# THE SKY IS NOT THE LIMIT:
# Multitasking Across GitHub Projects


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Octocat, here and elsewhere, by GitHub https://octodex.github.com


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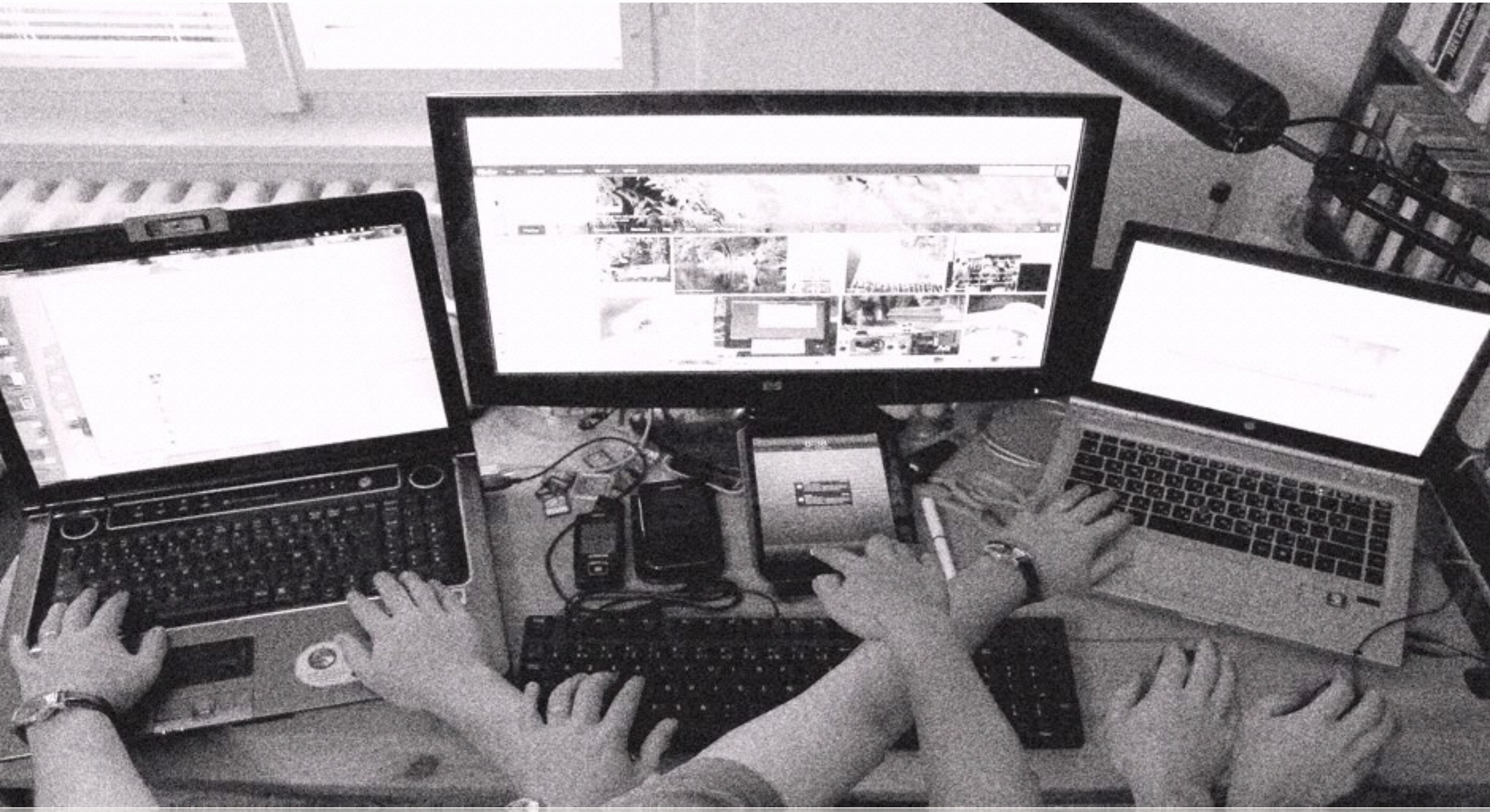
THE UNIVERSITY OF AUCKLAND NEW ZEALAND

University of Victoria

NSF 1247280 1414172

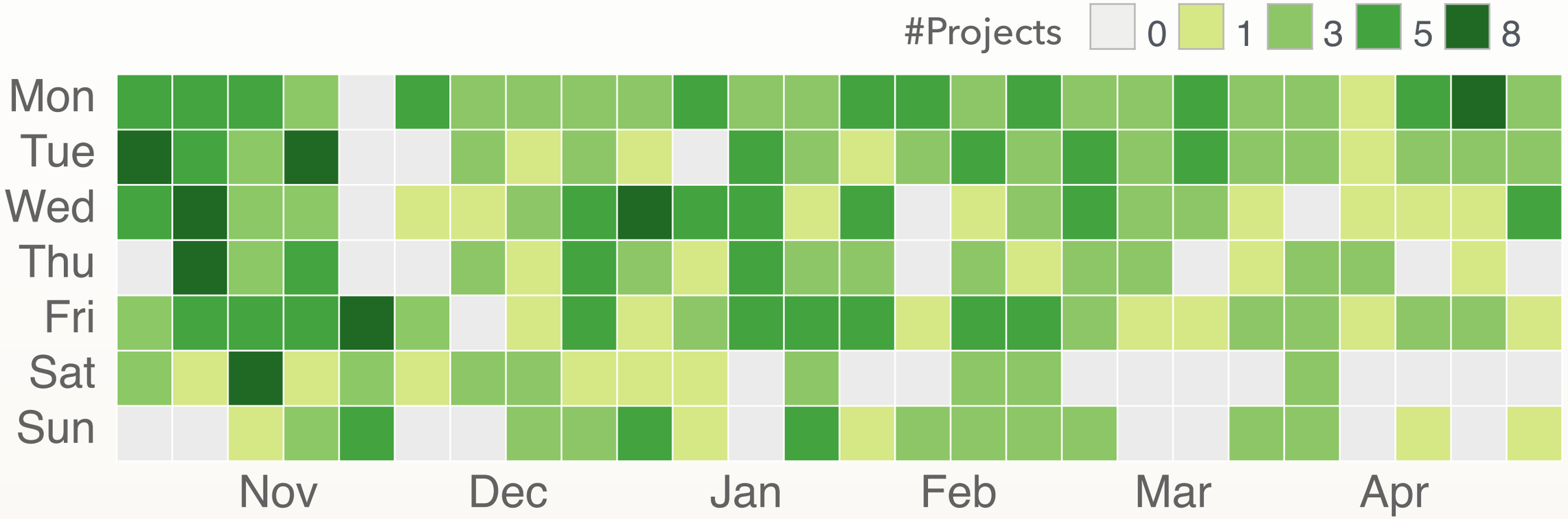
# Multitasking is common

#icsenumber



# Software developers multitask too

**EXAMPLE:** GitHub developer (25 Nov 2013 – 18 May 2014)



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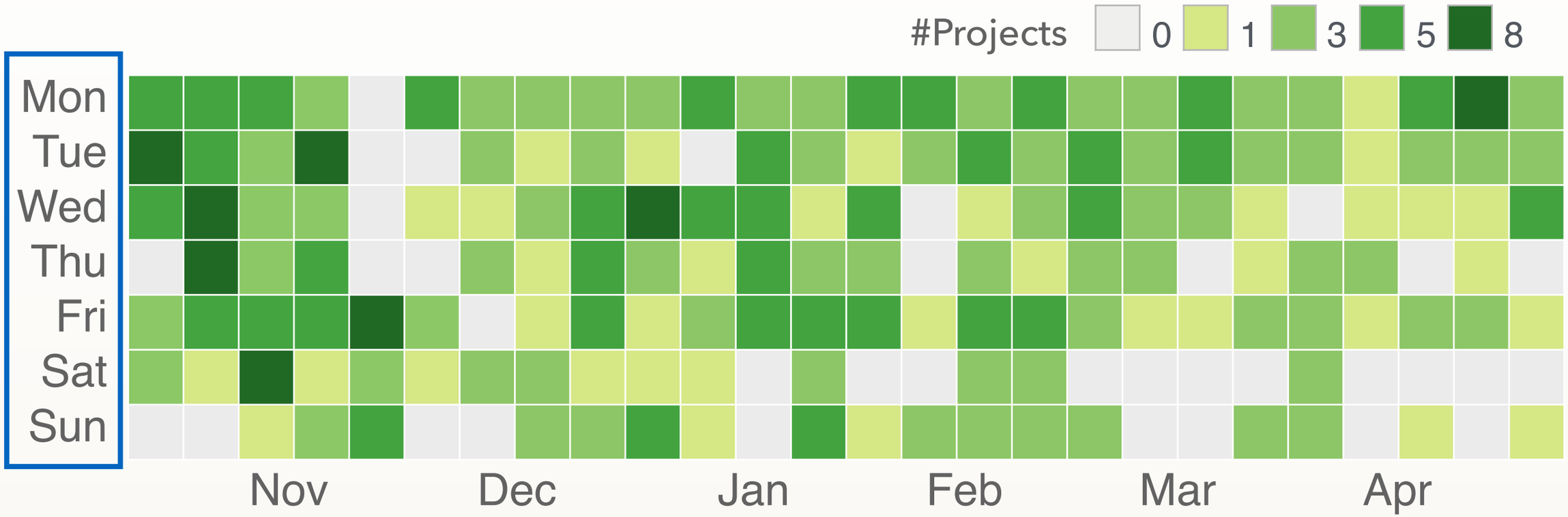

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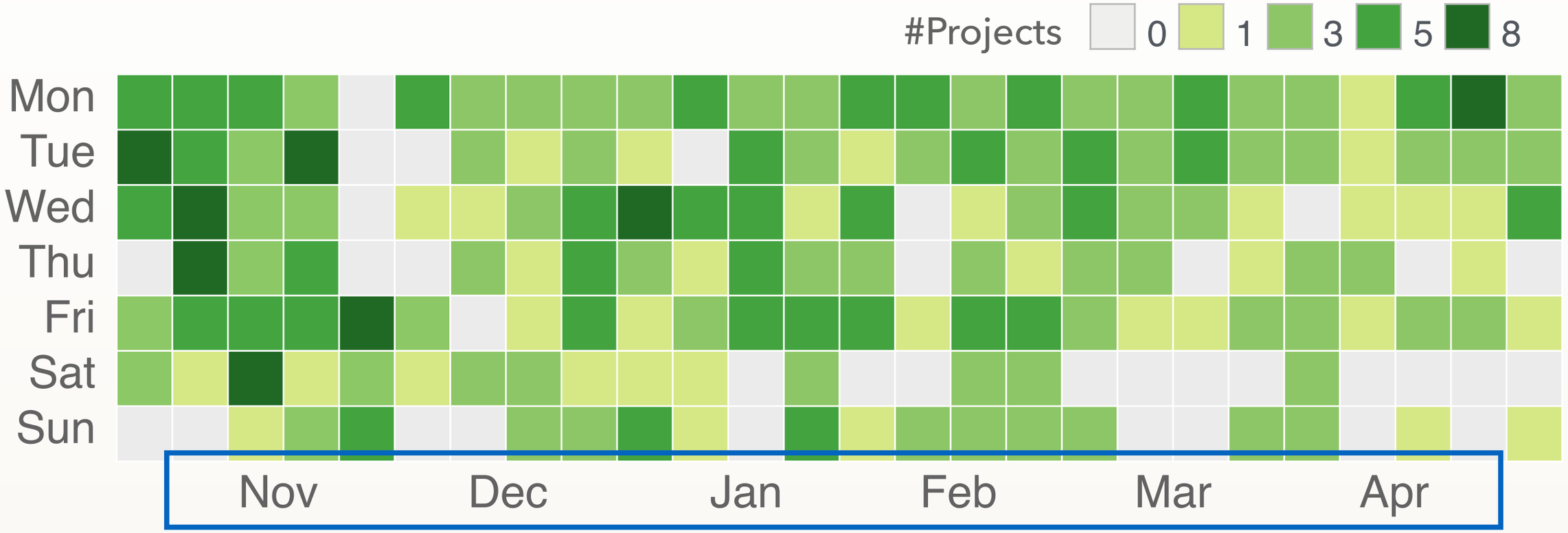

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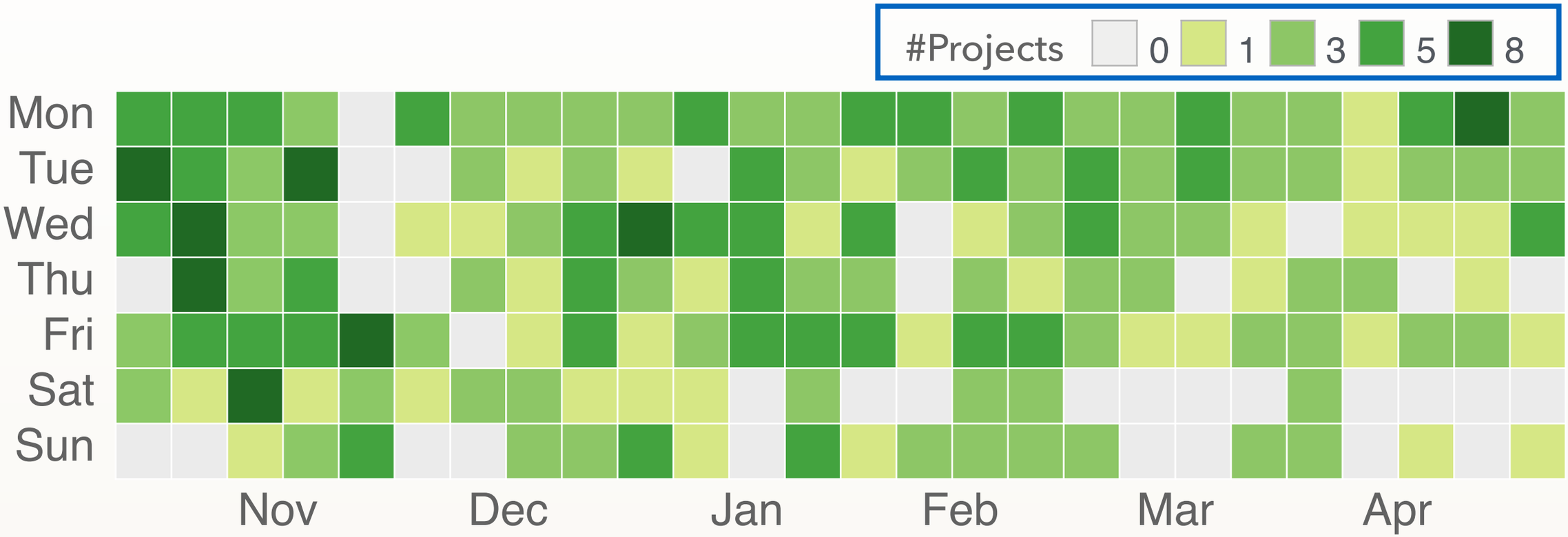

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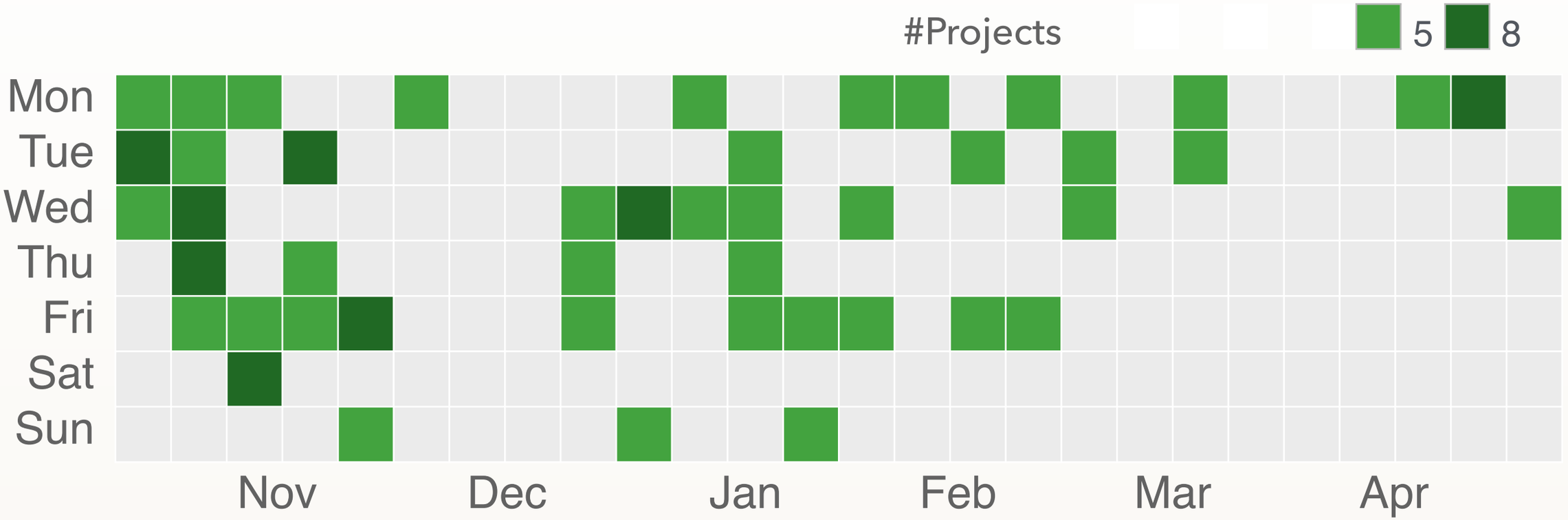

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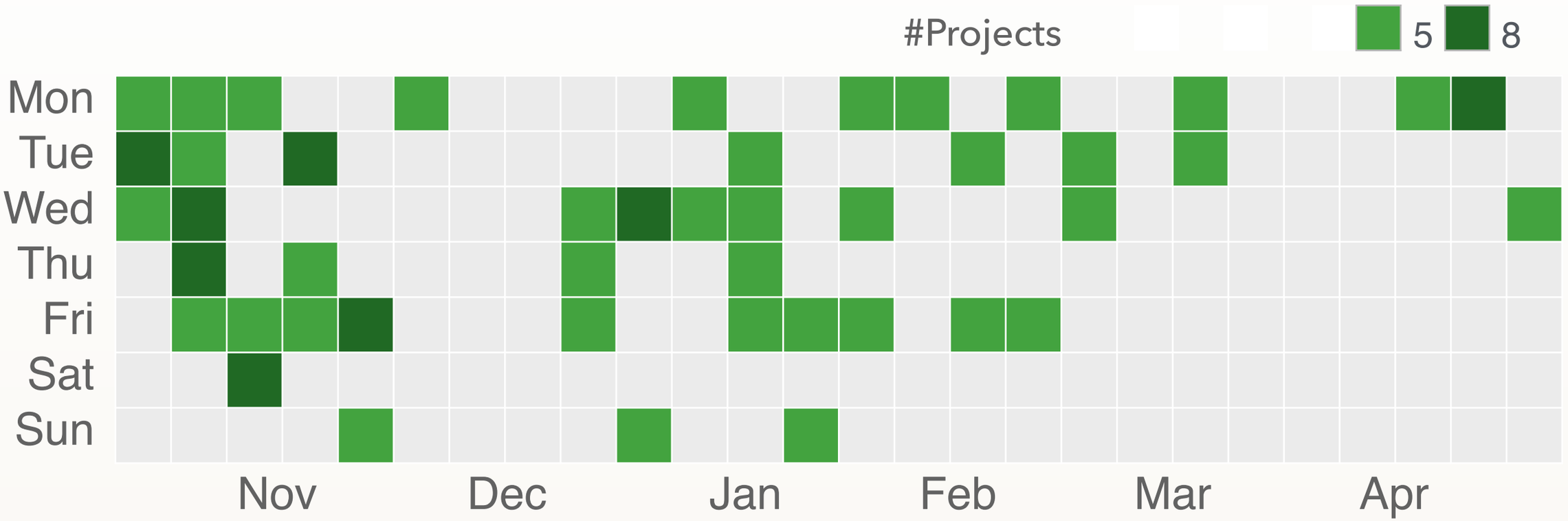


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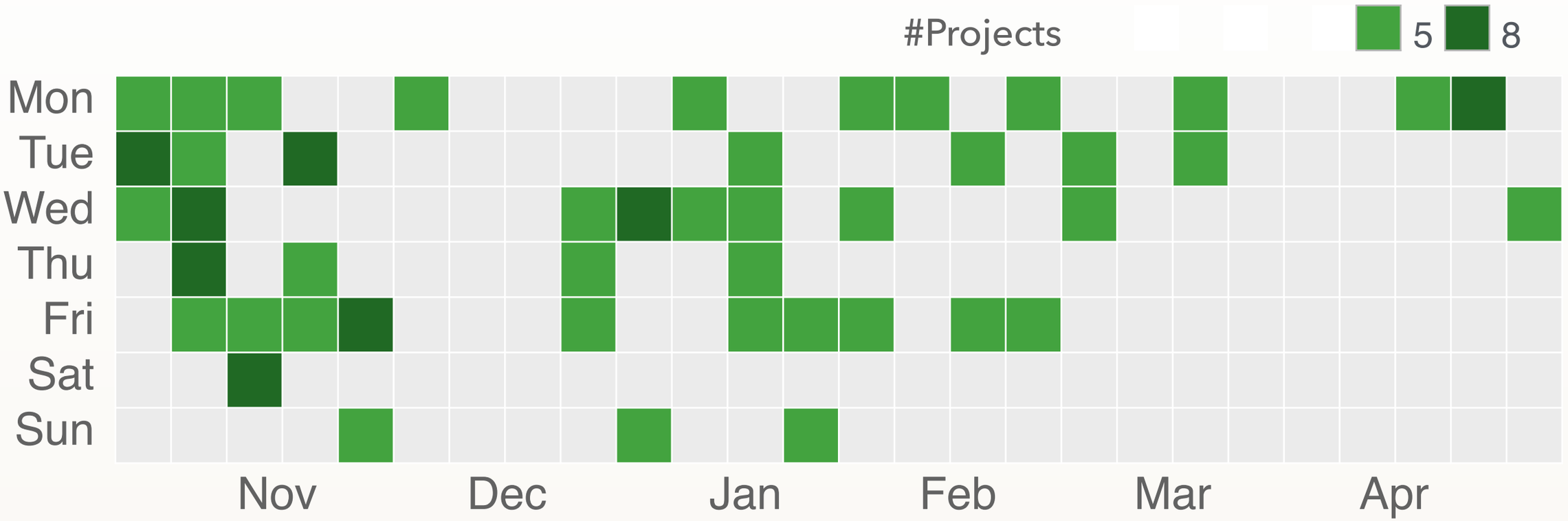


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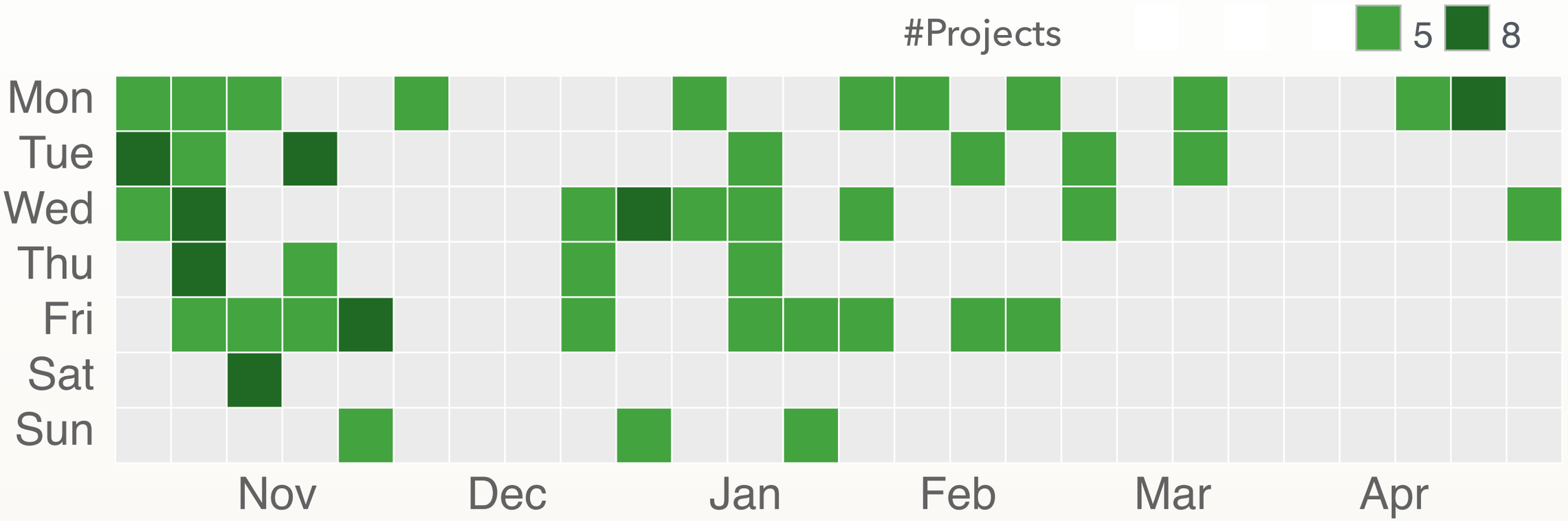


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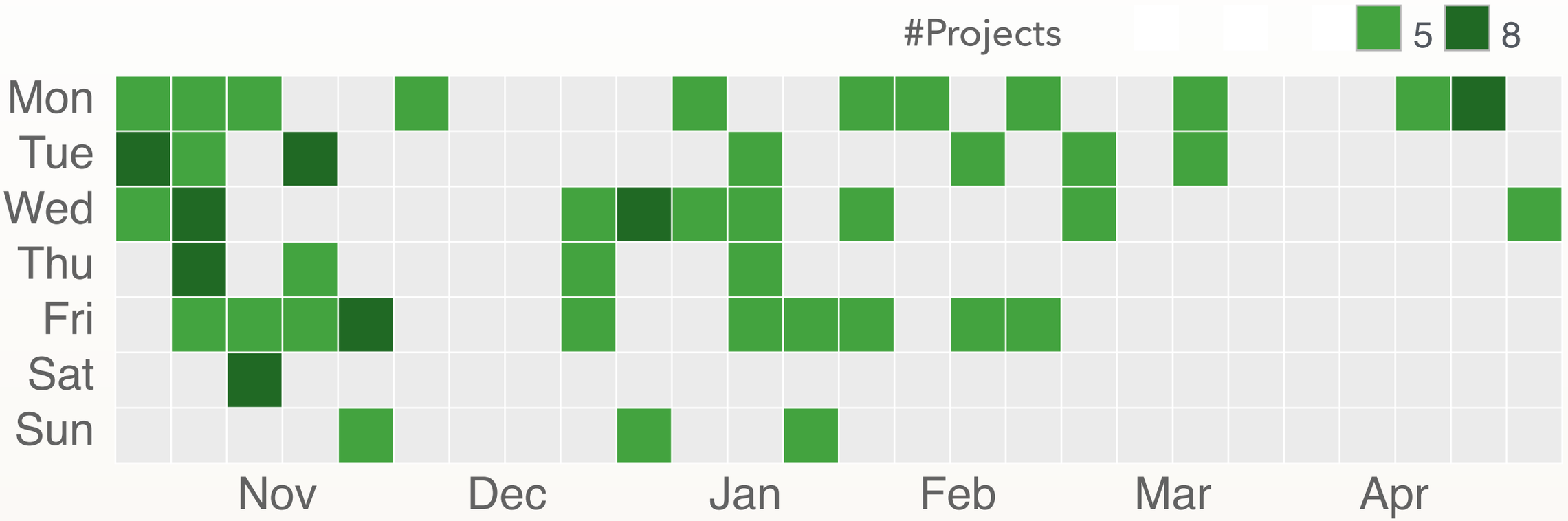


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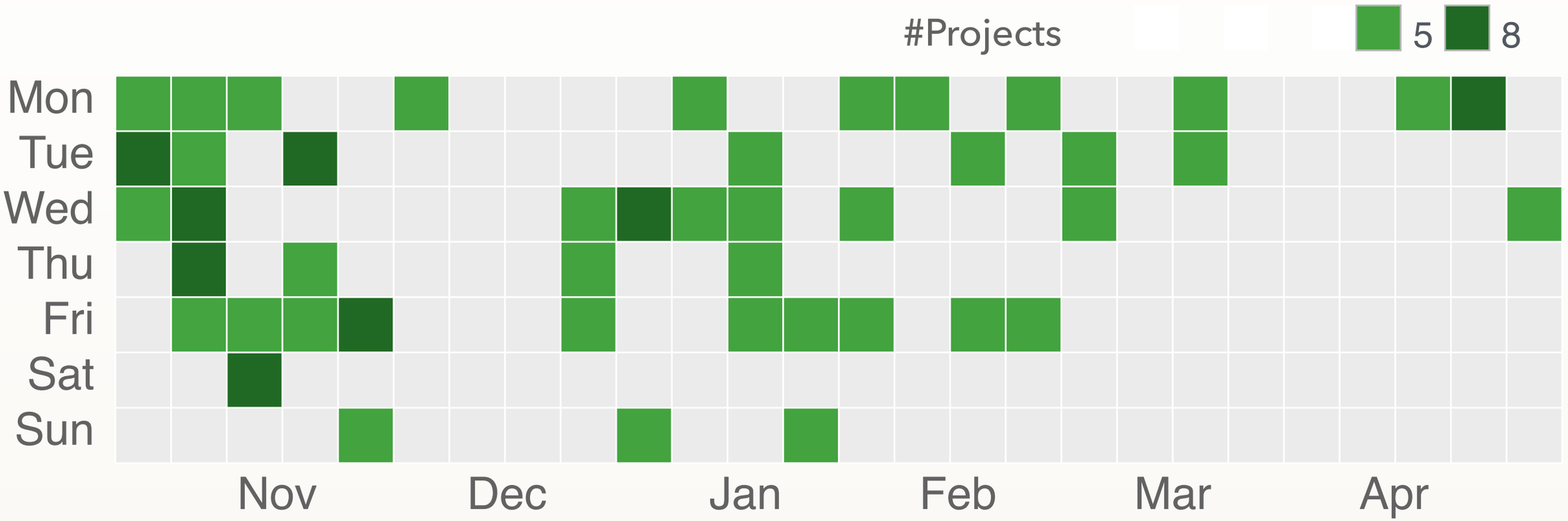


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  Depends on interruption duration, complexity, moment

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Mental congestion when too much multitasking

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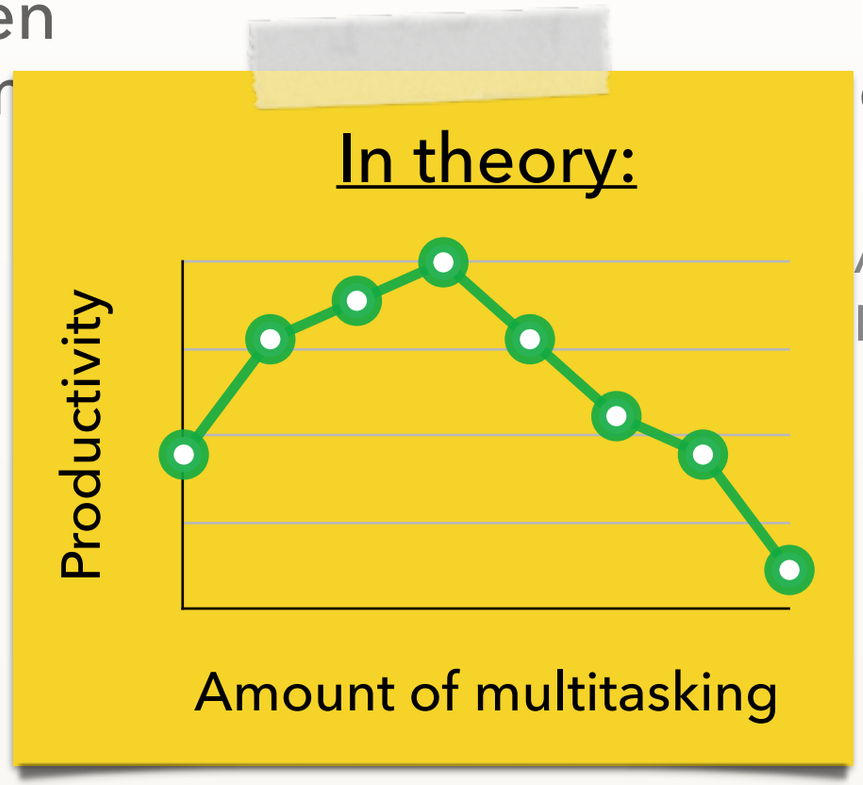


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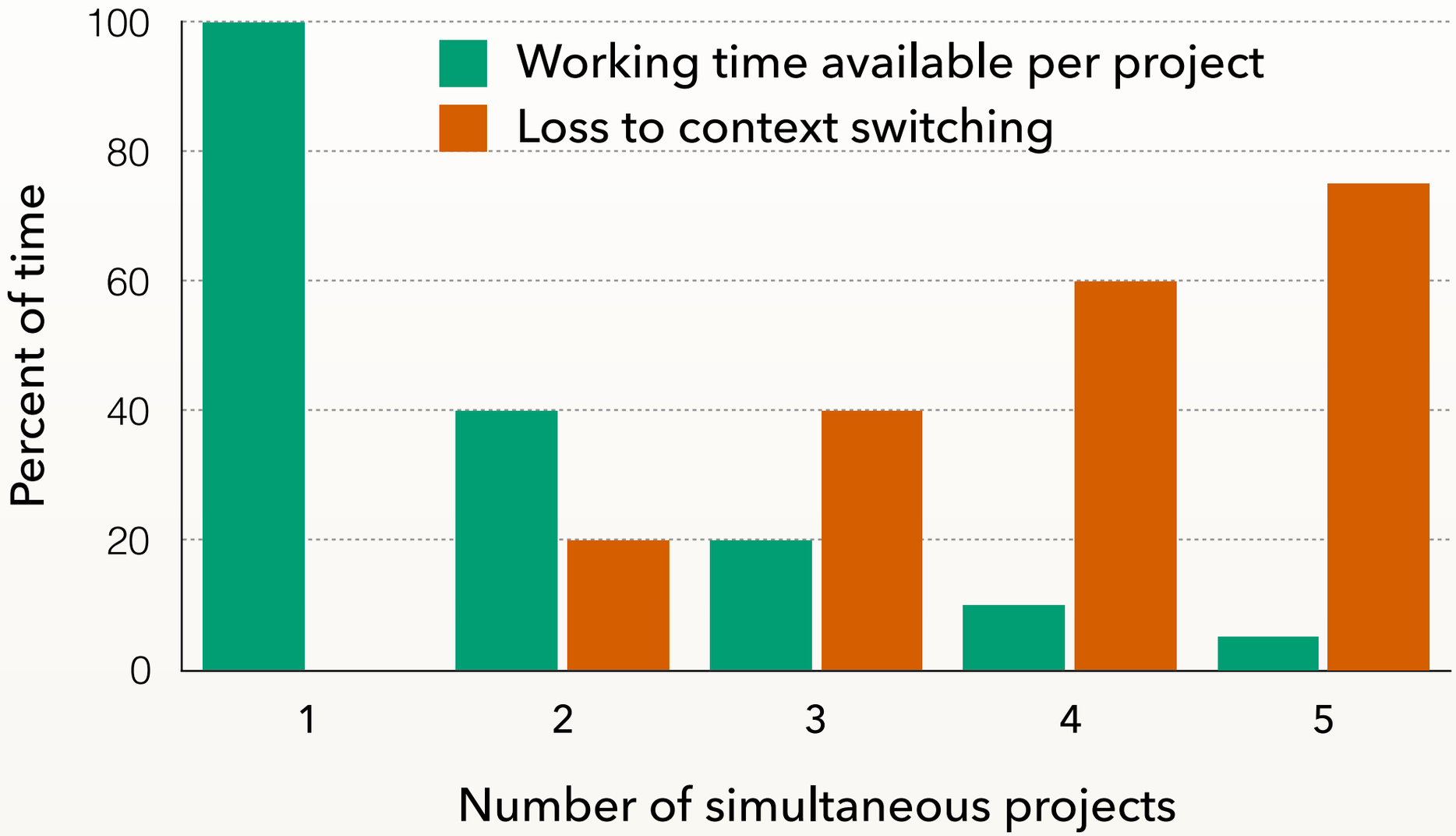


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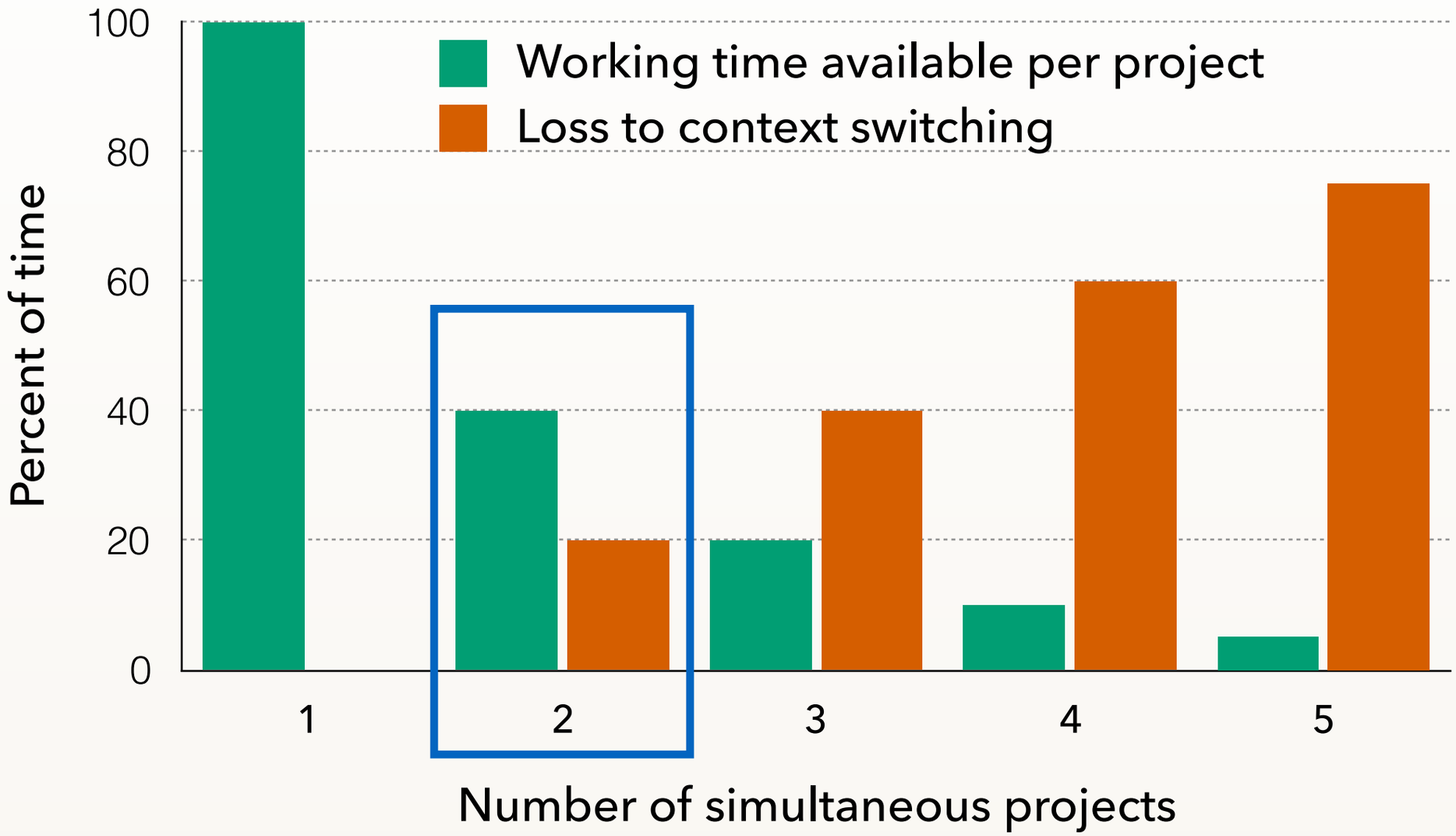


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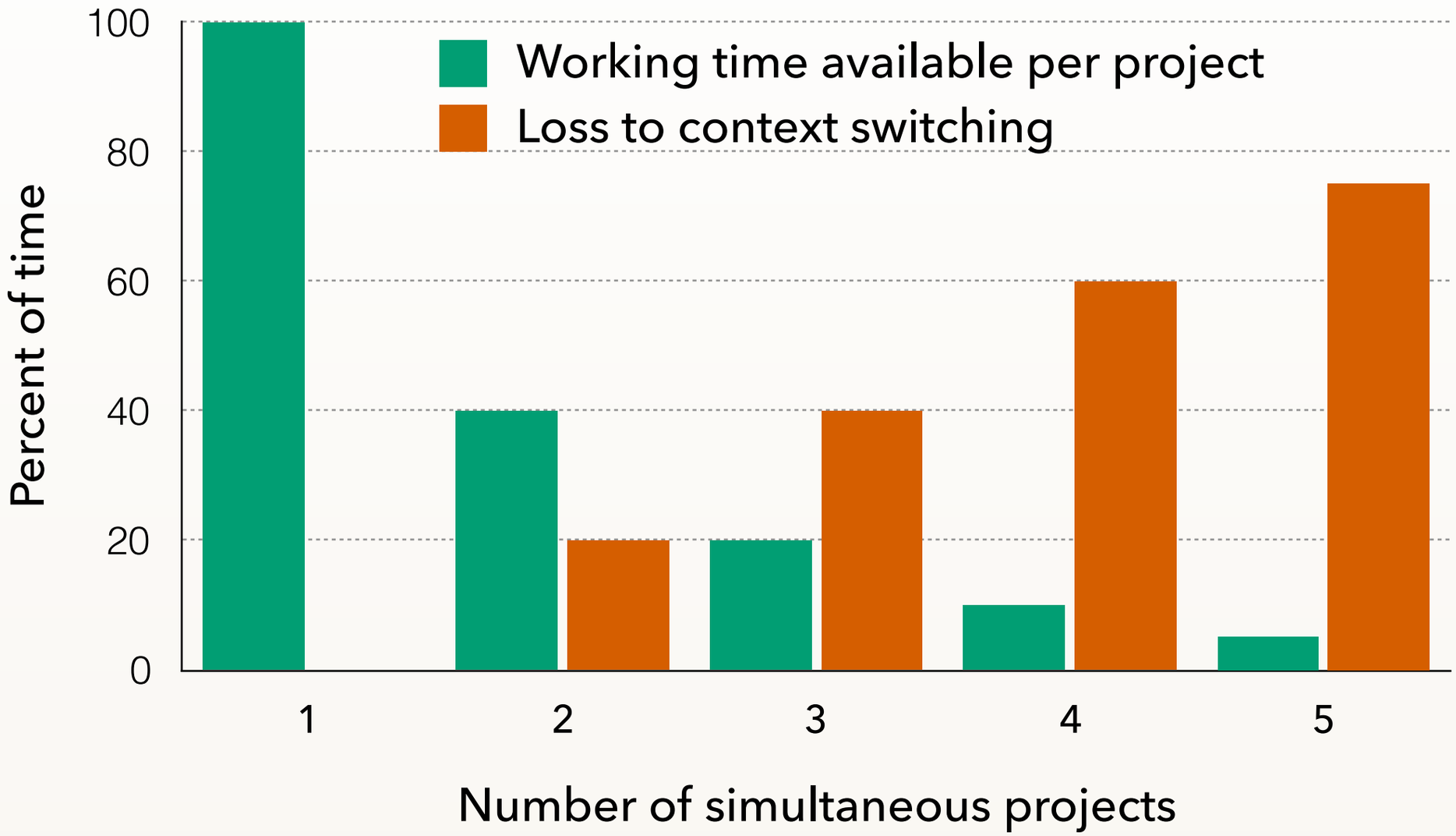


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## Recent work:

- Resuming interrupted tasks
  (Parnin and DeLine, 2010)
- Work fragmentation
  (Sanchez, Robbes, and Gonzalez, 2015)

# Hardly any empirical evidence

… but lots of data to test theories on.


14 million people

35 million projects

# This work: Large-scale empirical study

## WHAT?

**Multitasking across projects**

? Trends ? Reasons ? Effects ? Limits

## HOW?

**Sample:**

- 1,200 programmers
- 5+ years of activity
- 50,000+ projects total

**Data mining** + **User survey**
(15% resp. rate)

# This work: Large-scale empirical study

github SOCIAL CODING

WH

## Software developers multitask too

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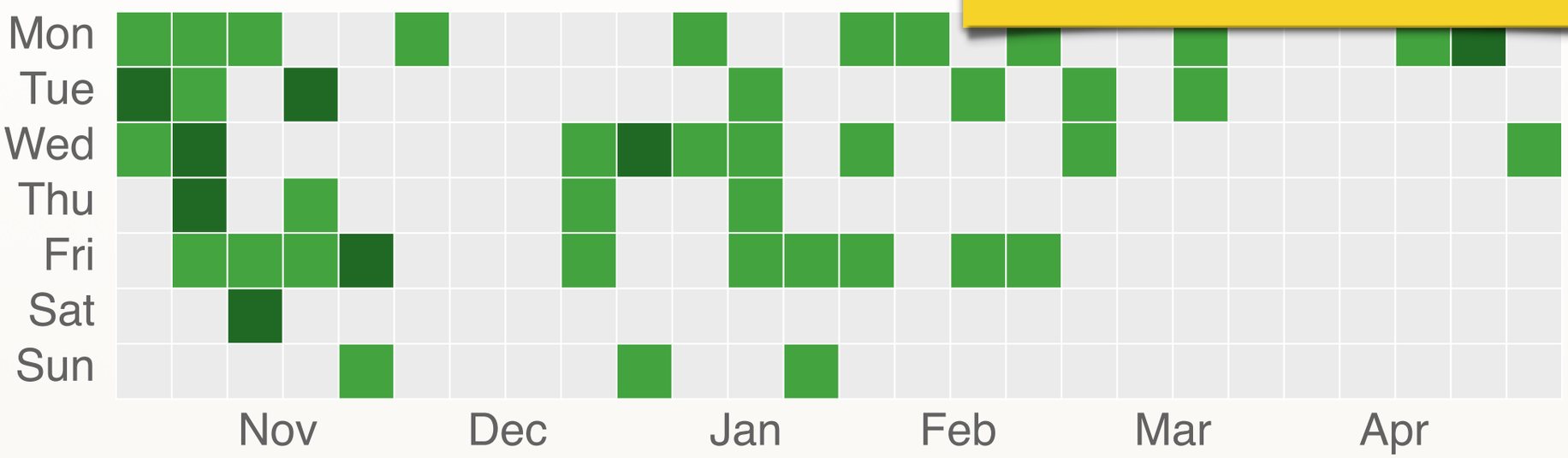


**Trends & Reasons: Details in paper**

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- Personal interest
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- Working for free? Motivations of participating in open source projects
  A. Hars and S. Ou. *HICSS 2001*
- The open source software development phenomenon: An analysis based on social network theory
  G. Madey, V. Freeh, and R. Tynan. *AMCIS 2002*
- Activity traces and signals in software developer recruitment and hiring
  J Marlow, L Dabbish. *CSCW 2013*

# Effects: perception vs. data

## PERCEPTION

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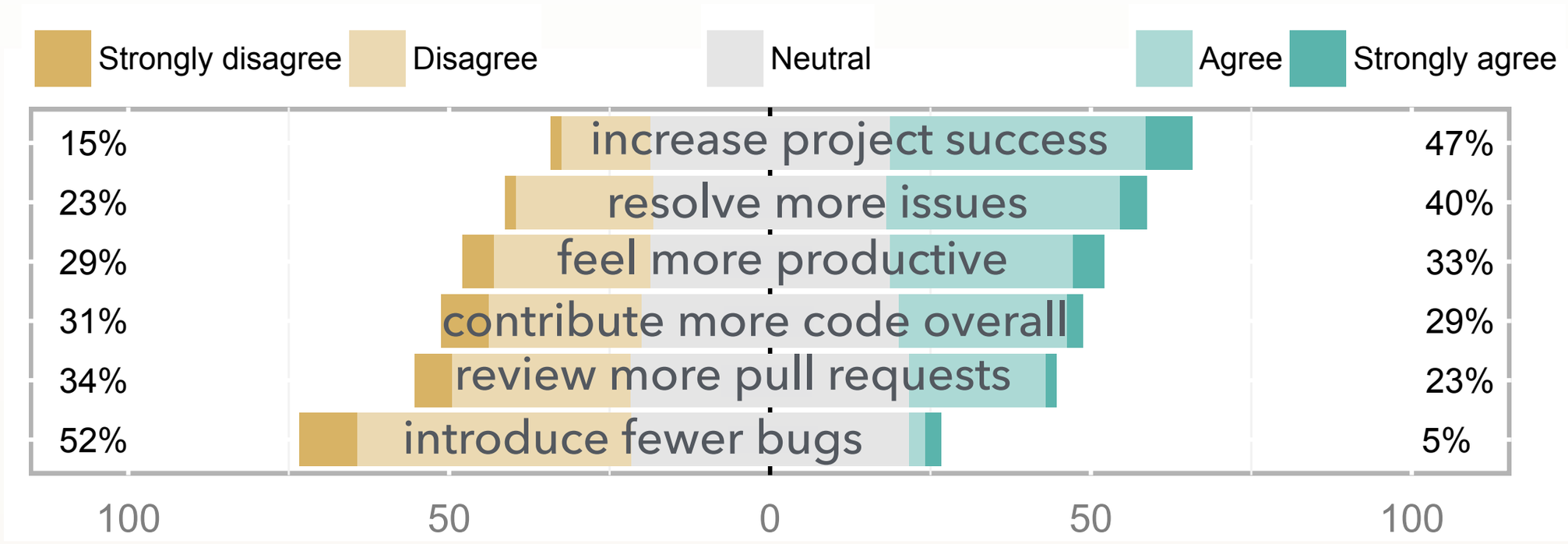

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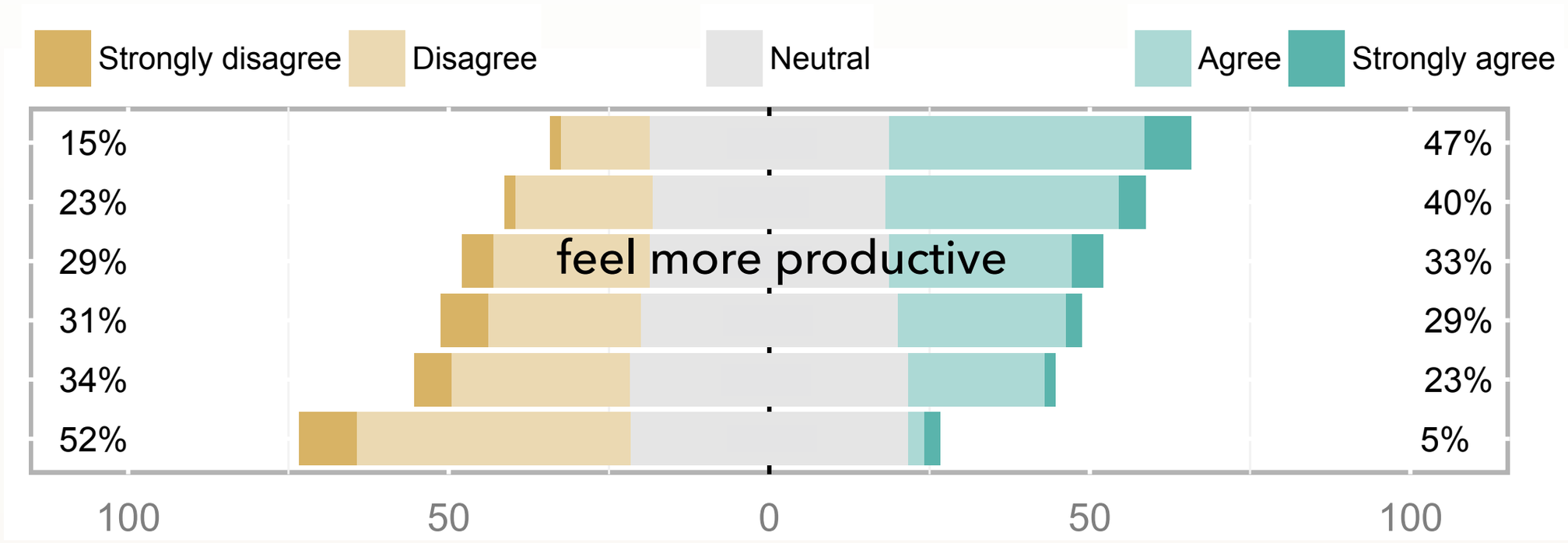

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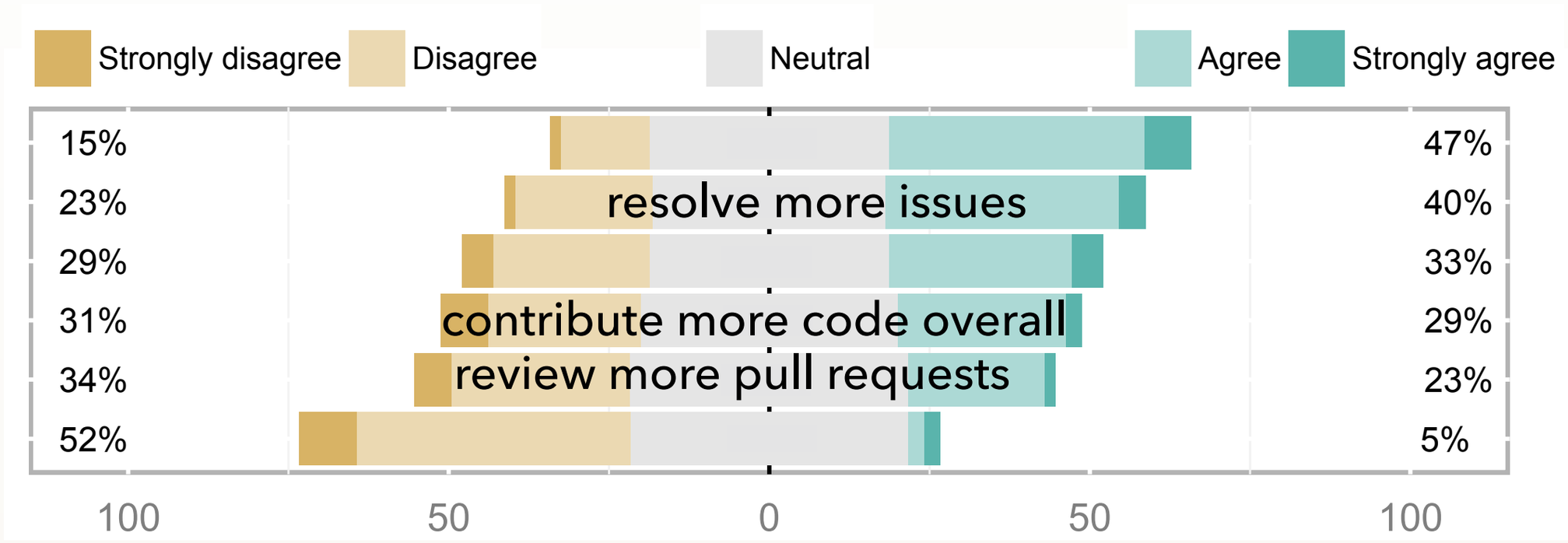

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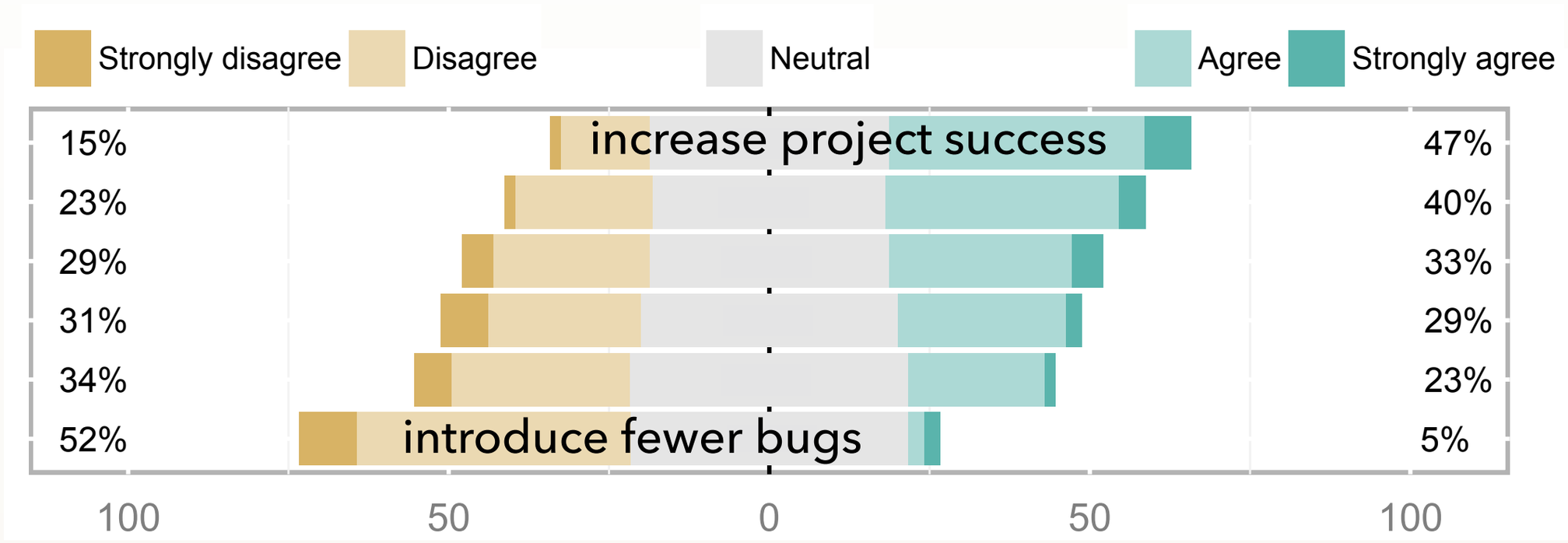

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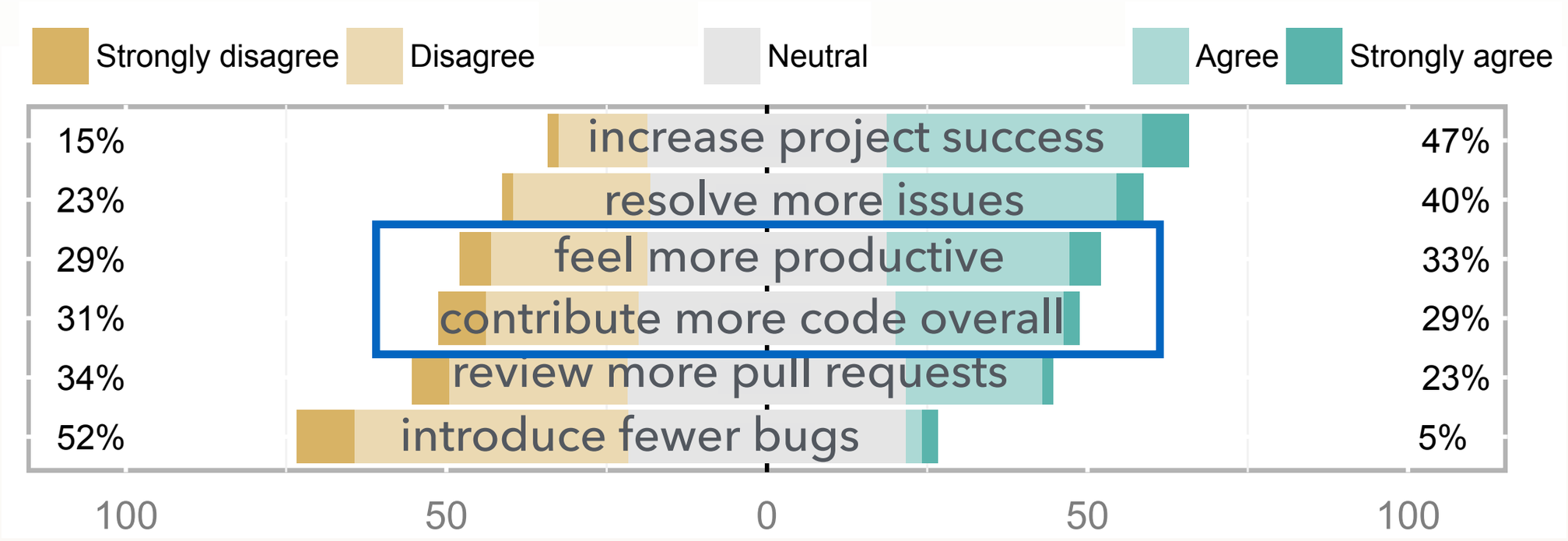


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Multitasking vs. code production

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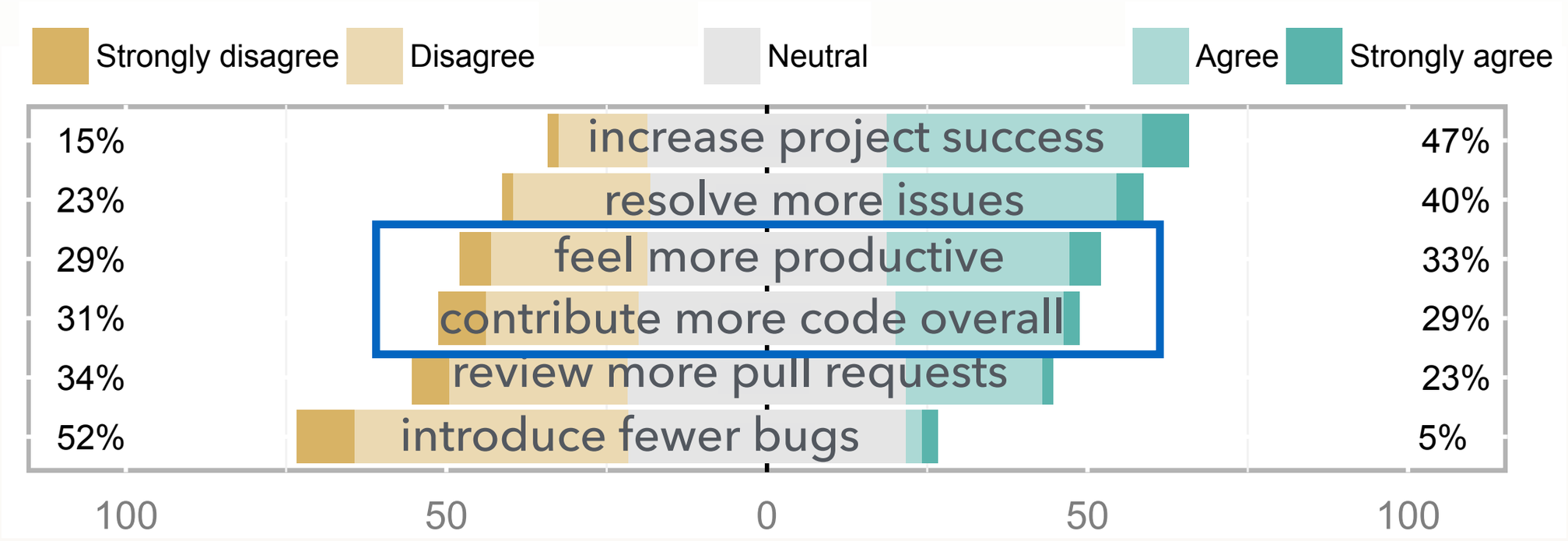


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Daily multitasking correlates to amount of code produced

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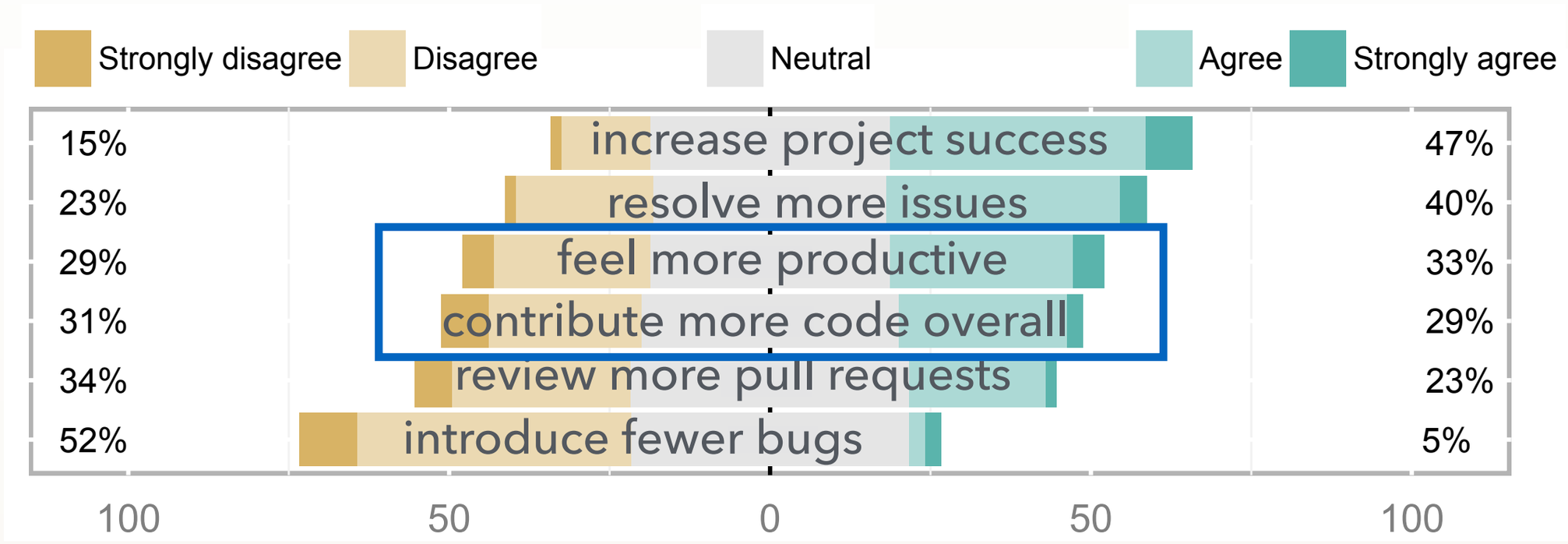


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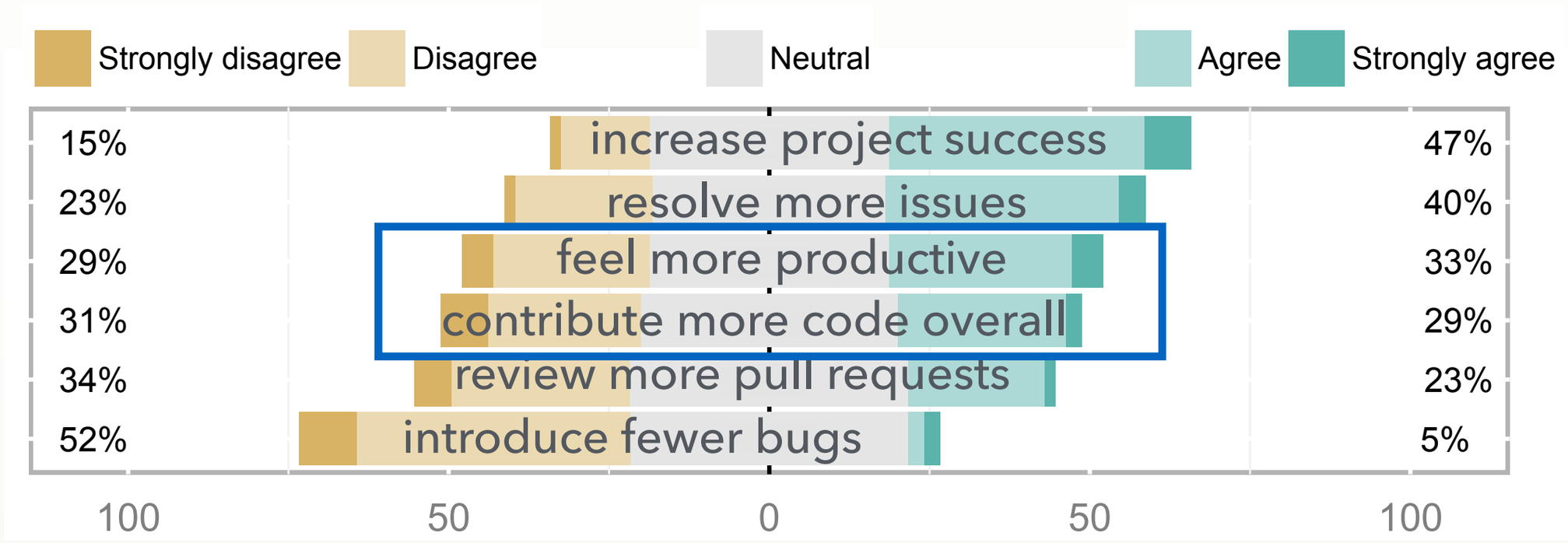


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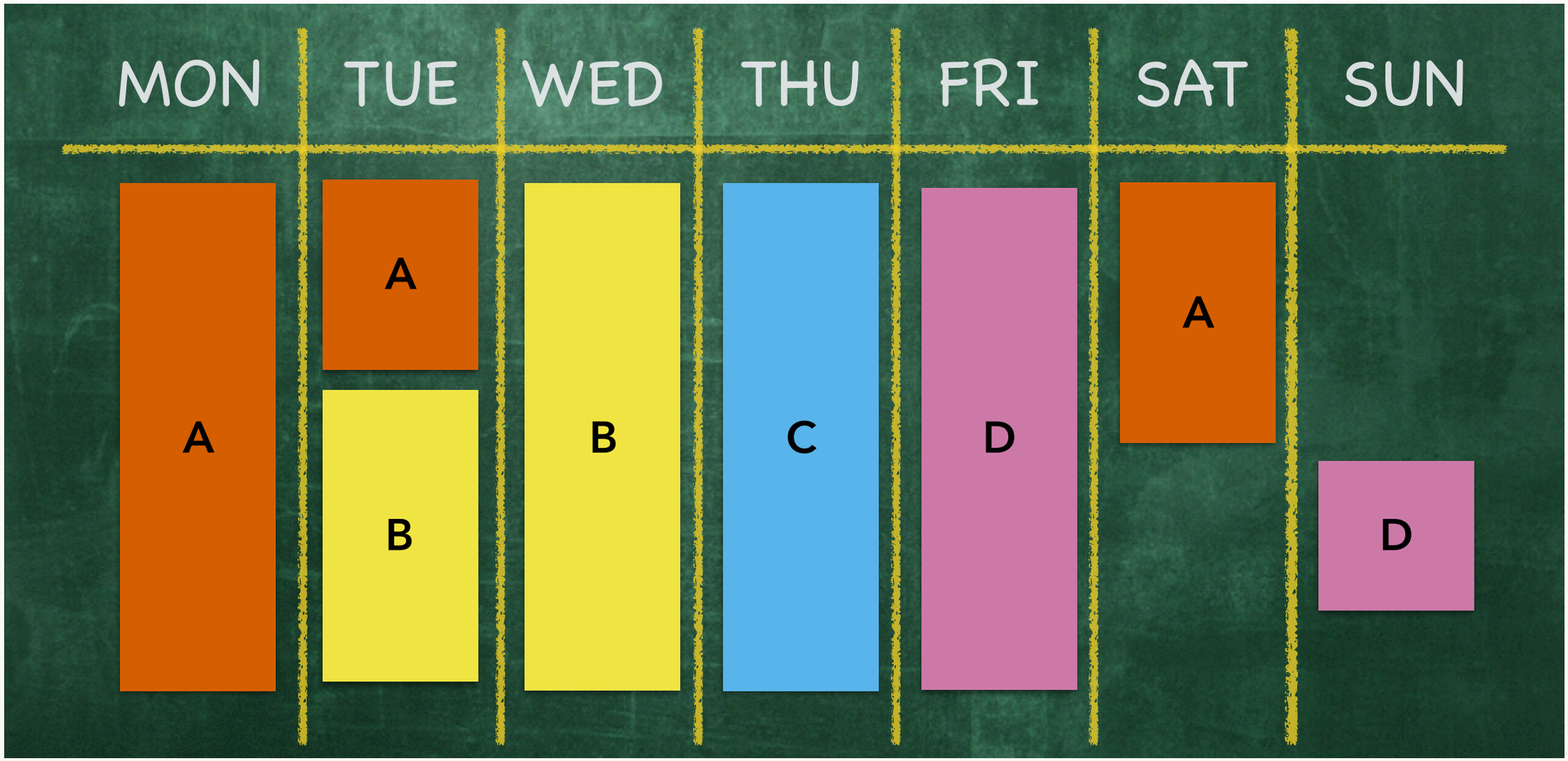
No scheduling is productive beyond 5 projects/week

# Modeling multitasking

- Period matters



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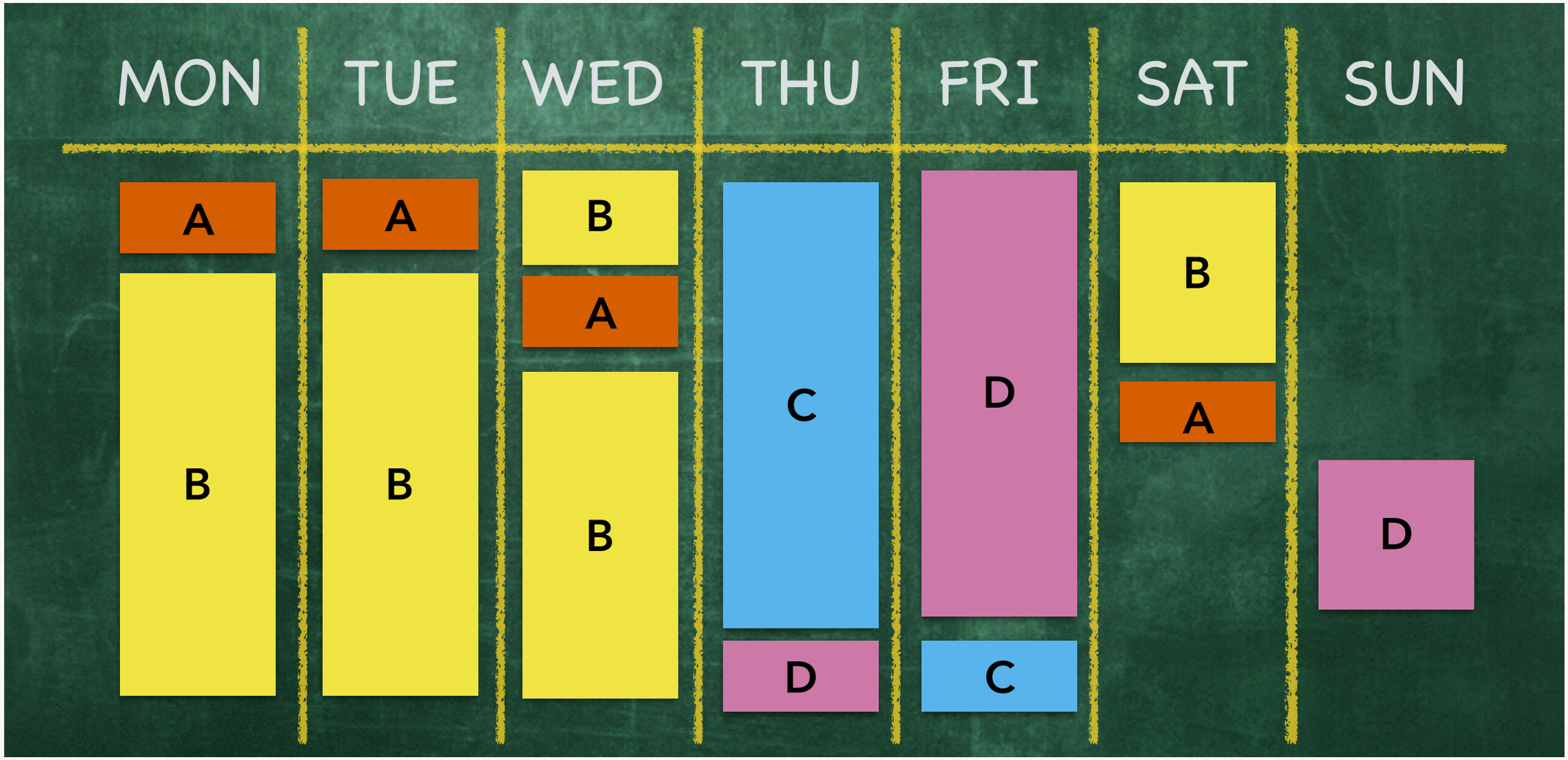

# Modeling multitasking

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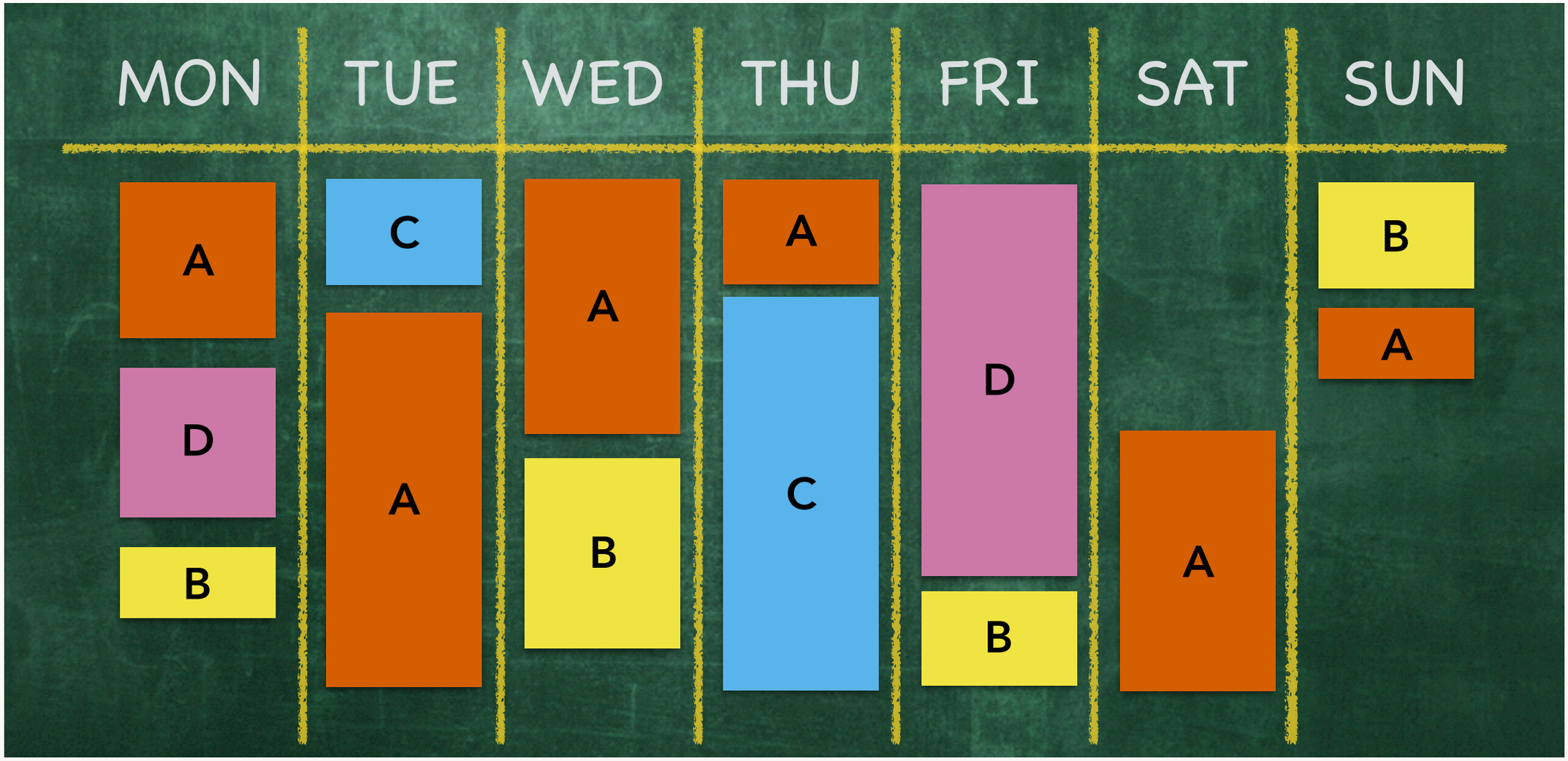
- …



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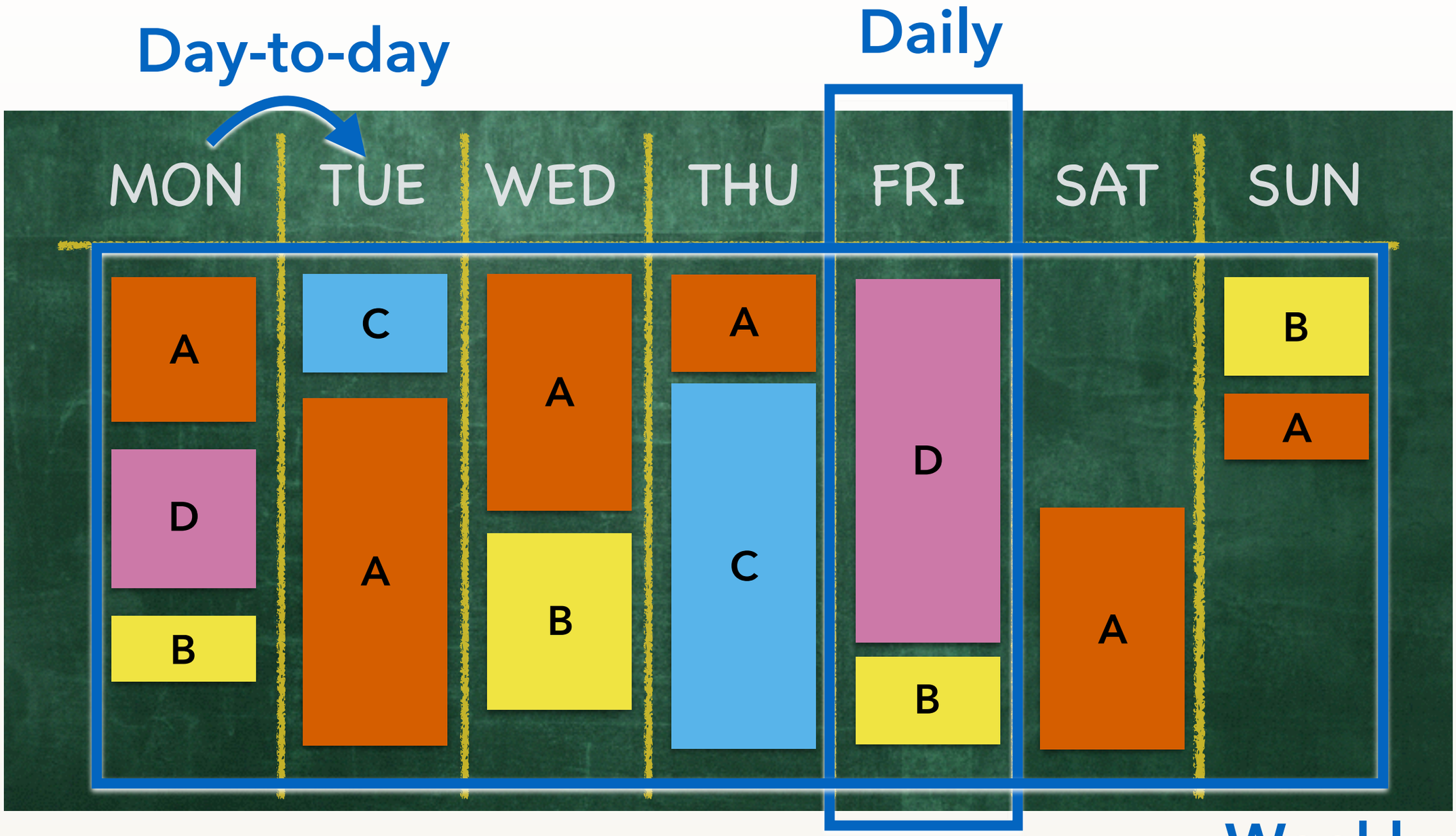


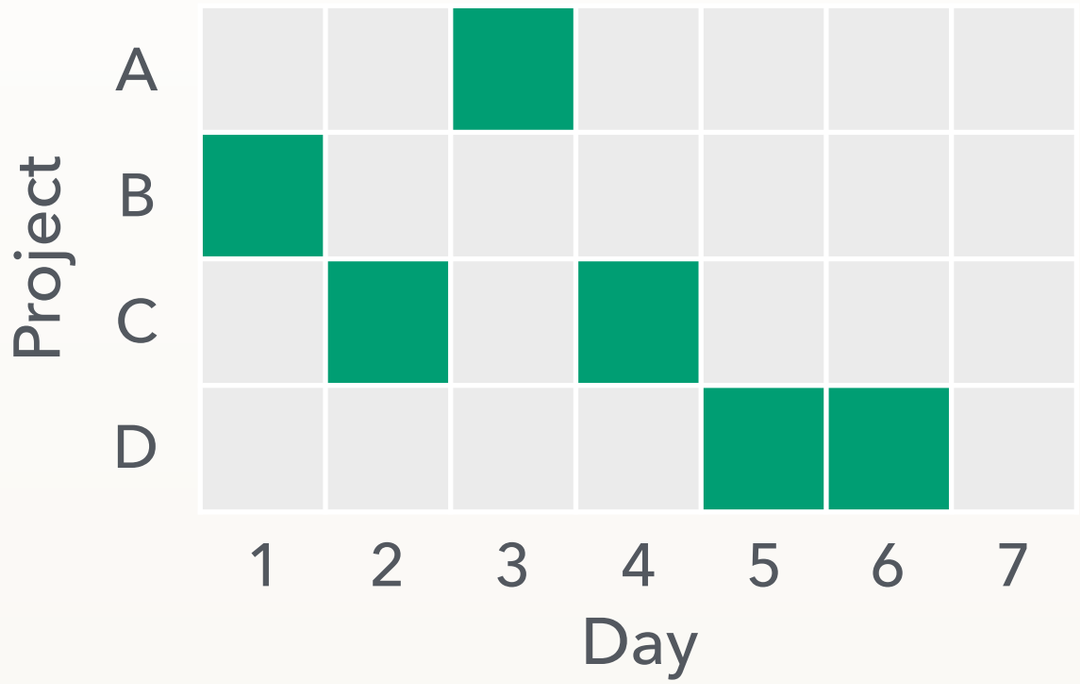

**WE MODELED:**

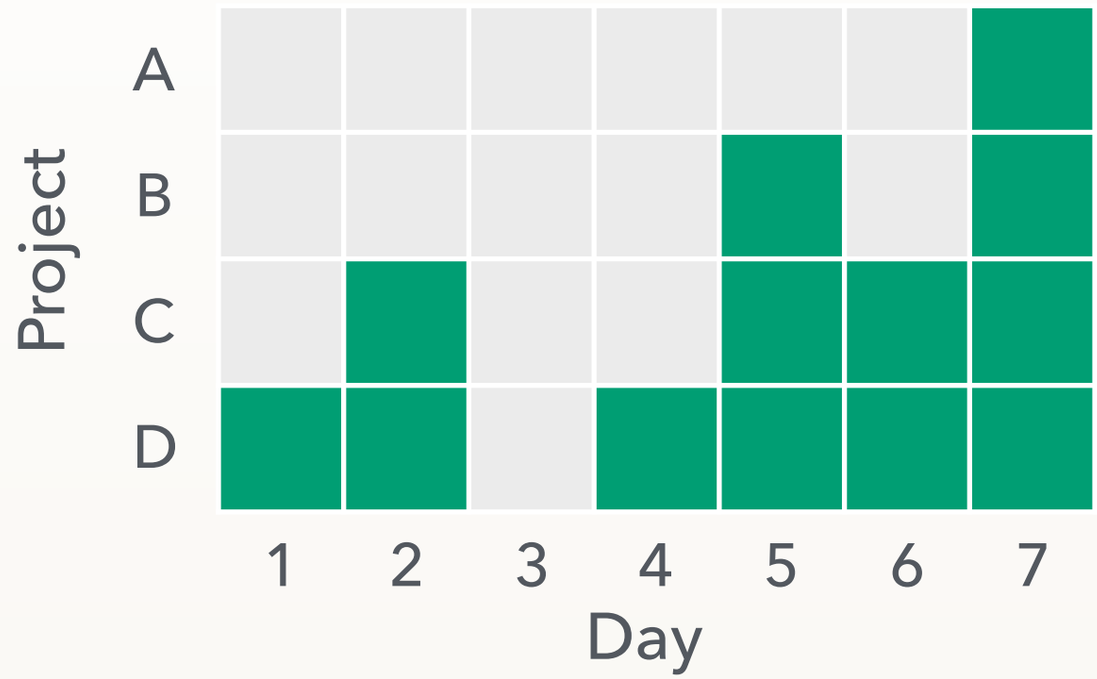
- One-week panels
- Three dimensions

# Multitasking dimensions

## 1. PROJECTS PER DAY

Working sequentially vs. Within-day multitasking



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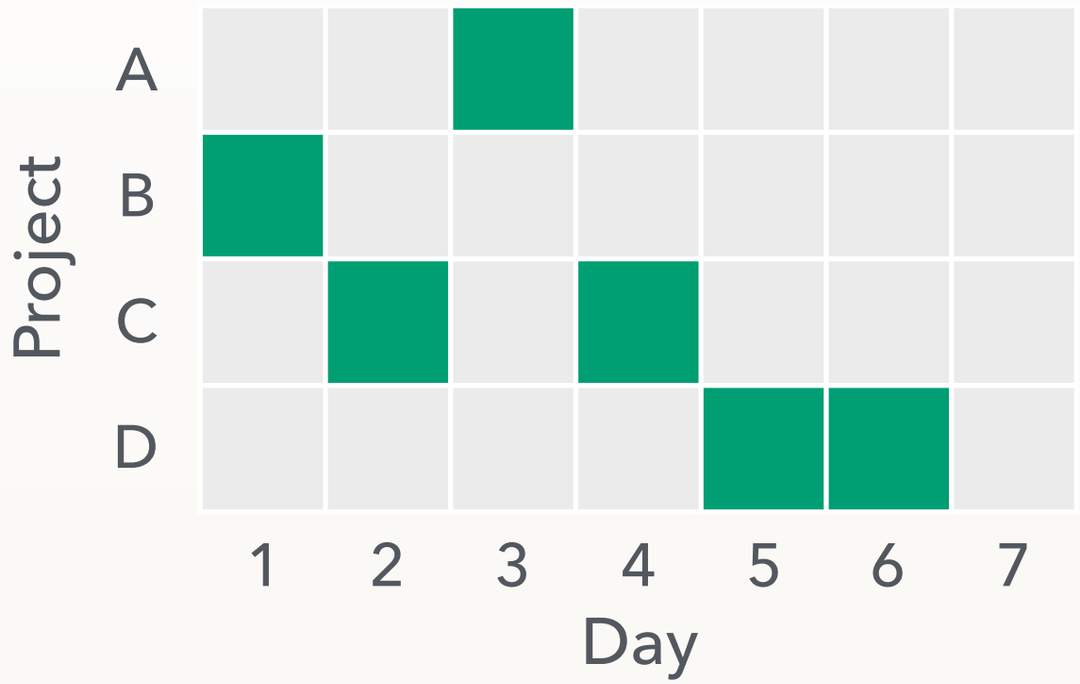
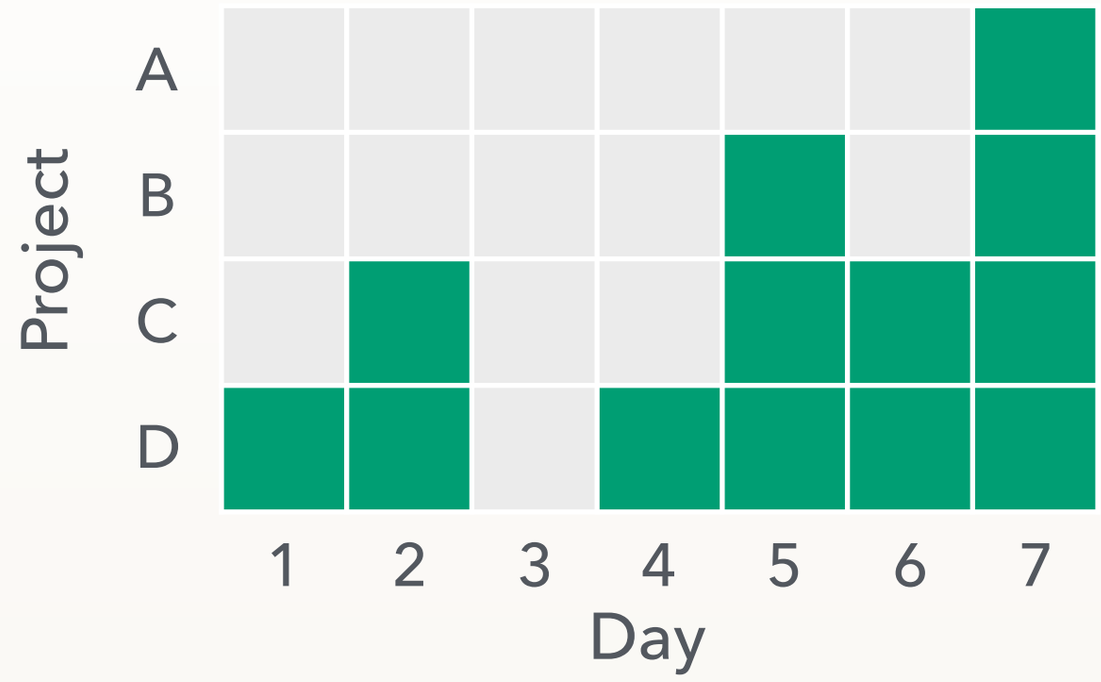



$\text{AvgProjectsPerDay} = 1$

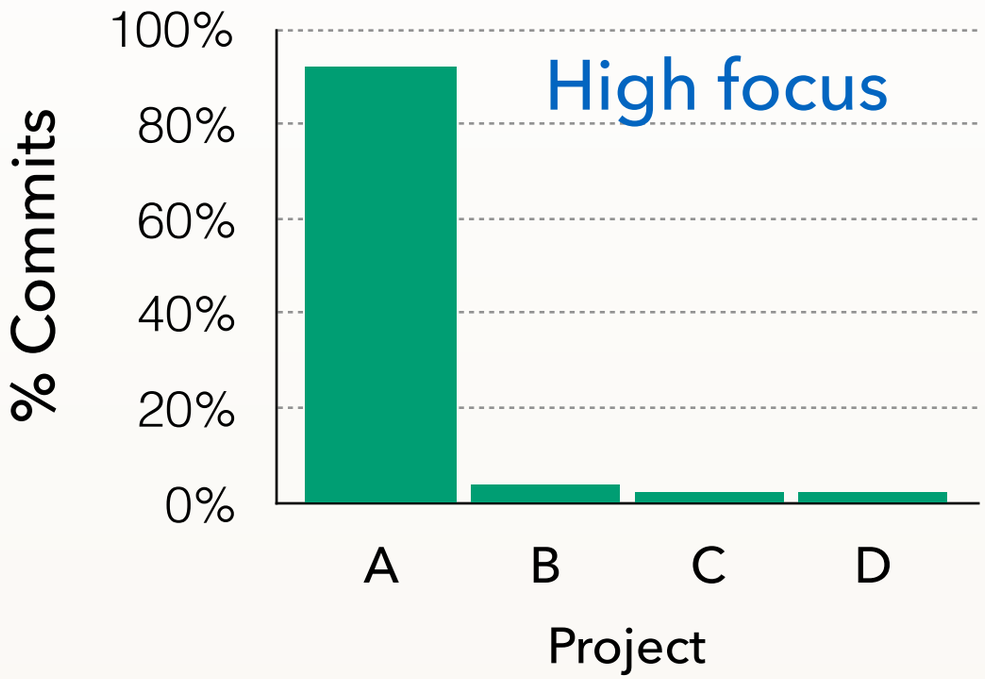


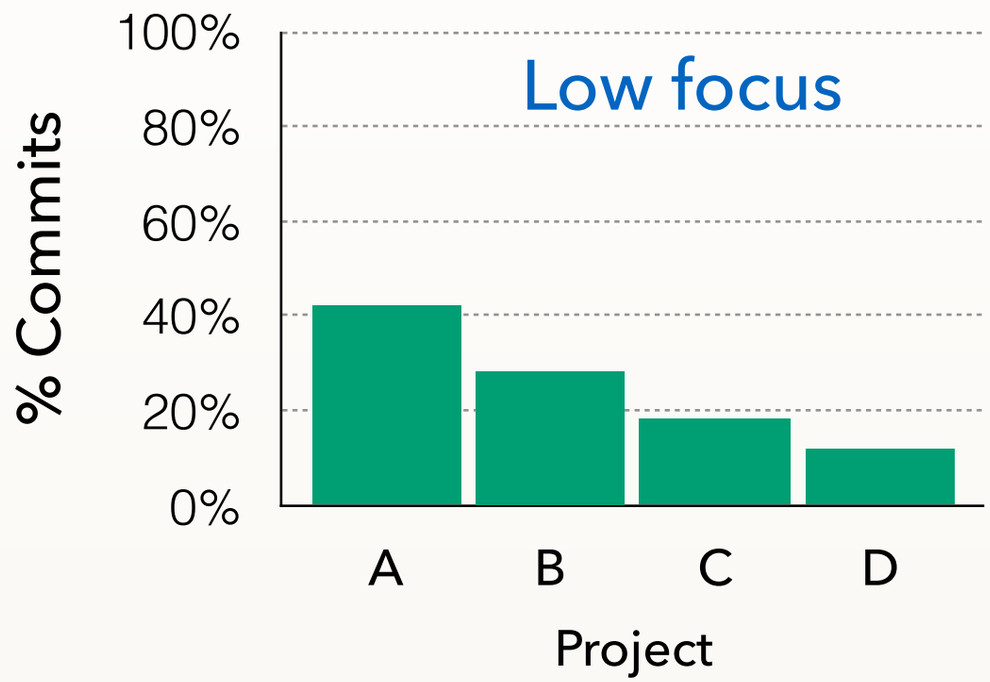

$\text{AvgProjectsPerDay} = 2.2$

# Multitasking dimensions



Focusing on one project vs. Contributing evenly to all



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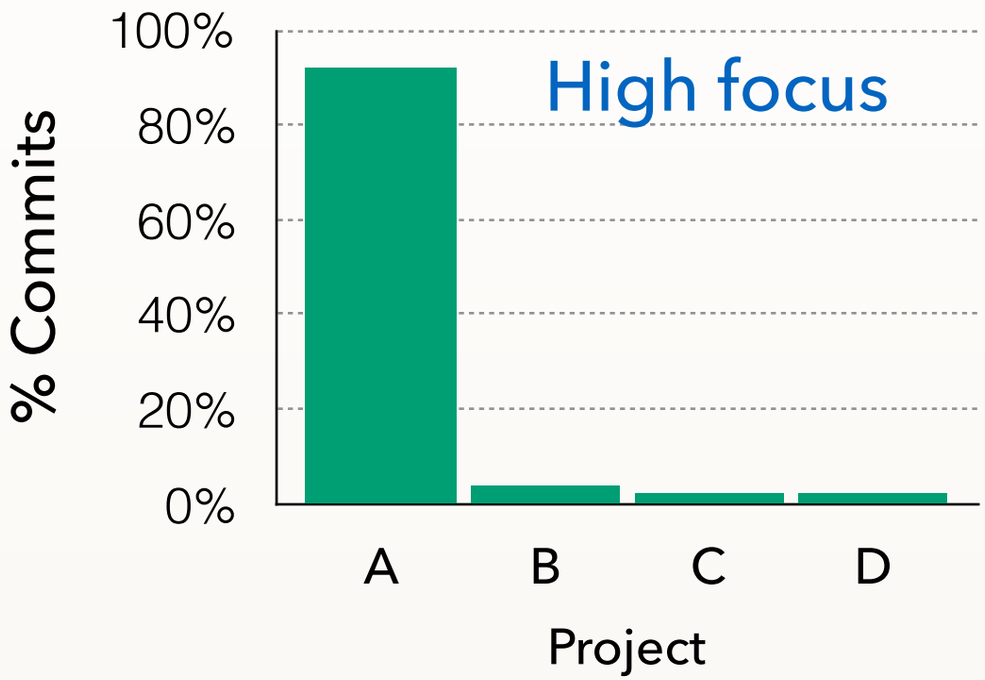


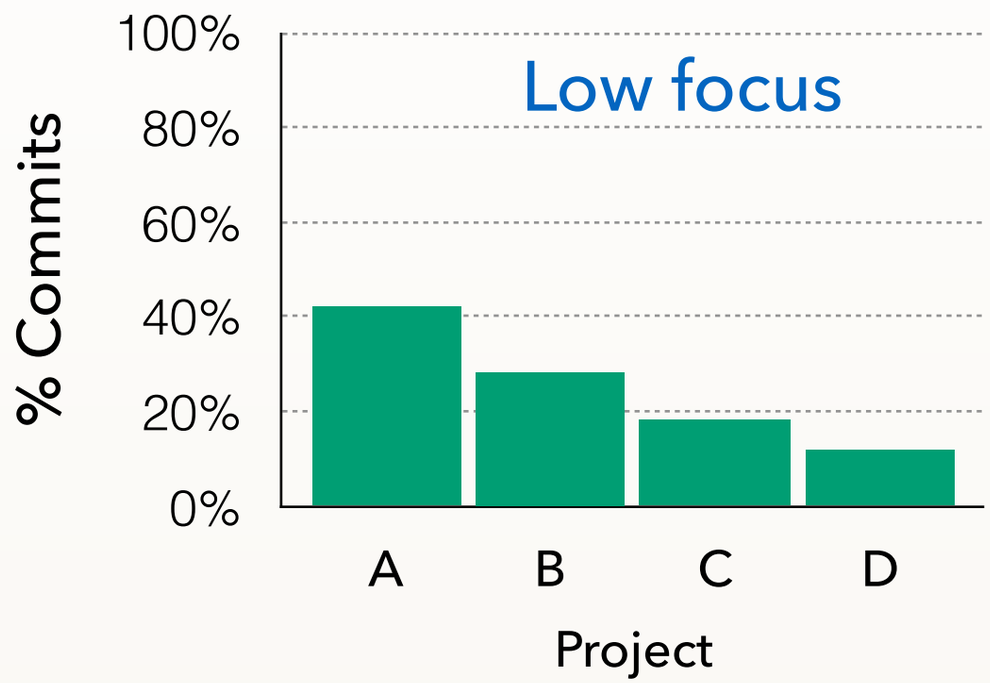


$$S_{\text{Focus}} = 0.25$$

$$S_{\text{Focus}} = 1.85$$

Shannon entropy: $S_{\text{Focus}} = -\sum_{i=1}^{N} p_i \log_2 p_i$

Fraction commits in project i

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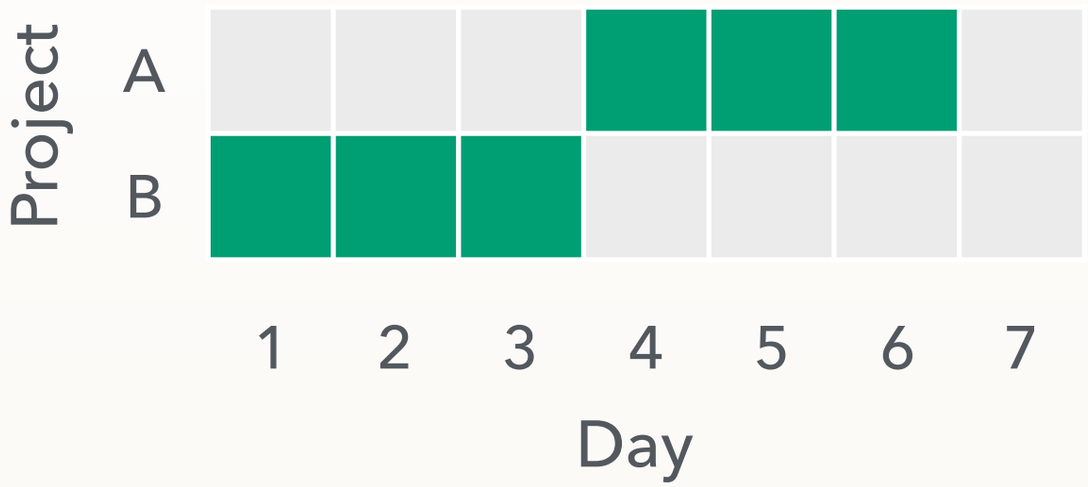
## Repetitive day-to-day




$$\text{AvgProjectsPerDay} = 1$$
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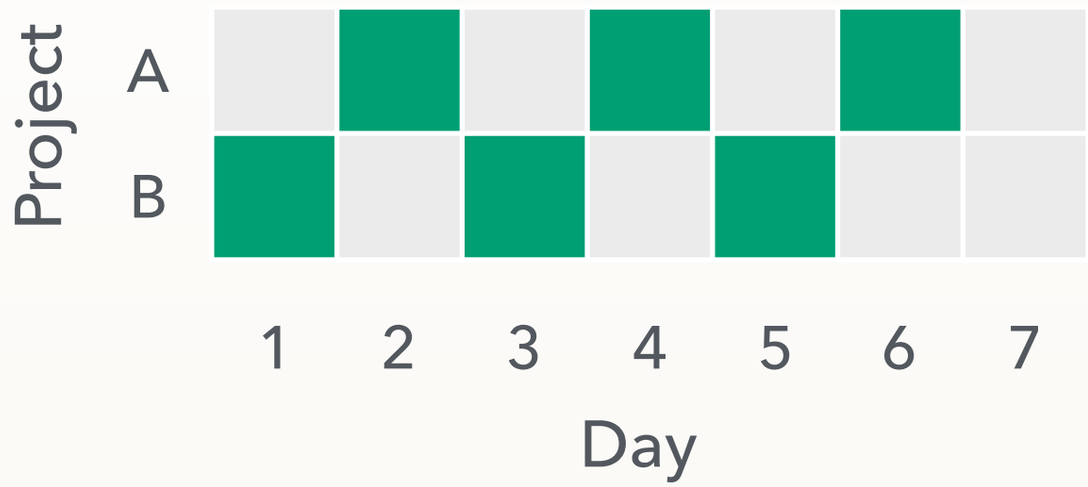
vs.

## Switching focus

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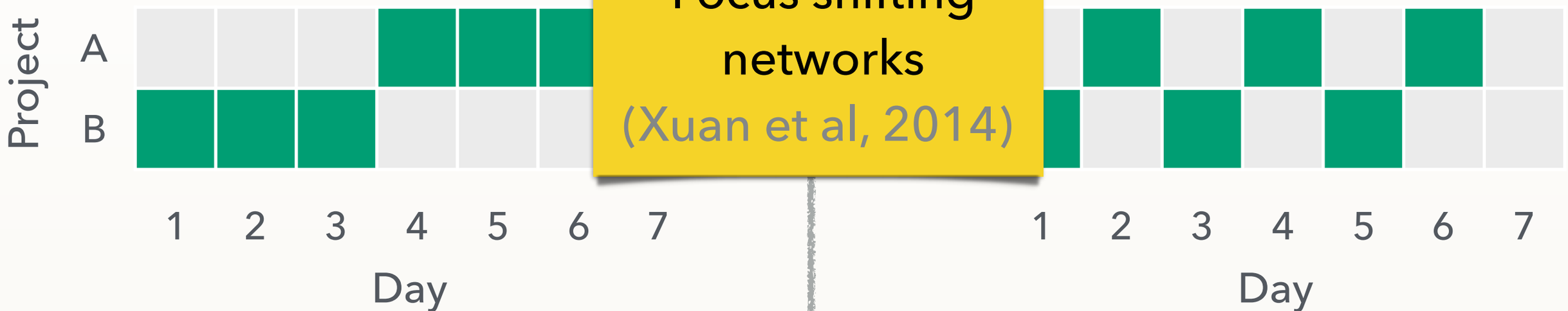
Repetitive day-to-day vs. Switching focus




Focus shifting networks (Xuan et al, 2014)

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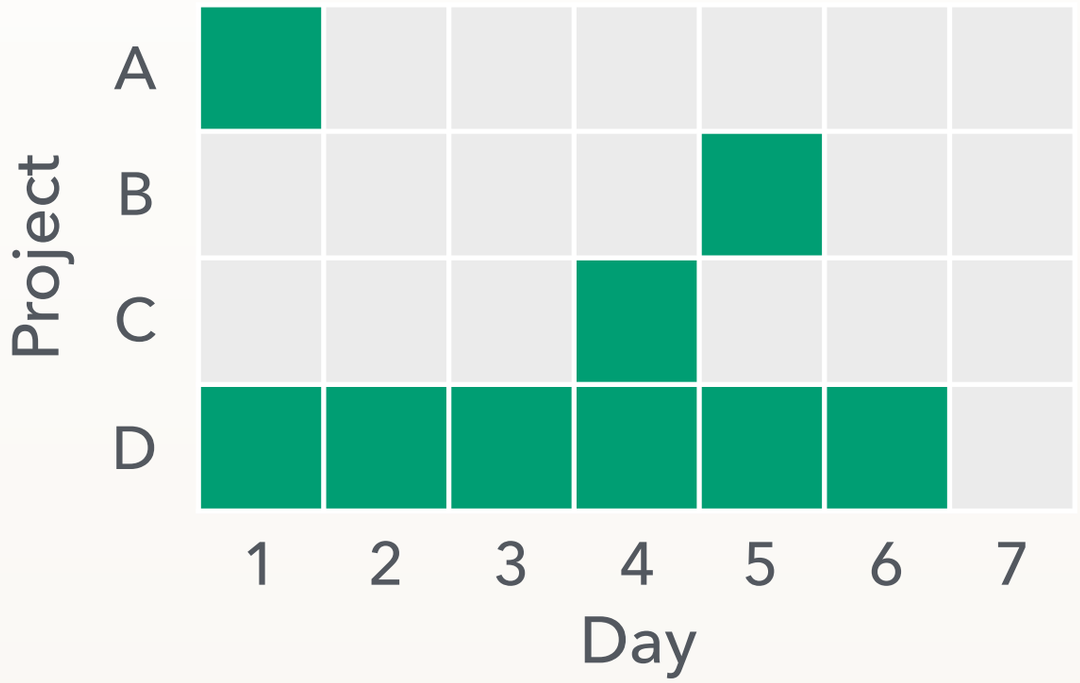

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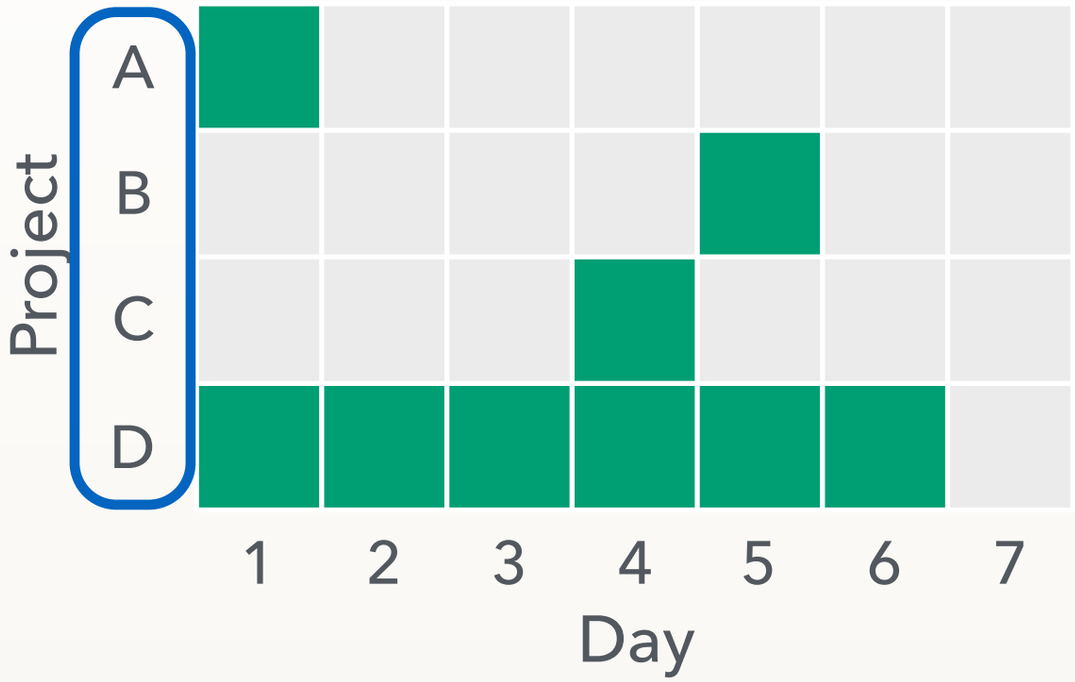


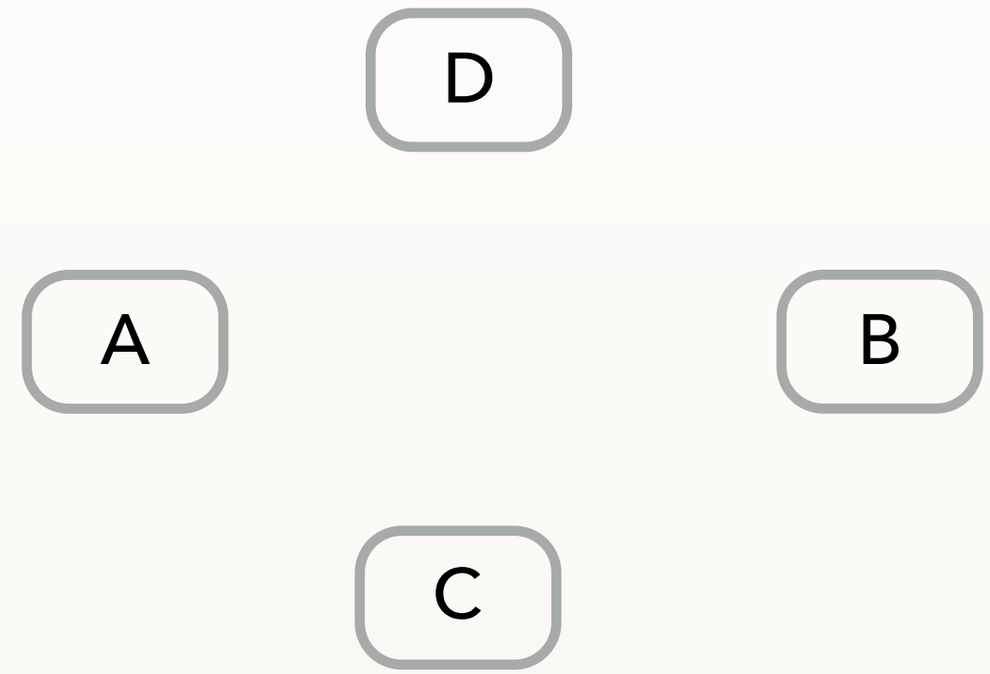

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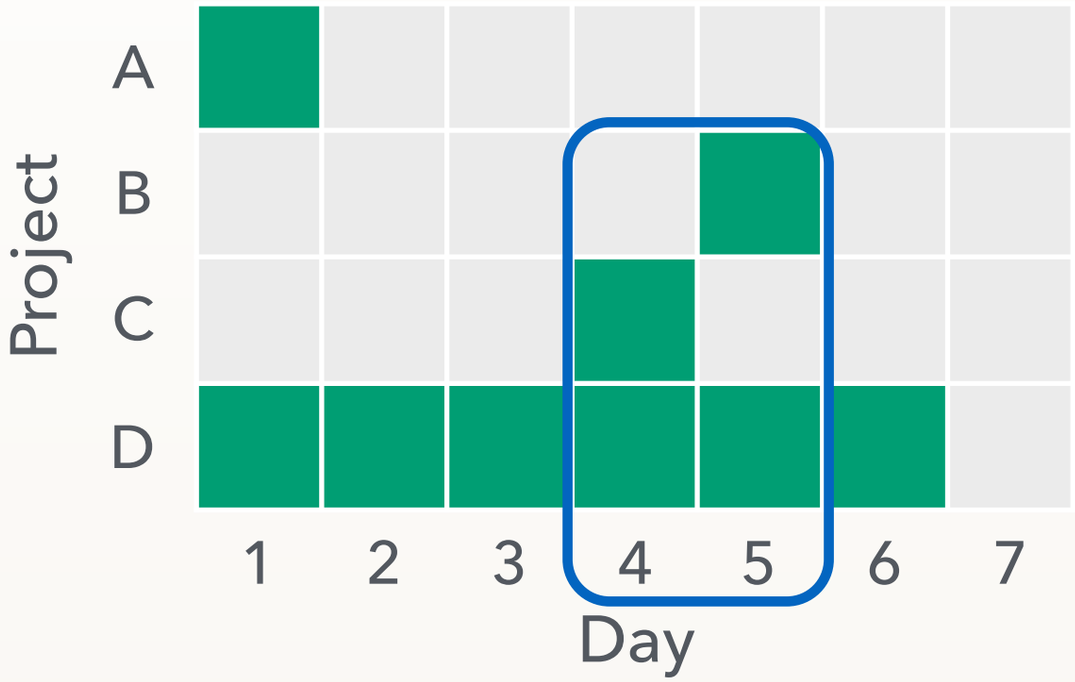
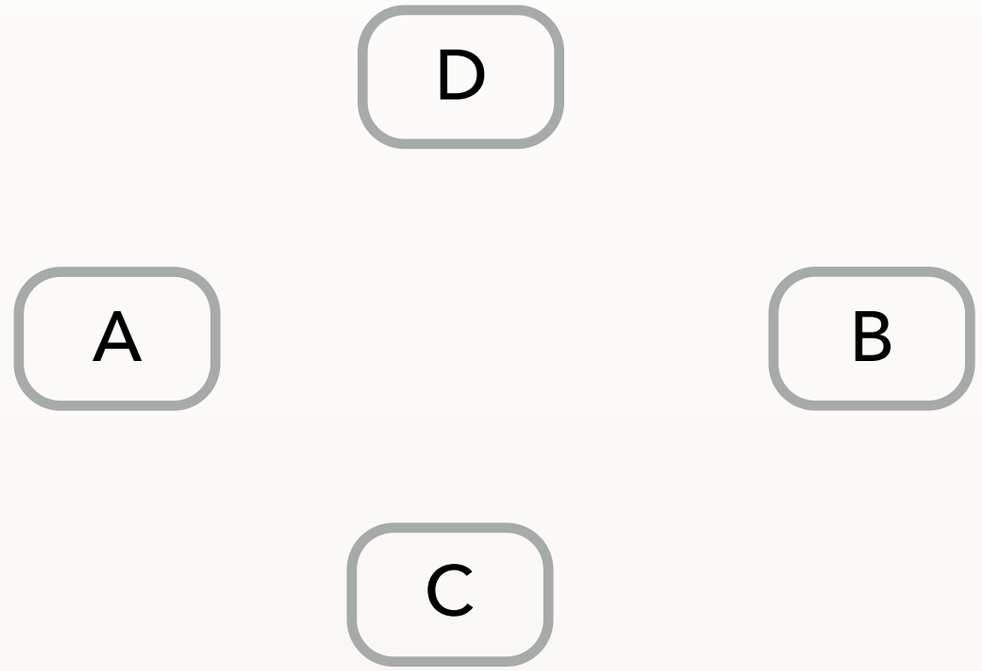
Repetitive day-to-day vs. Switching focus



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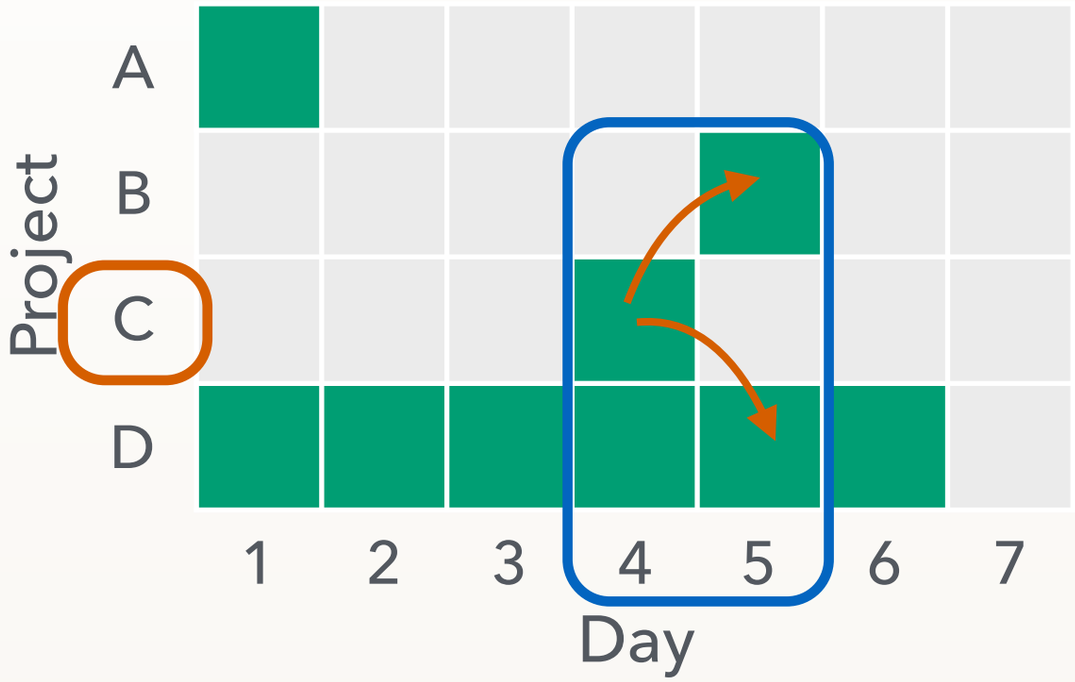


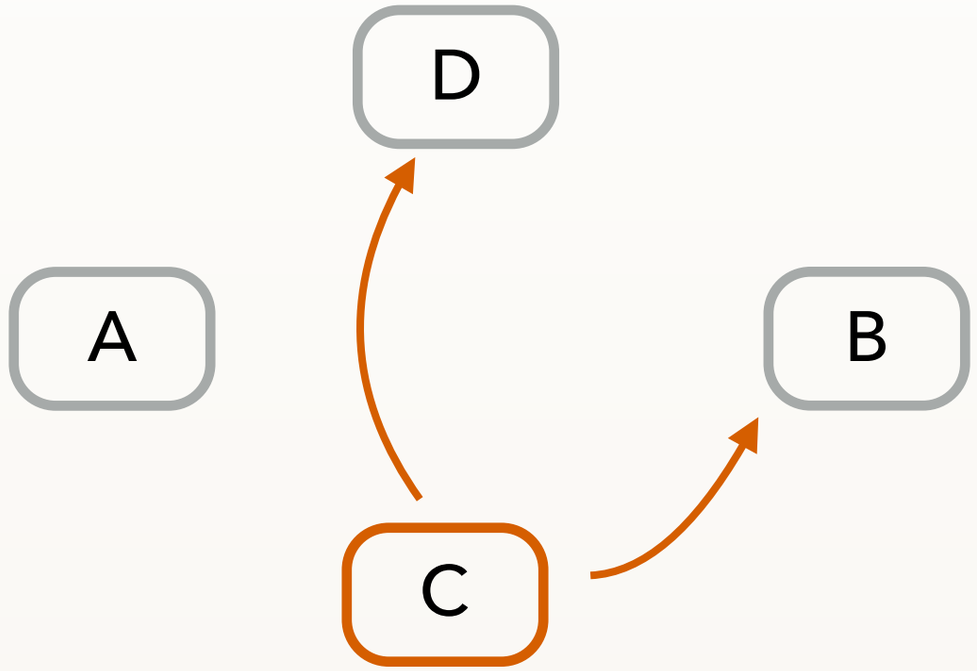

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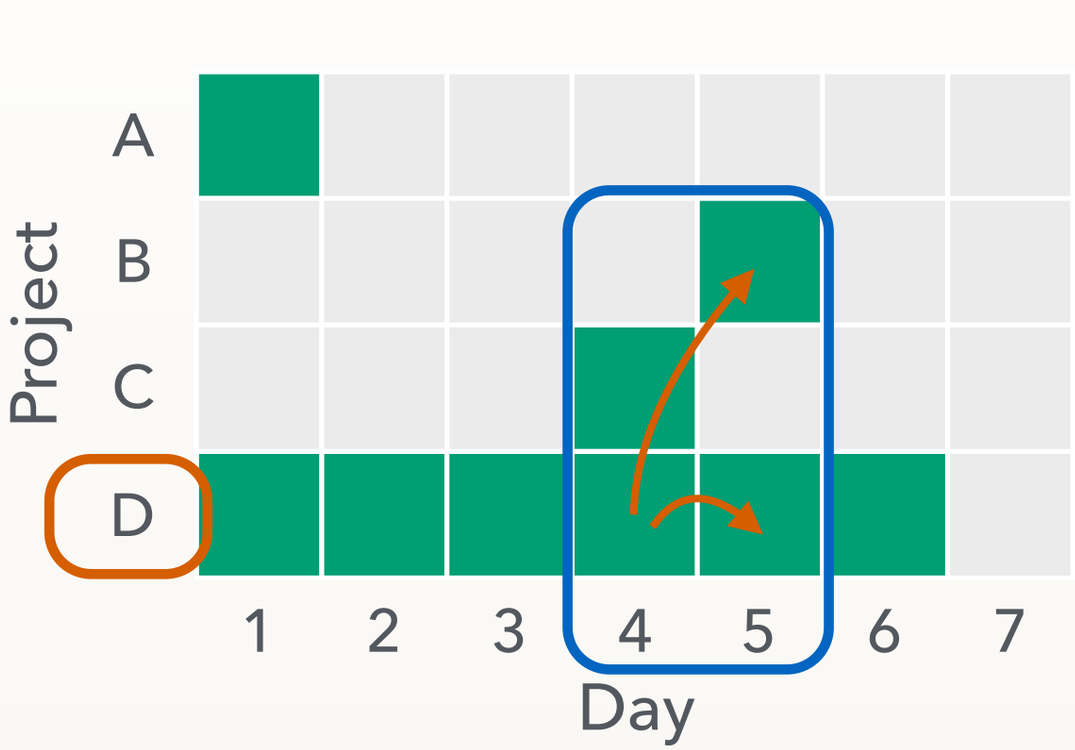


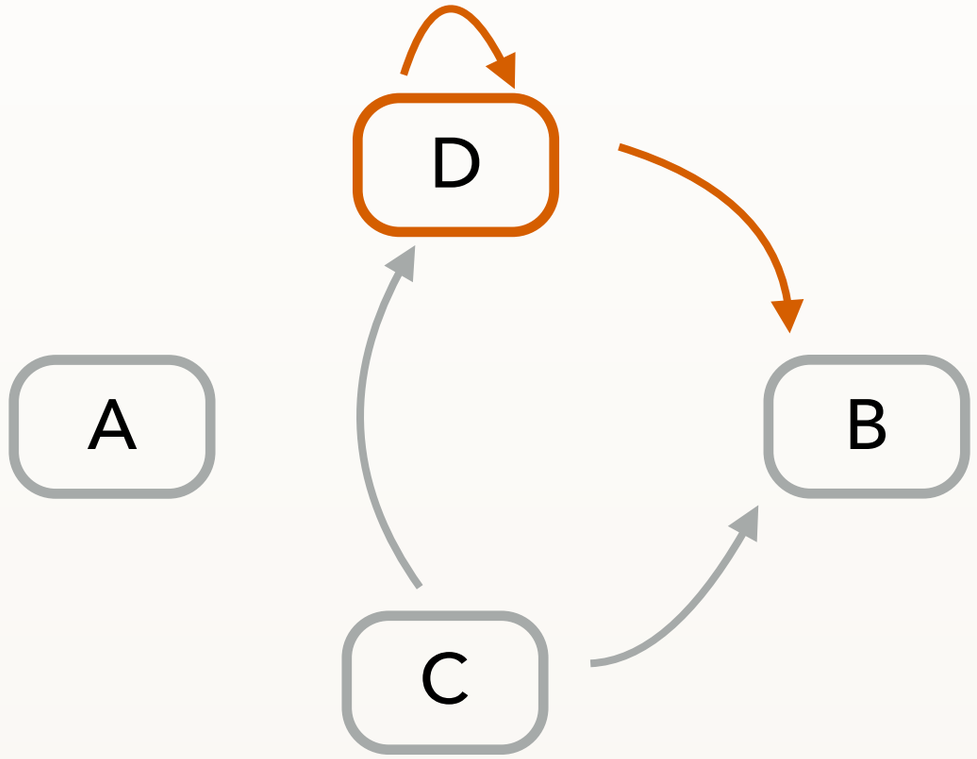

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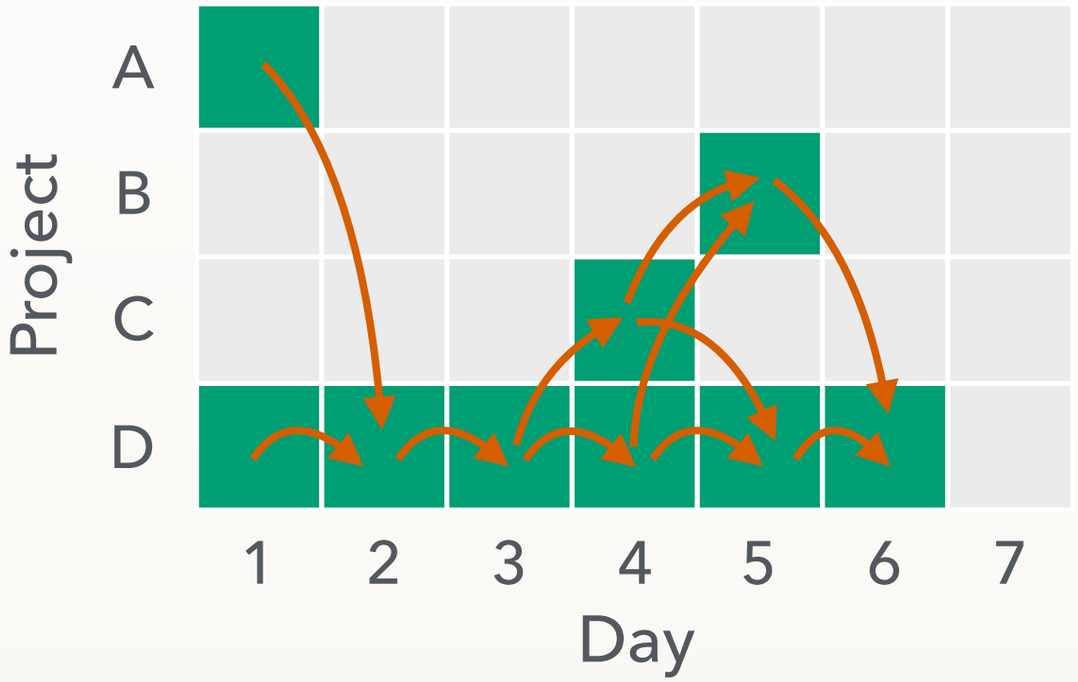


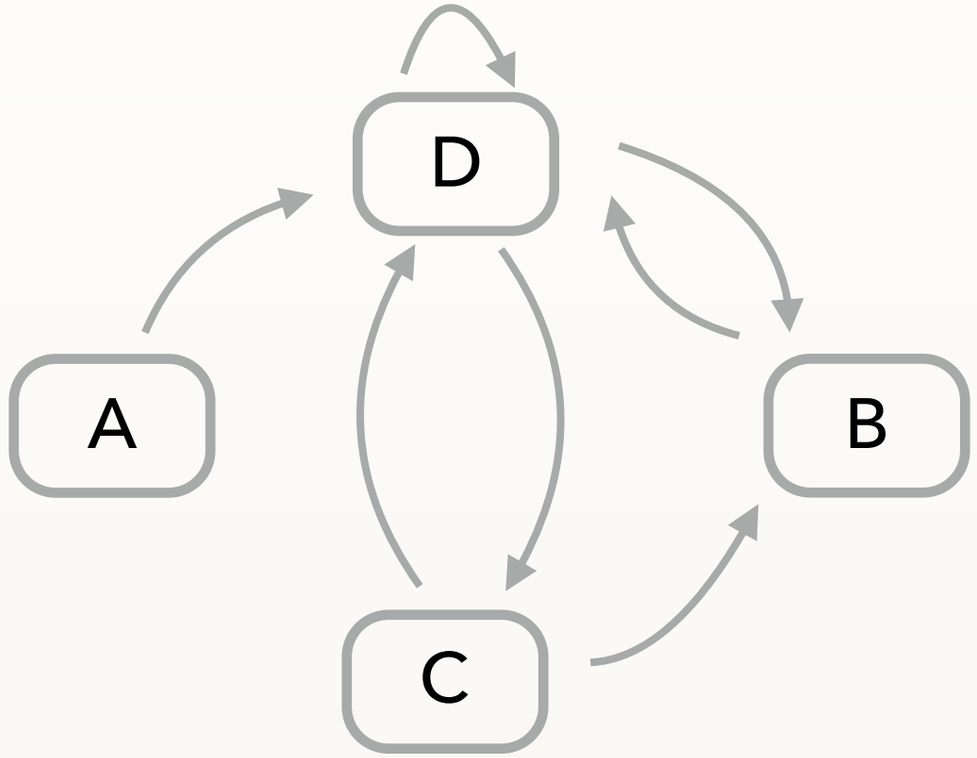

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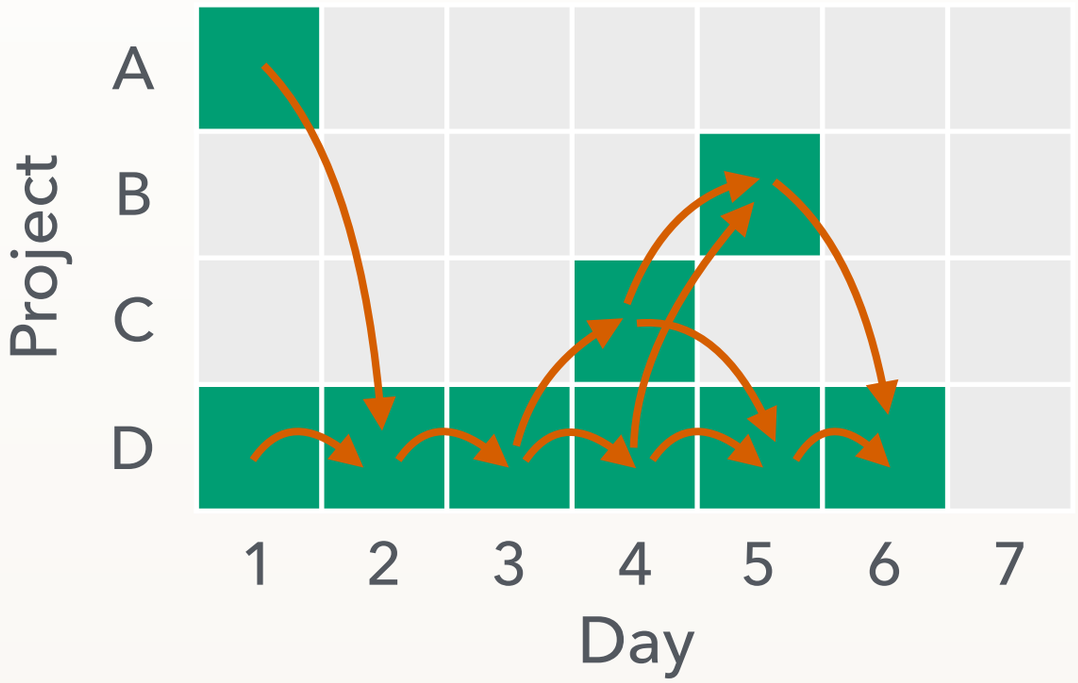


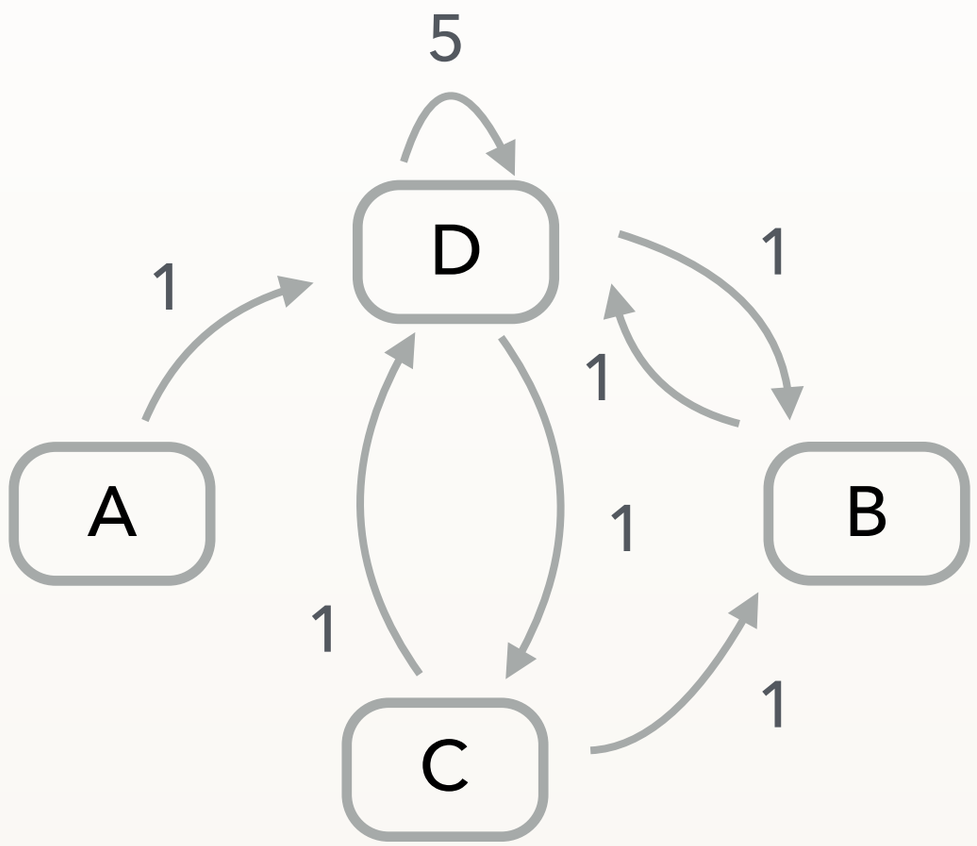

# Multitasking dimensions



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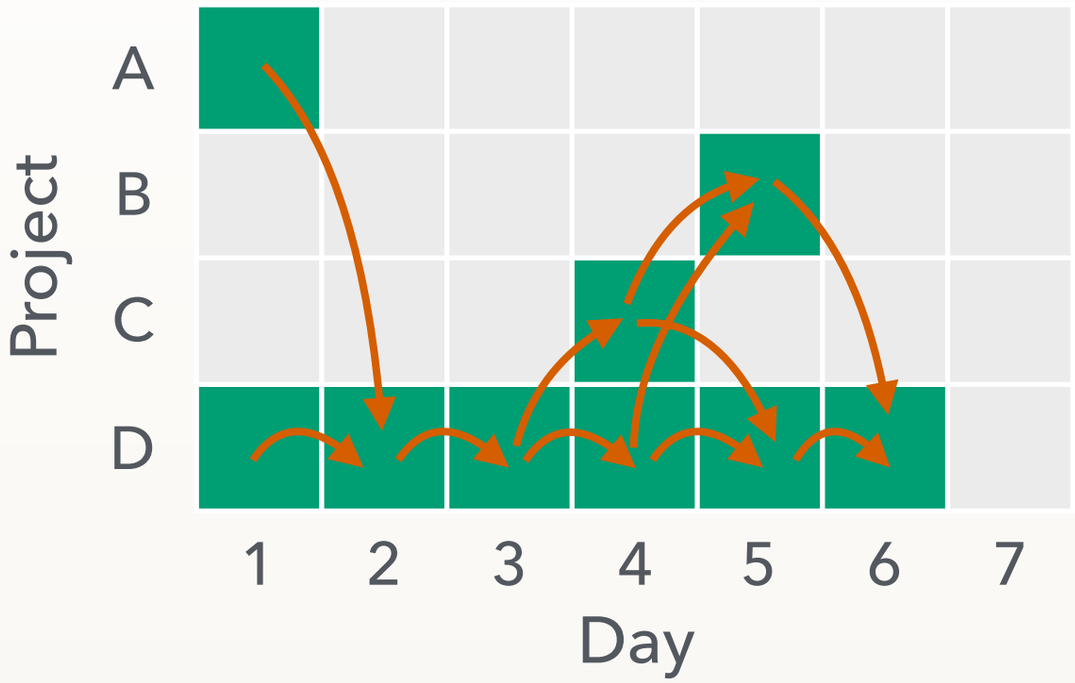


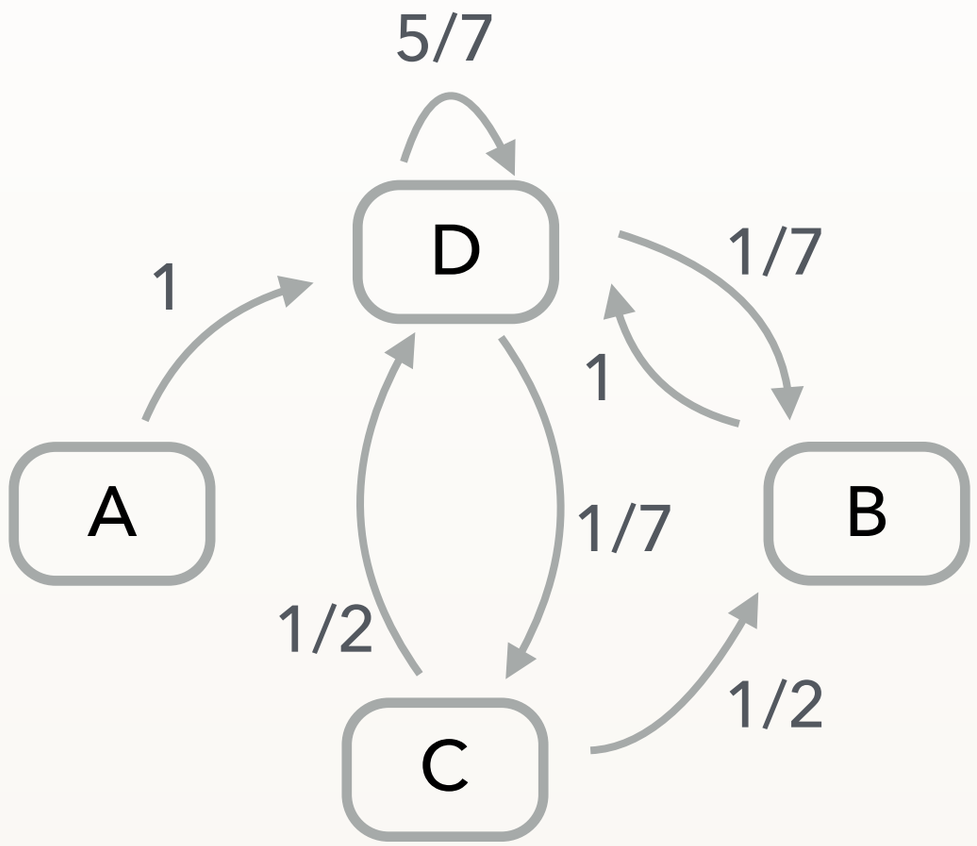

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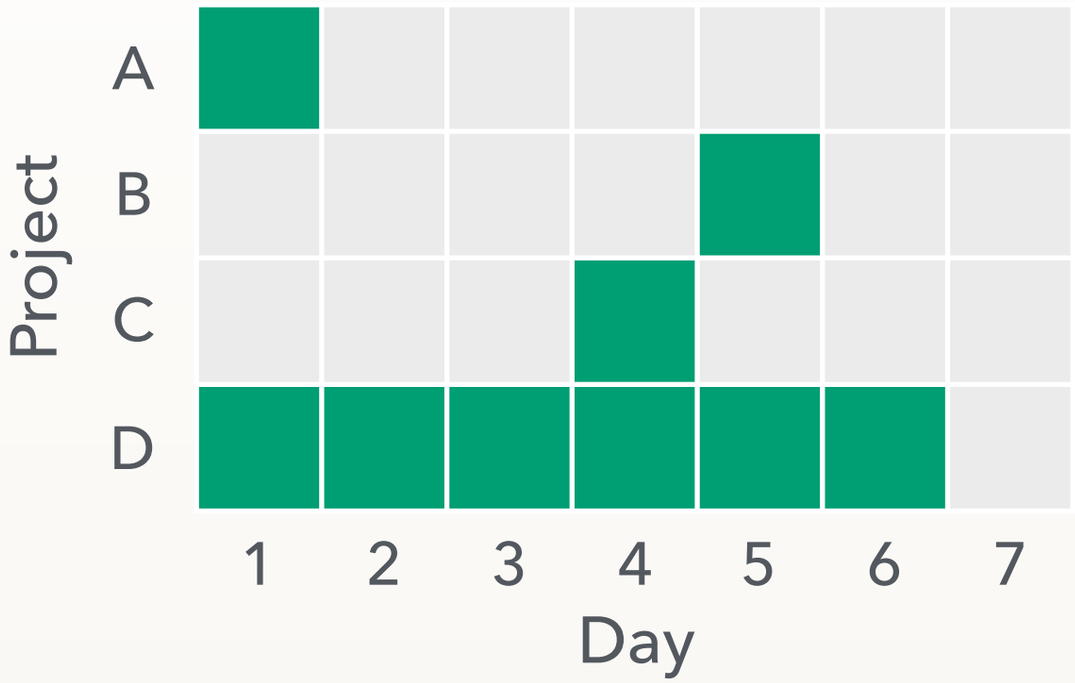
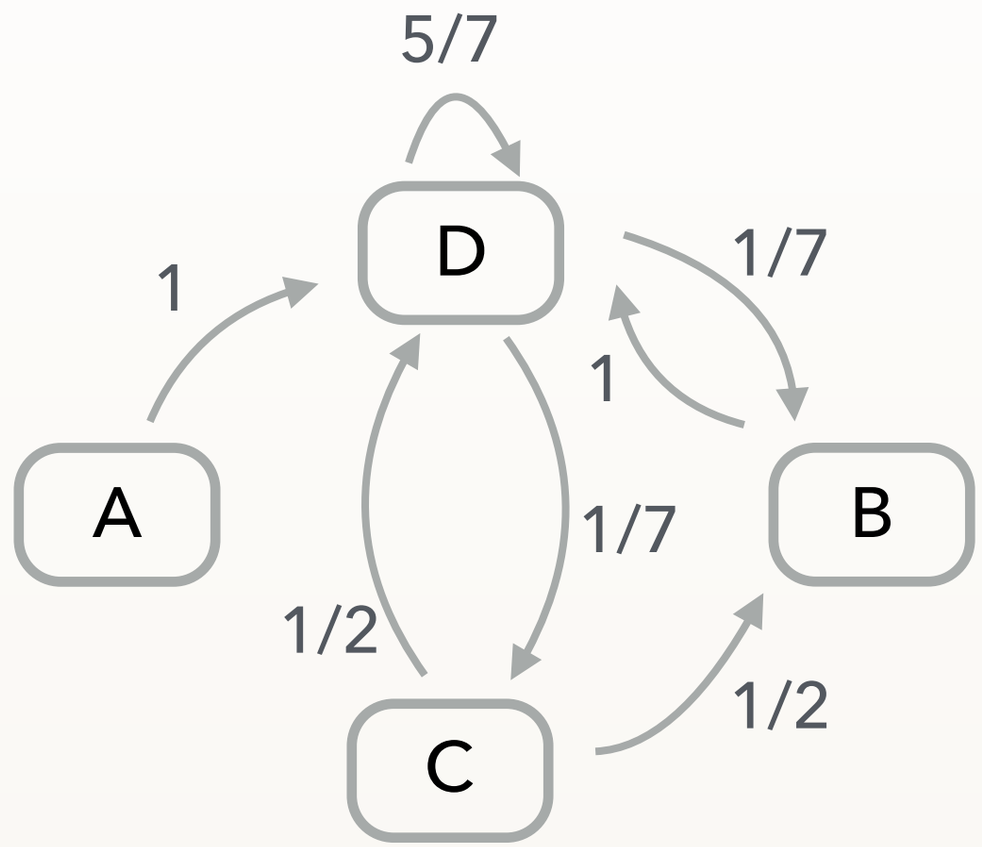


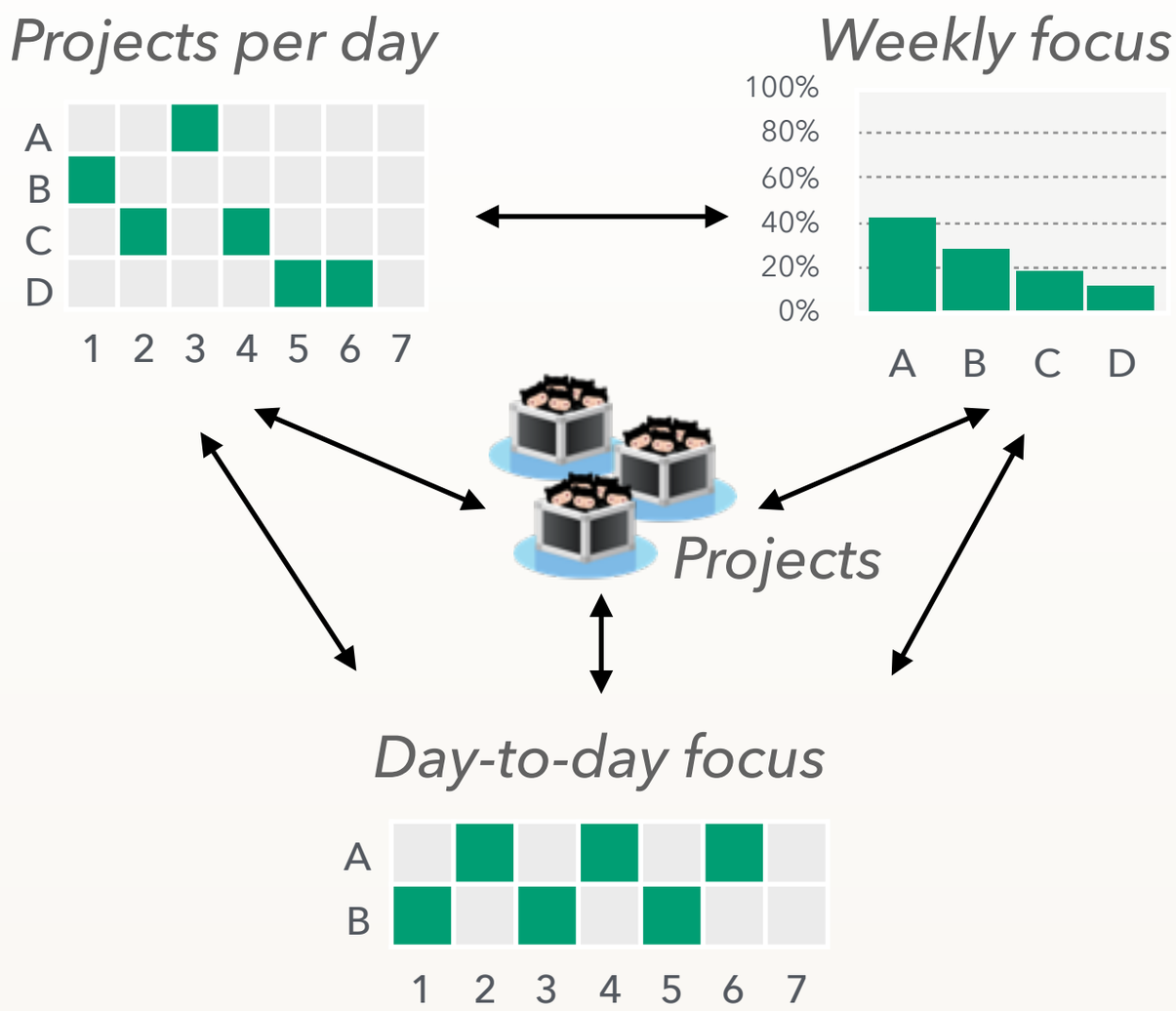

Markov entropy: $$S_{\text{Switch}} = -\sum_{i=1}^{N}\left[p_i \sum_{j\in\pi_i} p(j|i)\log_2 p(j|i)\right]$$

How predictable is my focus tomorrow if today I work on project j?

# Linear mixed-effects regression

**Response**:
LOC added / week

**Predictors:**




**Controls:**

- time
- total projects
- programming languages

**Longitudinal data**

- 1,200 developers
- 5+ years each: multiple weeks of observation

**Random effect**: developer

- developer-to-developer variability in the response

**Random slope**: time | developer

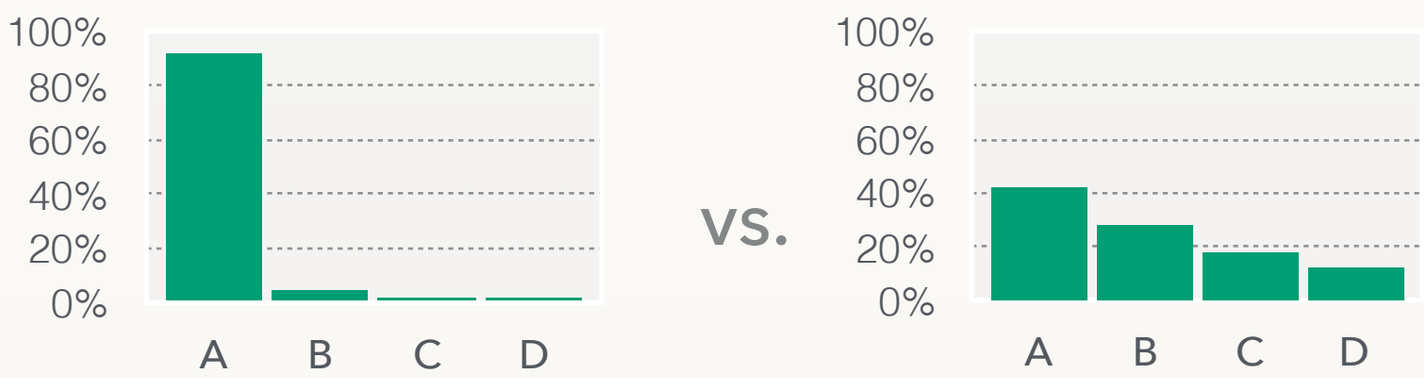
- developers more productive initially may be less strongly affected by time passing

# Multitaskers do more; scheduling matters

Higher LOC added

## Projects per day


## Weekly focus




## Day-to-day focus (repeatability)

# Multitaskers do more; scheduling matters

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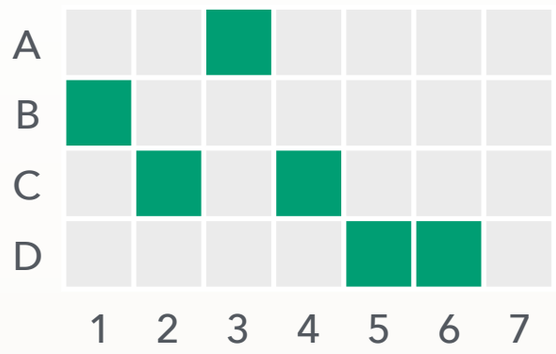
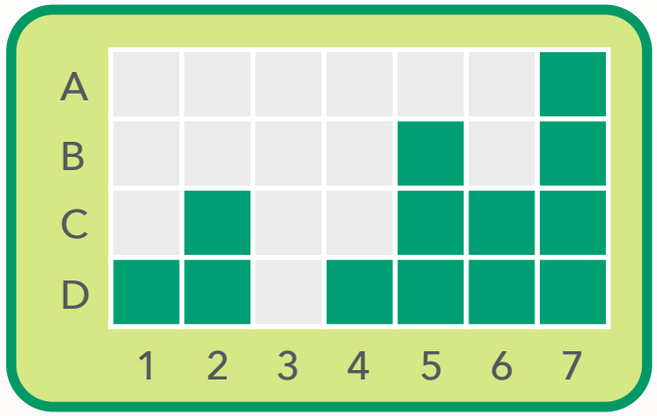
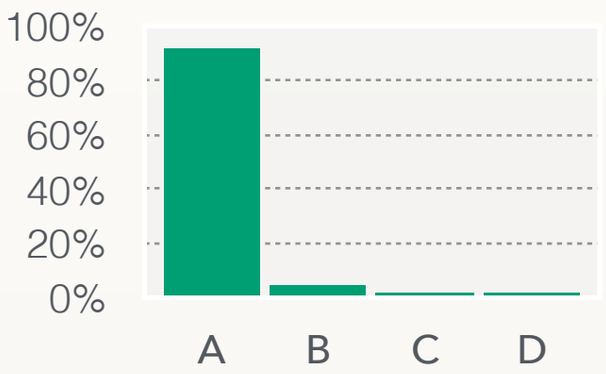



vs.




More within-day multitasking

## Weekly focus

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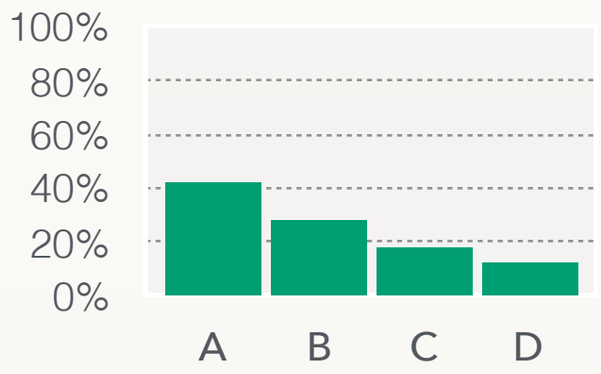


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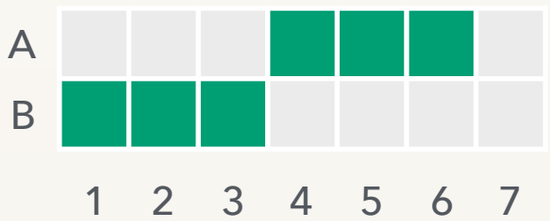

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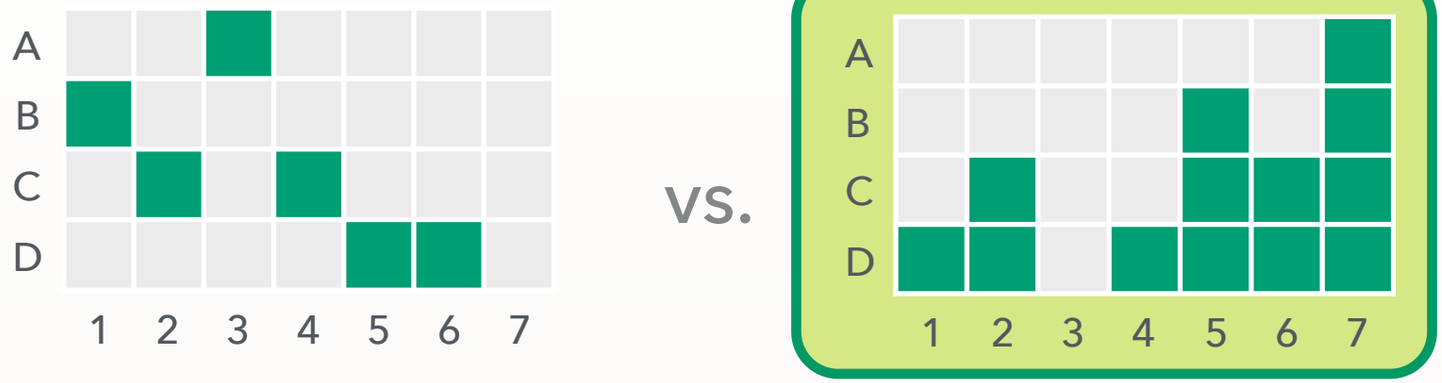


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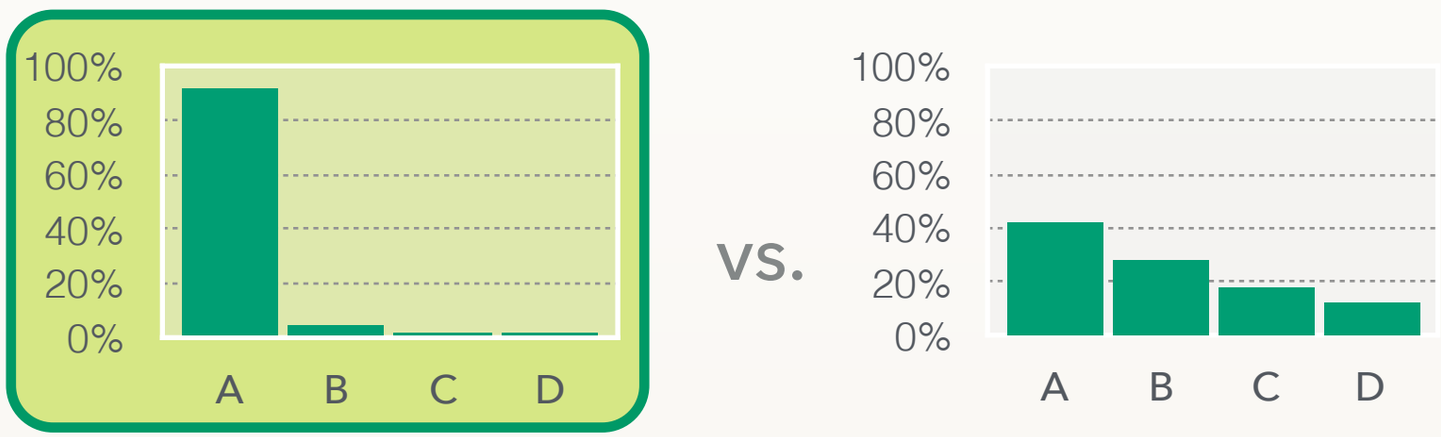


Higher focus

More repetitive day-to-day work

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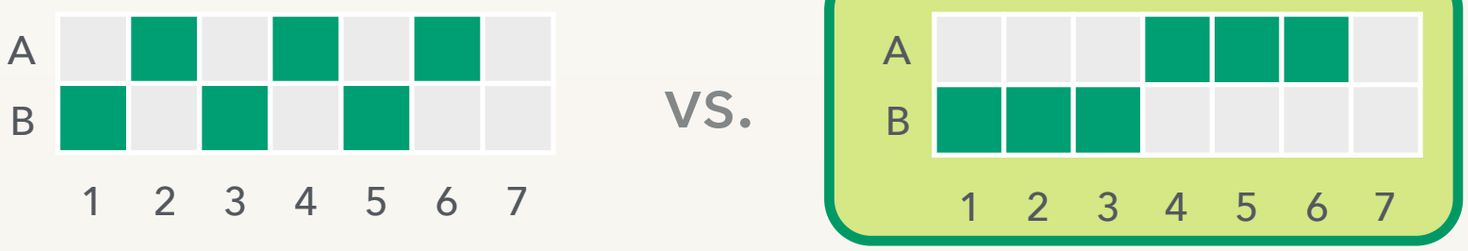

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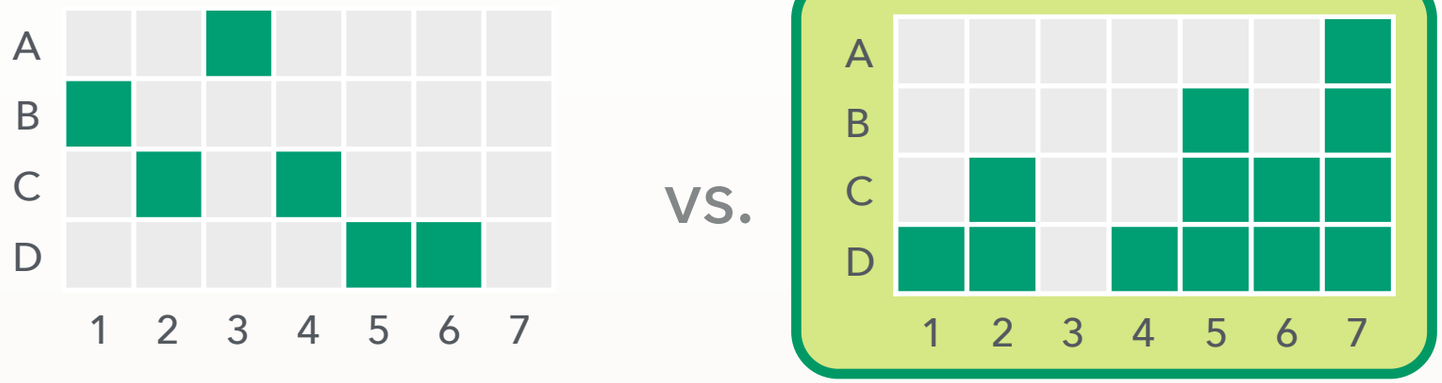


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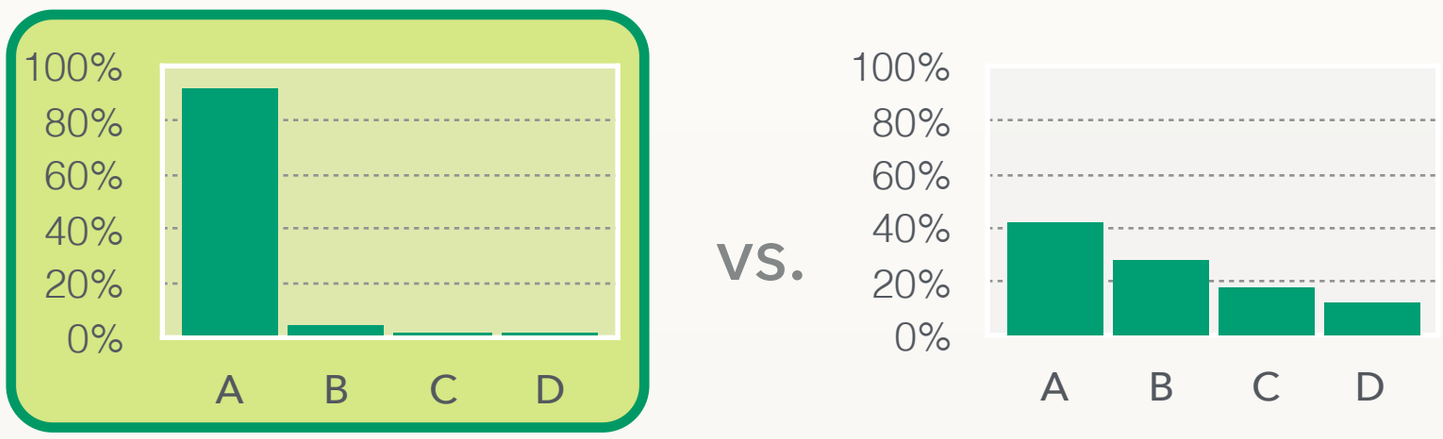


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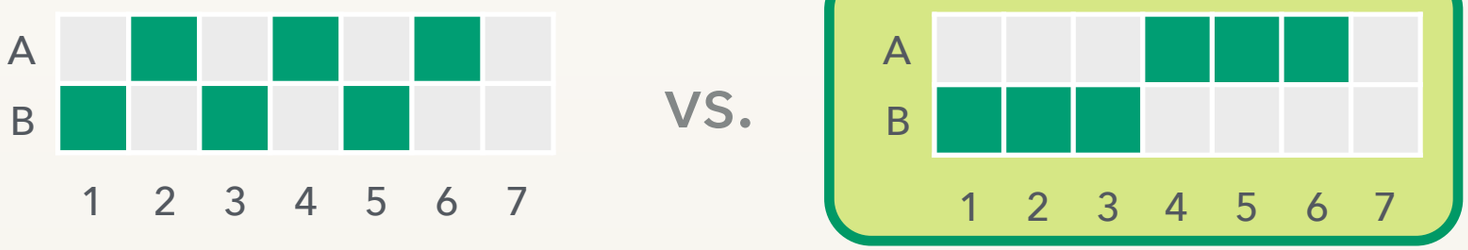


<u>Interaction effects</u>:

No scheduling is productive over 5 projects/week

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## Theory: How does multitasking affect performance?

### PROS

- **Fill downtime**

  Switch focus between projects to utilize tim more efficiently

  (Adler and Benbunan-Fich, 2012)

- **Cross-fertilisation**

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### CONS

- **Cognitive switching cost**

  Depends on interruption duration, complexity, moment

  (Altmann and Trafton, 2002) Borst, Taatgen, van Rijn, 2015)

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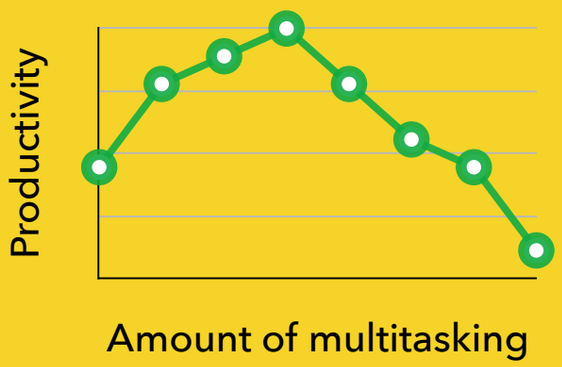
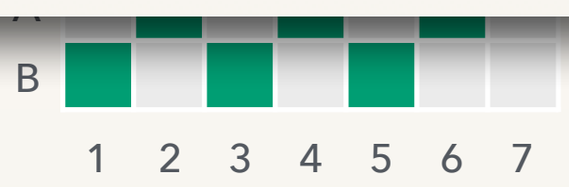
<u>In theory:</u>

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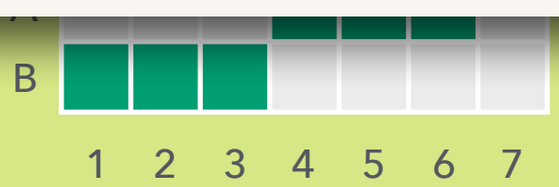


More within-day multitasking

Higher focus

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No scheduling is productive over 5 projects/week

# Implications - awareness

Average 2.7 projects/day (median 2; range 0–10)

Average 6 projects/week (median 5; range 0–30)

Multitasking correlates to amount of code produced

No scheduling is productive beyond 5 projects/week

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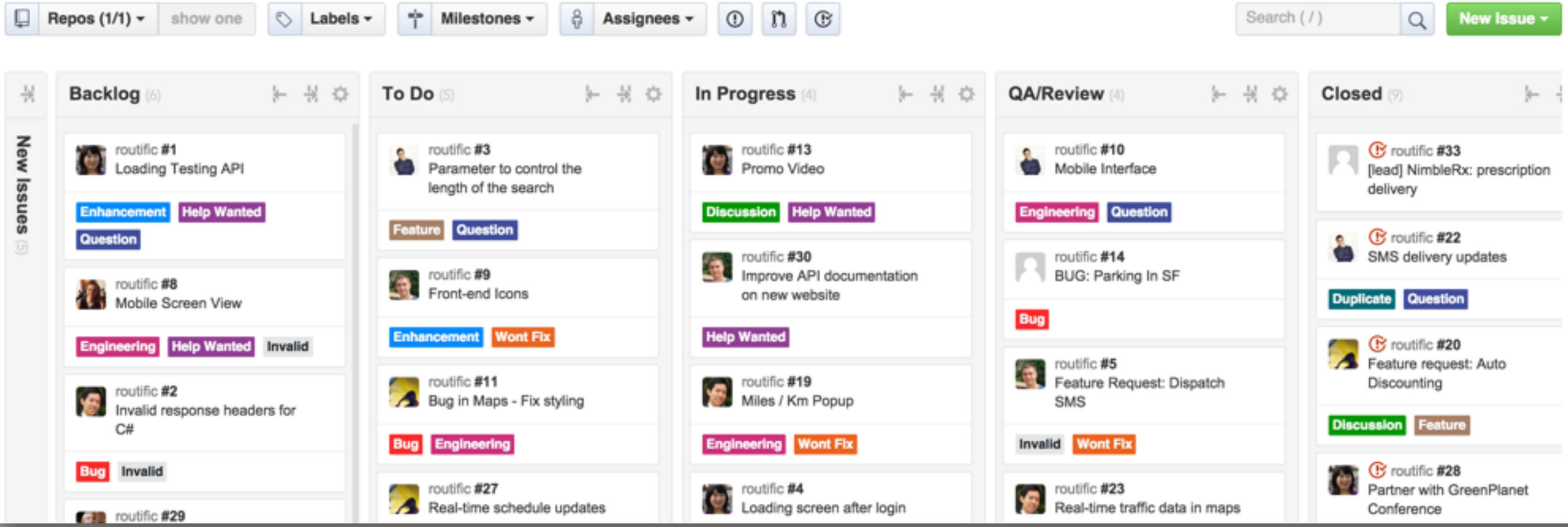
## TASK MANAGEMENT TOOLS

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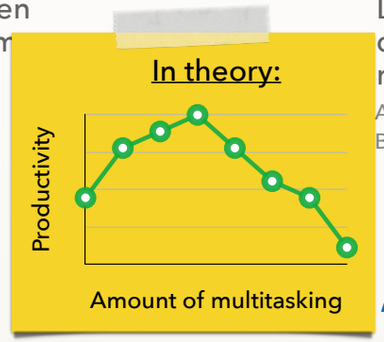


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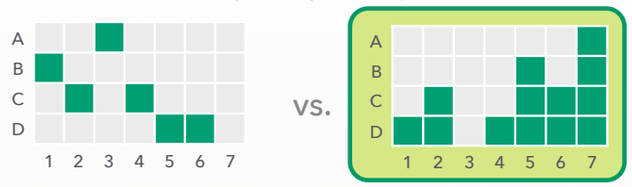
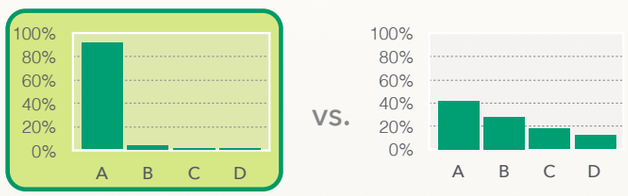



More within-day multitasking

Weekly focus




Higher focus

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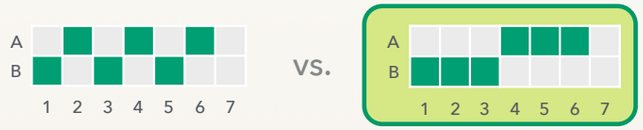
Day-to-day focus (repeatability)

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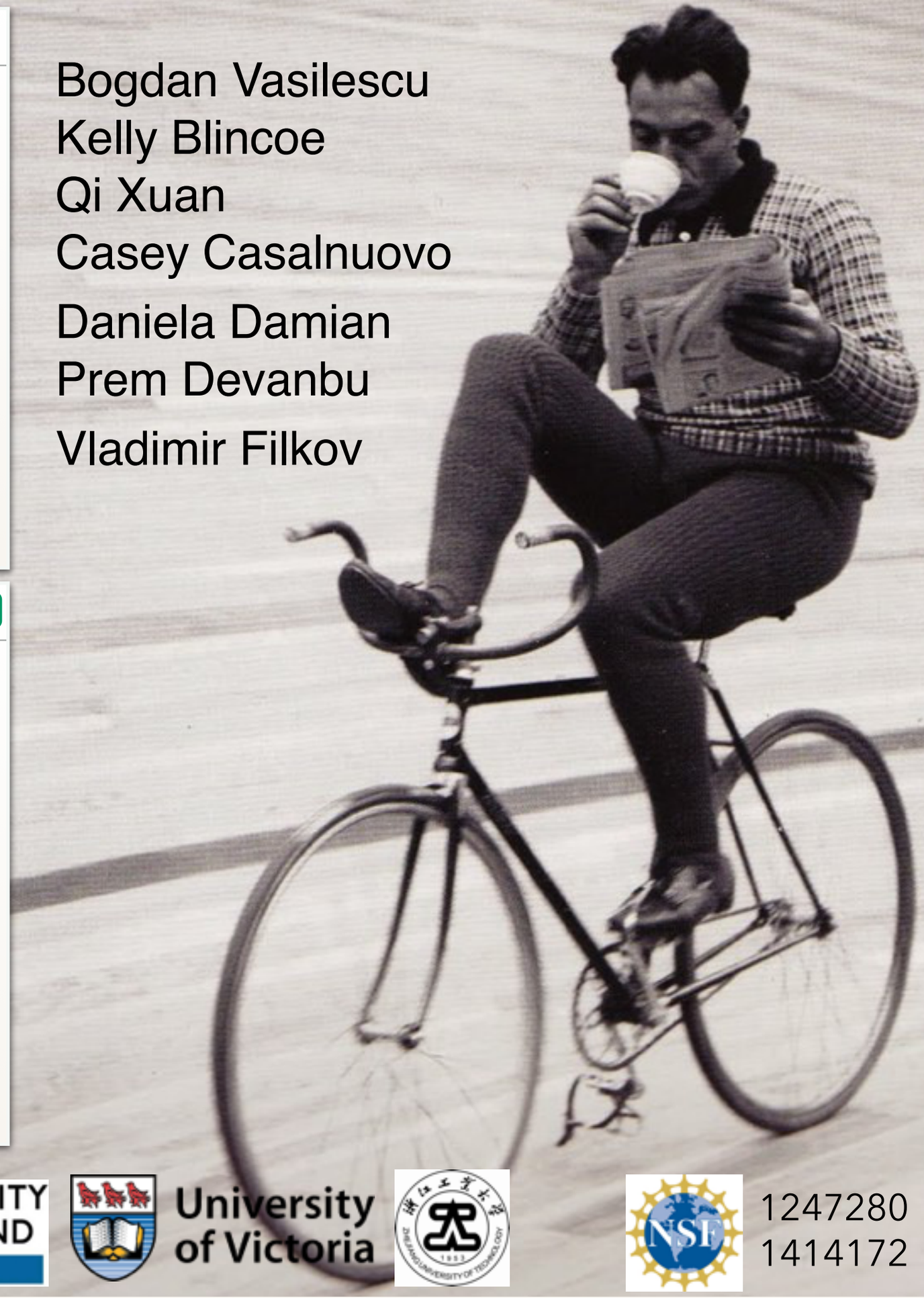

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