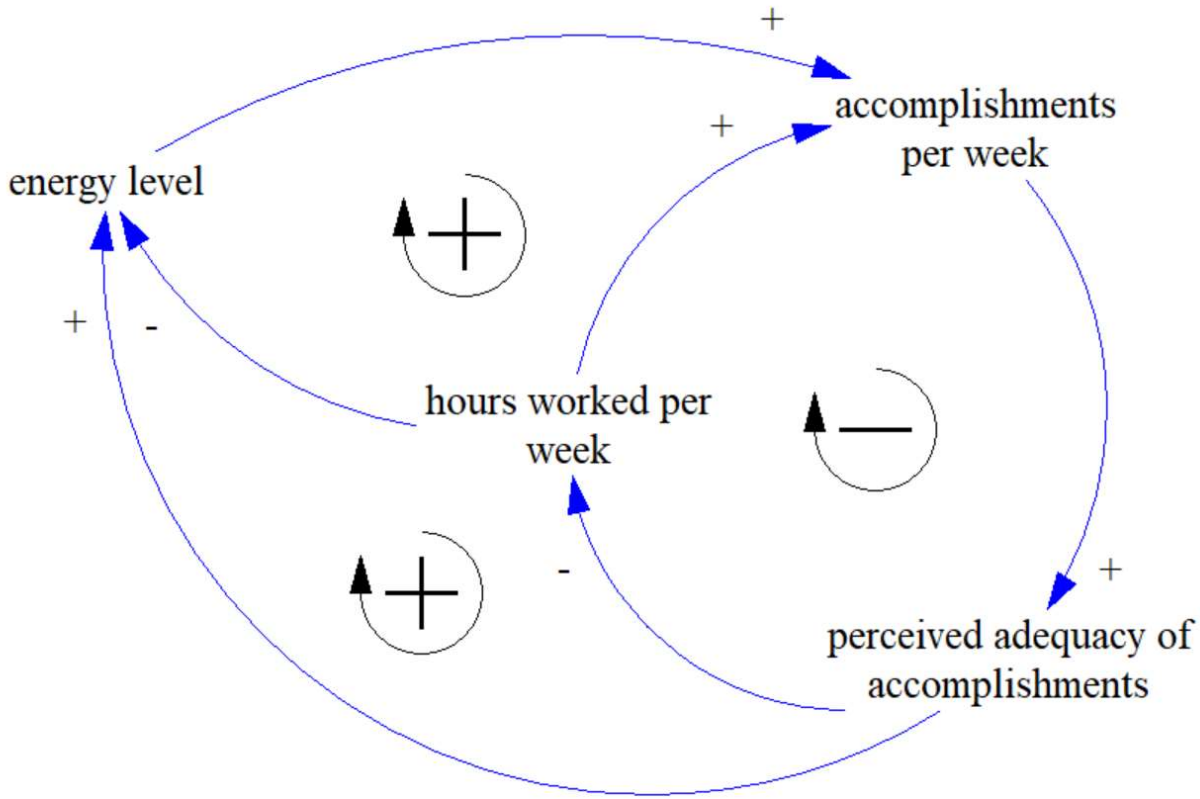
The DSL in Action

The original CLD «burnout model» (Homer 1985)



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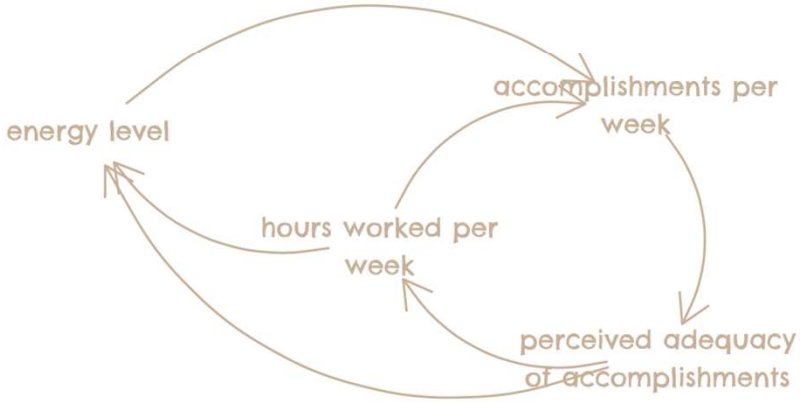
The DSL in Action

Default plot

```
cld %>% plot()
```



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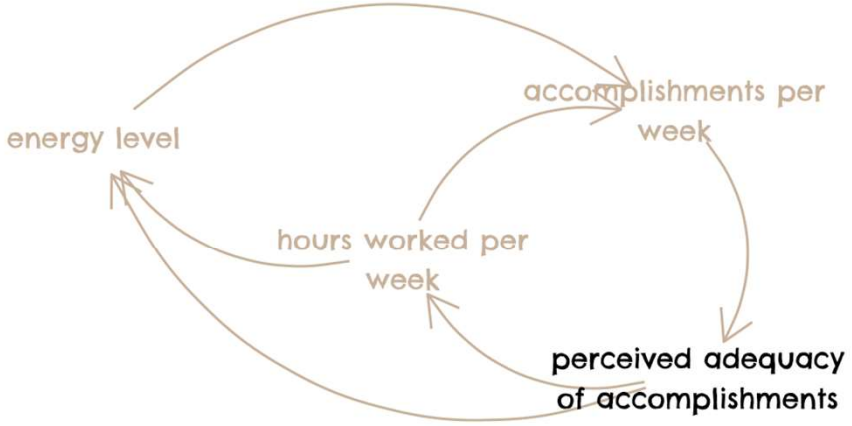
The DSL in Action

Select a starting point

```
cld %>%
  link(`perceived adequacy`) %>%
  plot()
```



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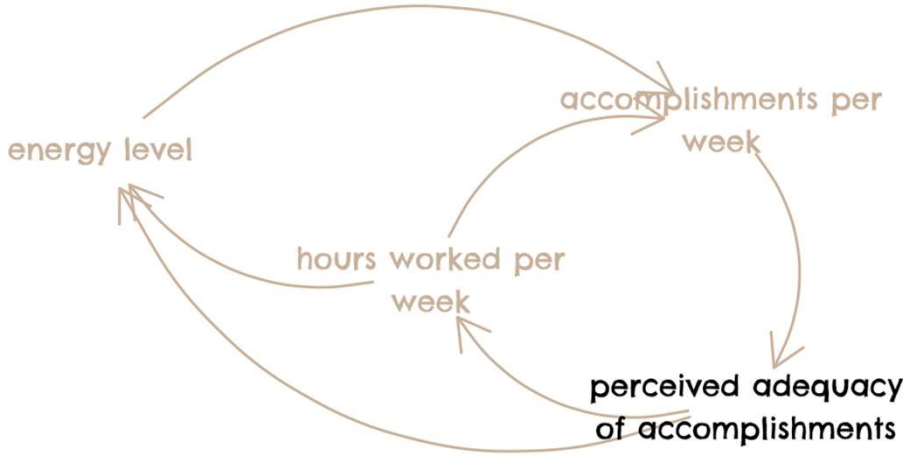
The DSL in Action

Start a «narrative»

```
cld %>%
  link(`perceived adequacy`) %>%
  describe(type = "text", "You (or your boss)
  are unhappy with your accomplishments.") %>%
  plot()
```



You (or your boss) are unhappy with your accomplishments.

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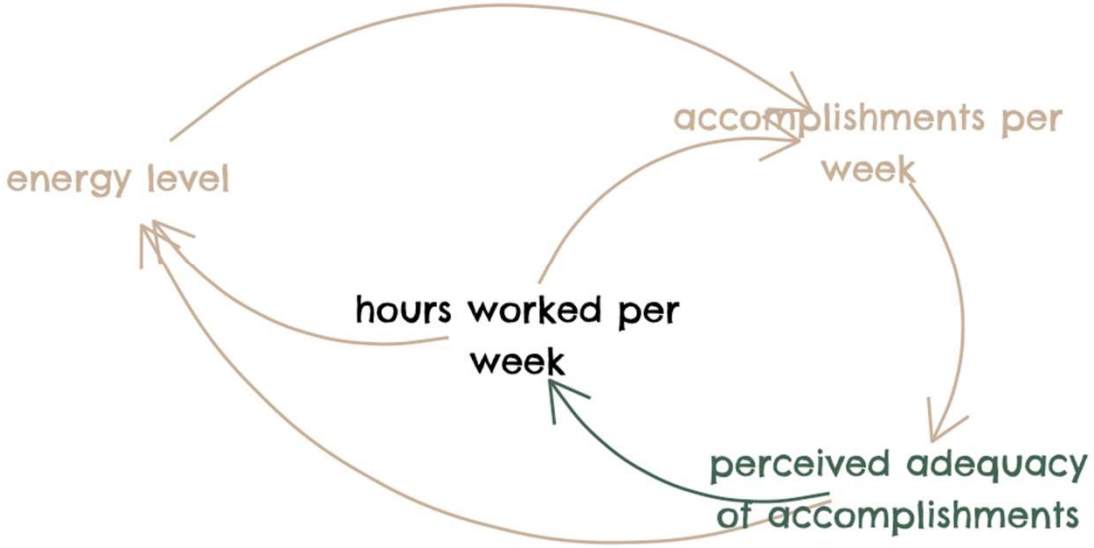
The DSL in Action

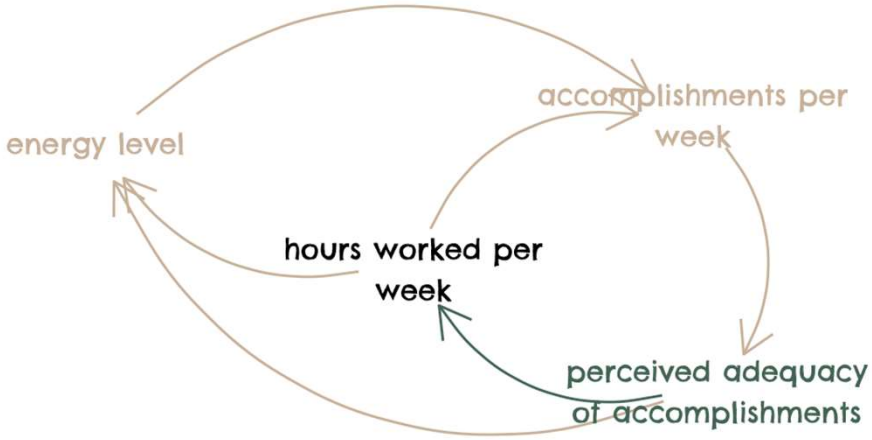
Define a causal chain

```
cld %>%
  link(`perceived adequacy` %->% `hours worked`) %>%
  link(`hours worked`) %>%
  plot()
```



Continue the «narrative»

```
cld %>%
  link(`perceived adequacy` %->% `hours worked`) %>%
  link(`hours worked`) %>%
  describe(type = "text", "As a reaction you start
    to work more hours per week.") %>%
  plot()
```



As a reaction you start to work more hours per week.

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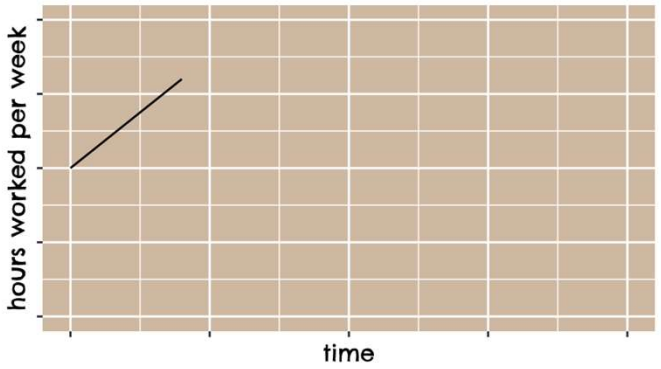
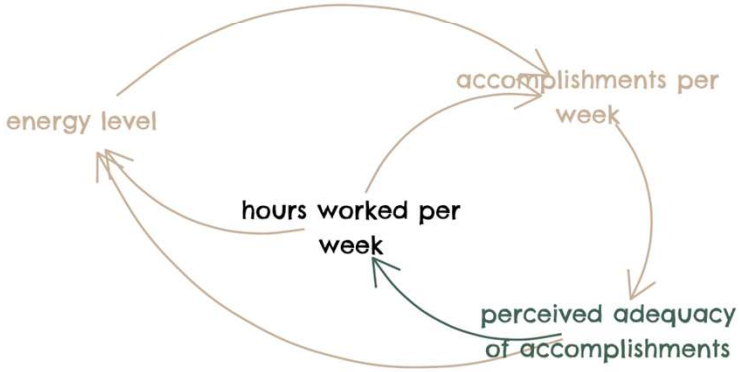
The DSL in Action

Add a Behavior-Over-Time Graph

```
cld %>%
  link(`perceived adequacy` %->% `hours worked`) %>%
  link(`hours worked`) %>%
  describe(type = "text", "As a reaction you start to work more
    hours per week.") %>%
  describe(type = "ref_mode", 0/.5 %-% .2/.8) %>%
  plot()
```





As a reaction you start to work more hours per week.

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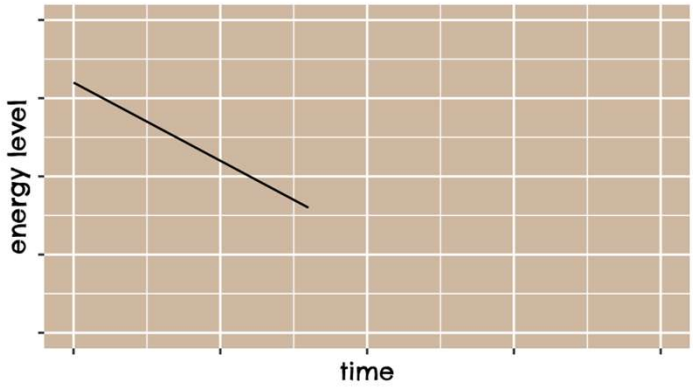
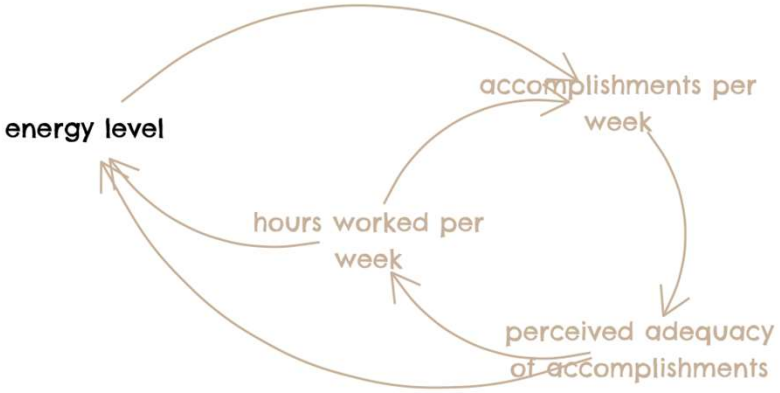
The DSL in Action

Different curve types

```
cld %>%
  link(`energy`) %>%
  describe(type = "text", "Your energy level starts declining.") %>%
  describe(type = "ref_mode", 0/.8 %-% .4/.4) %>%
  plot()
```





Your energy level starts declining.

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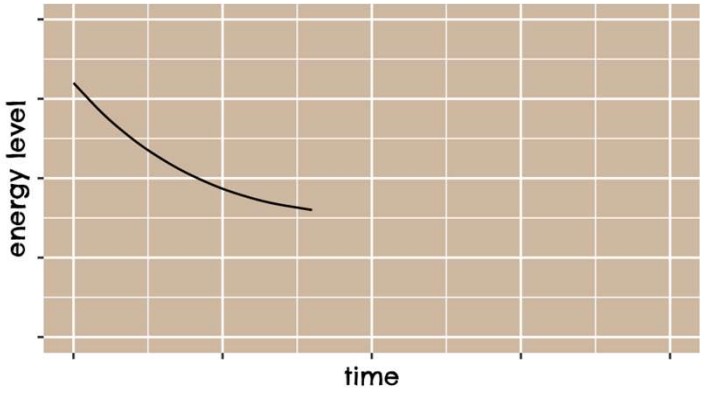

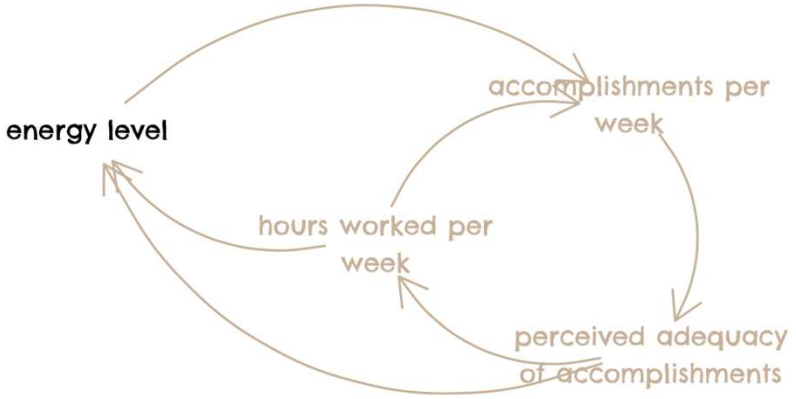

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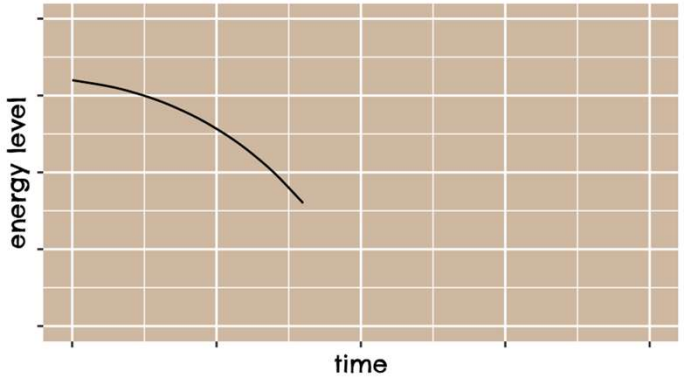

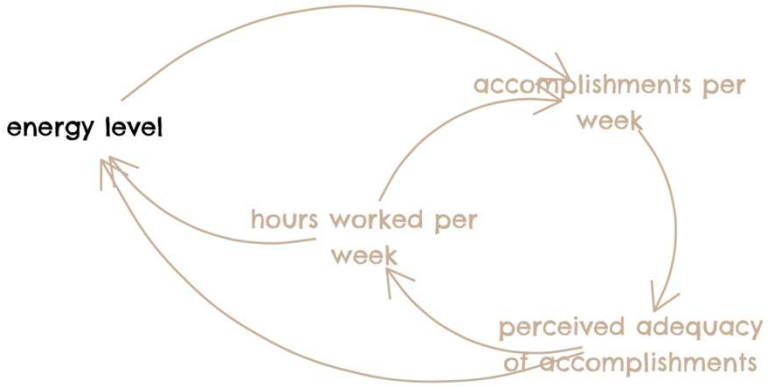

Your energy level starts declining.

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Conclusions

A New Approach to Communicate CLDs

- DSL allows us to explain CLDs **bit-by-bit**
  - To ensure that the CLD's **circular structure is not concealed,** the whole model is always kept visible (greyed out)
  - Highlighting certain elements helps to **break the CLD into understandable pieces**
- **Compensate for the information loss*** by providing additional descriptions
- **Reach a broader target audience** through a less technical look

* Because link and loop polarity sings are omitted

Communicate Systemic Complexity – Three connected layers

Textual Description <> Causal Structure <> Behavior-Over-Time Graphs

1. **Textual Description:** The first „touch“, accessible to all stakeholders, „narratives“
2. **Causal Structure:** Ensure that the narratives and variables are being interpreted as „belonging together“
3. **Behavior-Over-Time Graphs:** Hypothesize about the behaviour of the problem under study

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Applications

In numerous customer projects, the DSL turned out to be a very valuable tool:

i. to develop a common problem understanding;

ii. to communicate that understanding to stakeholders beyond the project team;

iii. to foster strategic decision-making.

A particular appealing application of the developed DSL is a project funded by 'Innosuisse - Swiss Innovation Agency' in the field of policy design for elderly care.

Resources

- R-Code is hosted at: https://github.com/ims-fhs/cld
- Short paper about (parts) of the DSL: https://www.springer.com/gp/book/9783030484385
- Models from the «Work-Life Balance 4.0» project (German): https://www.ost.ch/de/forschung-und-dienstleistungen/soziale-arbeit/ifsar-institut-fuer-soziale-arbeit-und-raeume/integration-und-arbeit/work-life-balance-40/wirkungszusammenhaenge
- The “Burnout Model” App (German): https://fhsg.shinyapps.io/burnout/
- Information on «Who Cares», the project in elderly care: https://forschungsmosaik.ch/alterspolitik-who-cares/

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Discussion

… I’m looking forward to further discuss the case. adrian.staempfli@ost.ch

Thank you!

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