The Gopher's Gambit: Survival Advantages of Artifact-Based Intention Perception

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Introduction

- A **designed or real** trap is handmade to be dangerous, while a **random** trap is uniformly sampled from the space of all possible configurations.

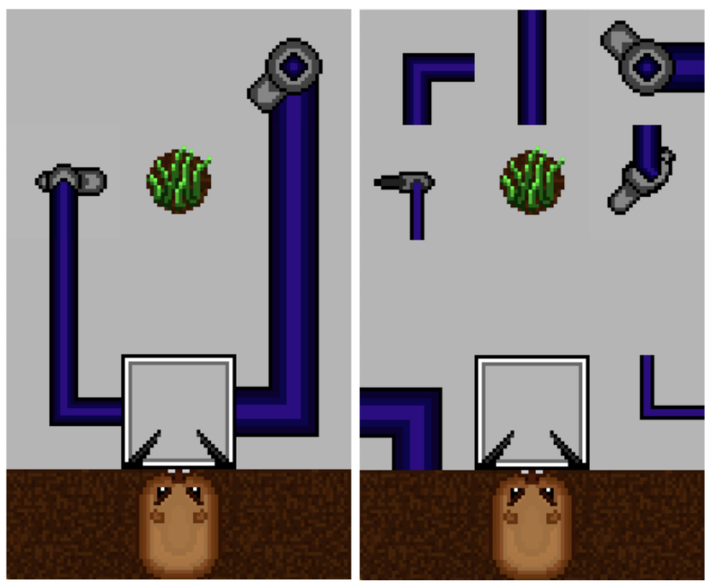


Figure 1: A real trap (left) and a randomly generated trap (right), in our simulated agent world.

- **Baseline** gophers randomly decide whether to enter a trap based on a given probability, while **intention** gophers use the **intention perception algorithm** to assess whether a trap is designed, judging from the **coherence** of its connections, and enters based on that.
- **Cautious** gophers isolate the intention variable by using a "faulty" algorithm that declares traps as designed with the same frequency as the real one, but without connection to the actual trap.

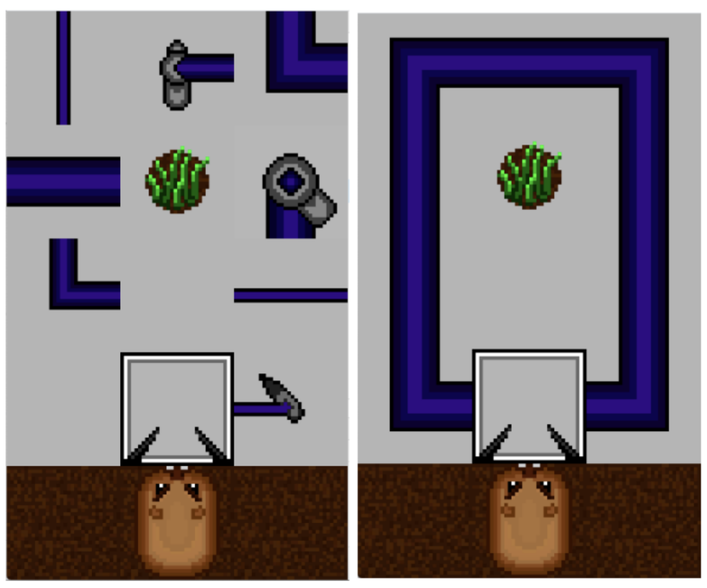


Figure 2: Coherence is correlated with functionality but does not imply it, as exampled by a functional incoherent trap (left) and a nonfunctional coherent trap (right).

Experimental Setup

We vary several probabilities: the baseline gopher's entering a trap, encountering a designed trap, and an **arrow** (the laser-like cell) killing the gopher. The default values are given below. For each set of parameter values we run 10,000 independent trials.

Table 1: Default values for experiment parameters.

Param.	Description	Value
P_e	Prob. of entering trap	0.8
P_r	Prob. of real trap	0.2
$P_{k,w}$	Kill prob. of wide arrow	0.45
$P_{k,n}$	Kill prob. of normal arrow	$\frac{2}{3}P_{k,w}$
$P_{k,s}$	Kill prob. of skinny arrow	$\frac{1}{3}P_{k,w}$
MFI	Maximum Fasting Interval	4

Intention Perception Algorithm

We reject the null hypothesis that a trap is randomly generated at an α level of 0.0001, corresponding to a **surprise value** of 13.29 bits. We calculate the surprise value of a trap configuration with

$$S(x) = -\log_2 \left[|\mathcal{X}|(1 + \ln |\mathcal{X}|) \frac{p(x)}{F_g(x)^{-1}} \right],$$

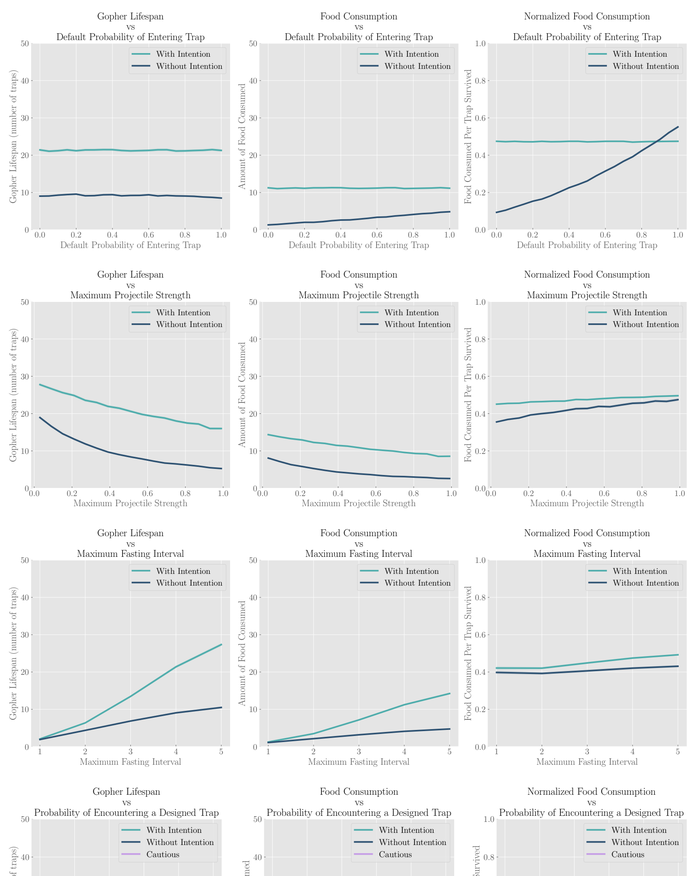
(Montañez, 2018; Hazen et al., 2007), where

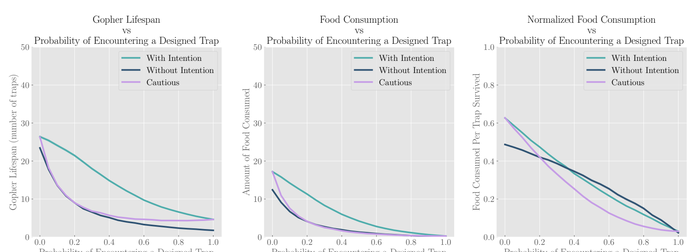
- x is a configuration (i.e., trap)
- $\mathcal{X}$ is the space of all configurations
- $p(x) = 1/|\mathcal{X}|$
- $F_g(x) = M_g(x)/|\mathcal{X}|$
- $M_g(x) = |\{x' \in \mathcal{X} : g(x') \geq g(x)\}|$
- $g(x)$ is the number of coherent connections per nonempty cell of x.

Results

"Signal" in the configurations can be **exploited** through statistical methods, providing **survival advantages.**

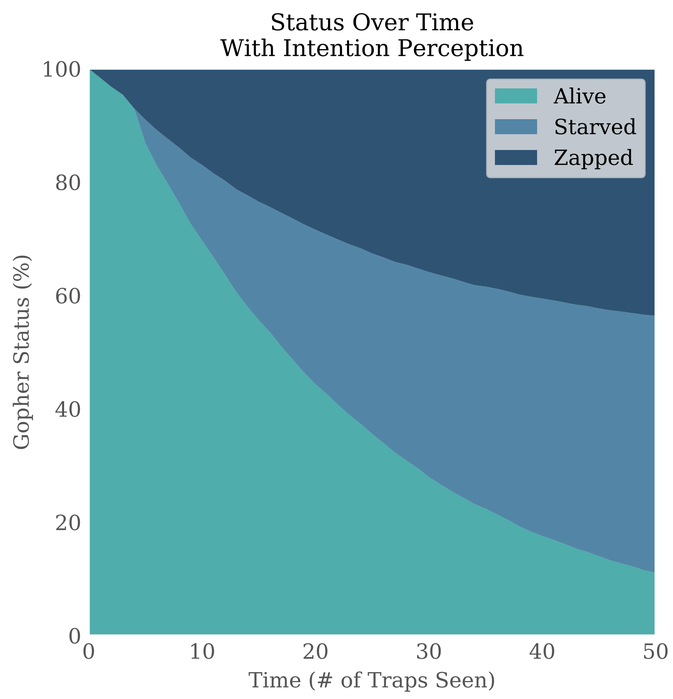
The graphs below show that the intention gophers (light blue) typically have longer lifespans.

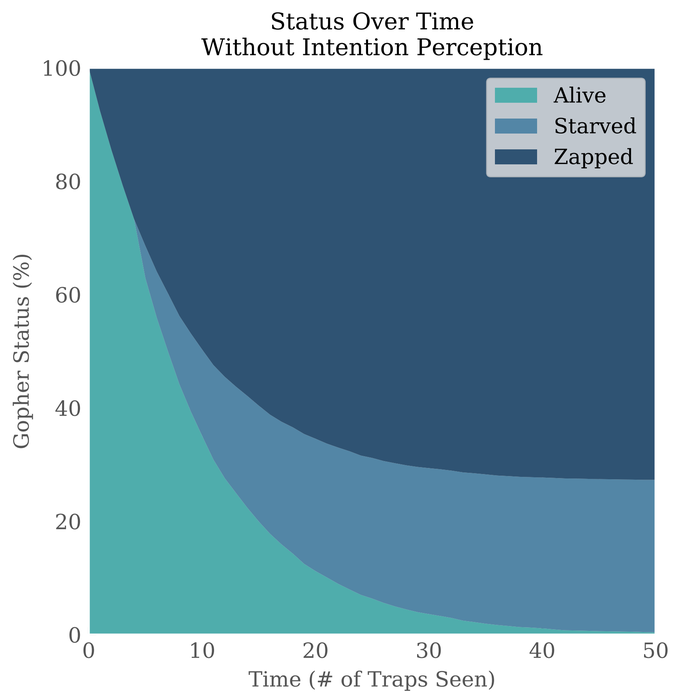




The advantage of intention perception is greatest when **safety is the priority.**

The following plots reveal that intention gophers are more likely to die of starvation than the baseline gophers, but are more likely to remain alive overall.





Conclusion

- **Detection of intentional configurations is possible** (and highly accurate) through statistical analysis of artifacts.
- Knowledge of intention can be **exploited by artificial decision-making systems**.
- Intention perception is **helpful** in a **majority** of tested cases.
- Benefit of intention perception is **greater when prioritizing safety** over food consumption.

Acknowledgments

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