Variations on **Error Strategy** of Foraging Ants

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Purpose of this study

To investigate

the Strategy of Errors

in the group forging of ants

--Motivation 1--

J. theor. Biol. (1983) **105,** 259–271

Probabilistic Behaviour in Ants: A Strategy of Errors?

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(*Received* 15 *October* 1982, *and in revised form* 5 *May* 1983)

Animal behaviour is probabilistic. This is exemplified by the communication behaviour of ants during food-searching. Experimental evidence

--Motivation 1--

Experiments to quantify the following ability of pheromone path by 2species of Tetramorium(シワアリ)

nest  food

TABLE 1

Comparison between recruitment accuracy in two ant species

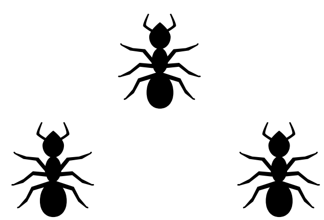
		Tetramorium impurum	*Tapinoma erraticum*
Length (%) of single recruitment trails actually followed by recruit		17 (40)	67·7 (47)
Percentage of recruits reaching the food source	Alone	8·9 (45)	73·6 (216)
	In group	60 (10)	—
	Total	18·2 (55)	73·6 (216)

J.Theor.Biol.(1983) J.L.Deneubourg et al.

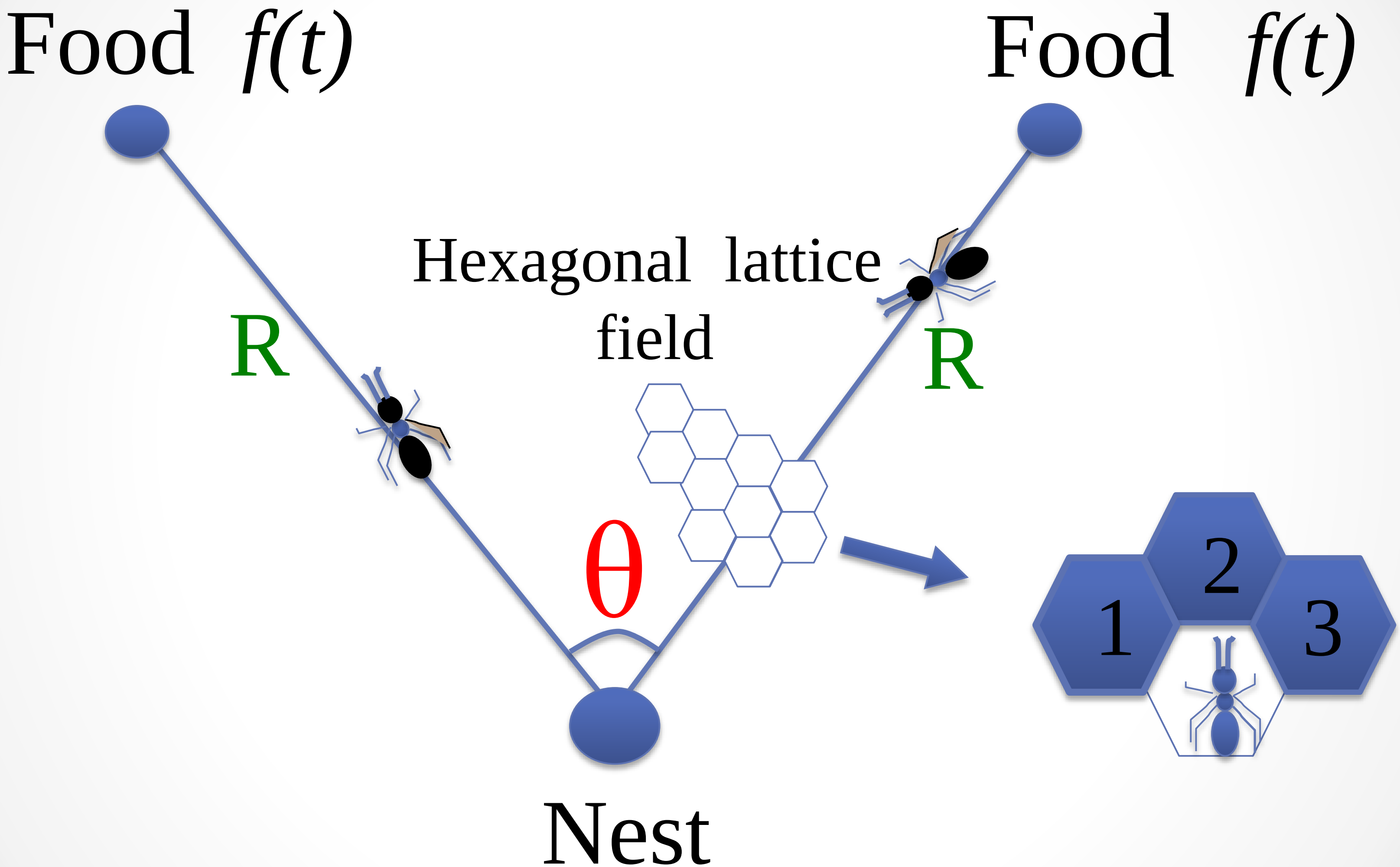
‘ Probabilistic behavior of ants: **a strategy of error** ? ’

§3.Computational mode

---multi-agent model

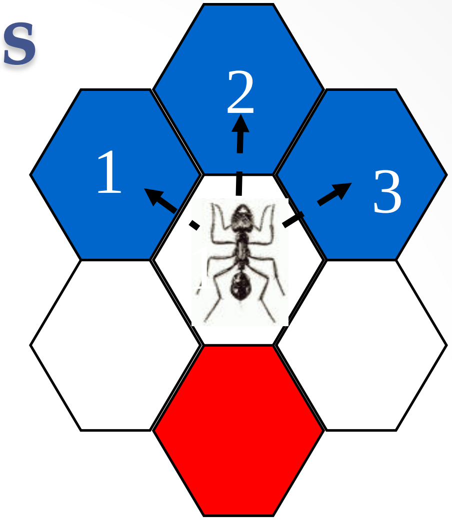


Setup of Simulation Field



- θ, R : Environmental Parameters

Choice of moving direction in each step by Chemo-taxis



- Choose one cell among three frontal cells

Prob. of choosing i-th cell (i={1,2,3})

$$P(i) \propto (\alpha_k \rho_i + z)^n \quad (n = 10)$$

ρ_i: pheromone density in i-th cell

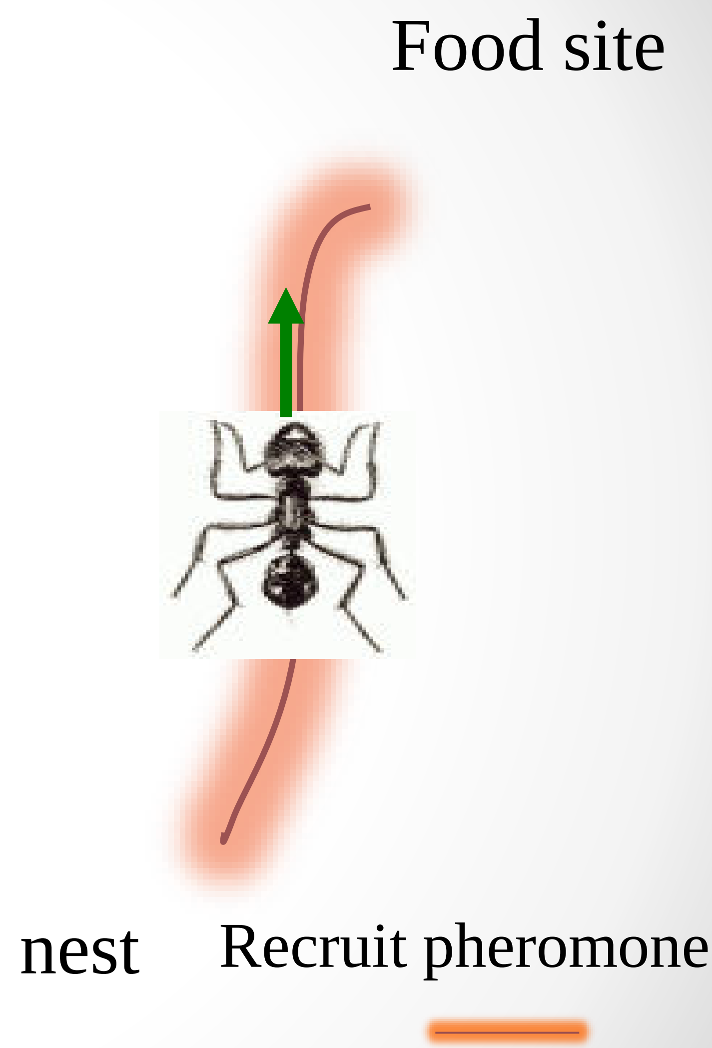
α_k: accuracy of k-th ant

(**normalization** $P(1)+P(2)+P(3)=1$)

Walking Modes in foraging trip 1

1. Exploring mode

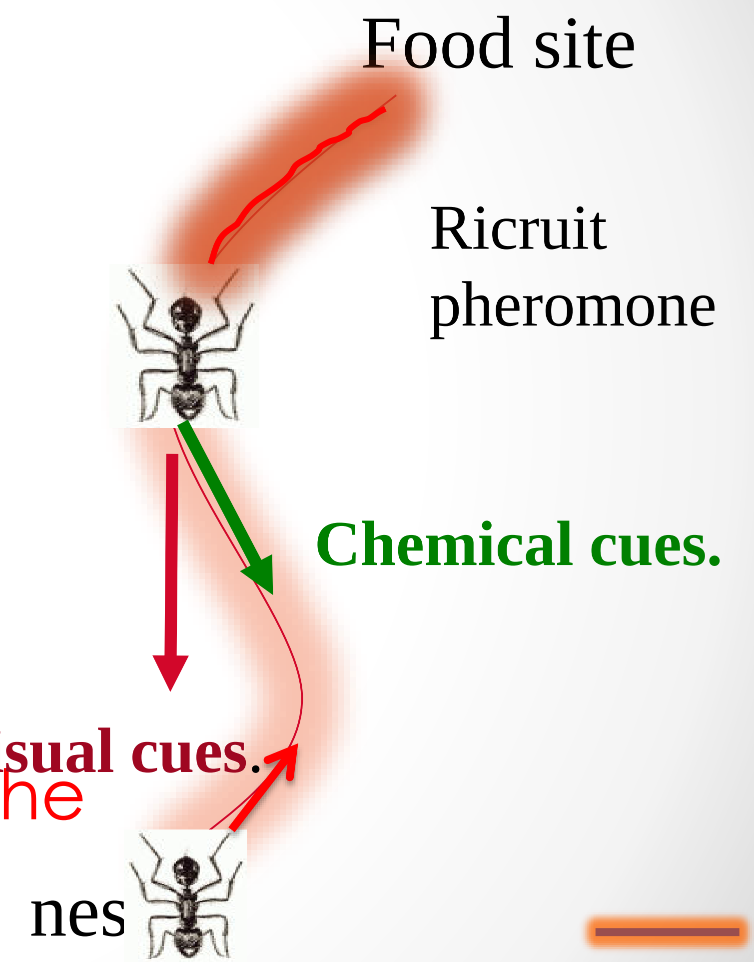
   explore food following recruit pheromone



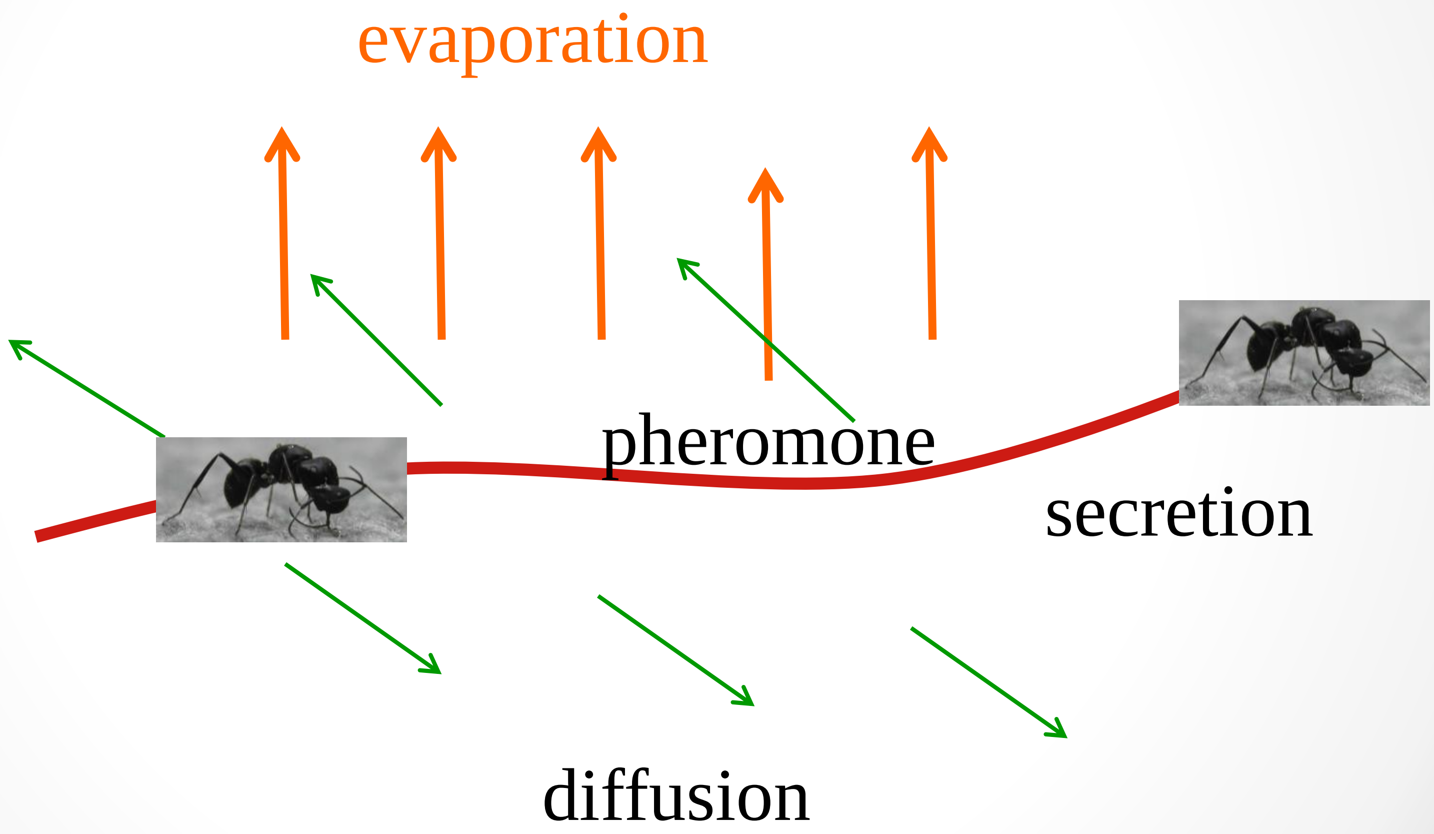
Walking Modes in foraging trip 2

2.Homing mode

- Move according to Chemical cues and/or Visual cues
- Put recruit pheromone
- On reaching nest, go back to the exploring mode

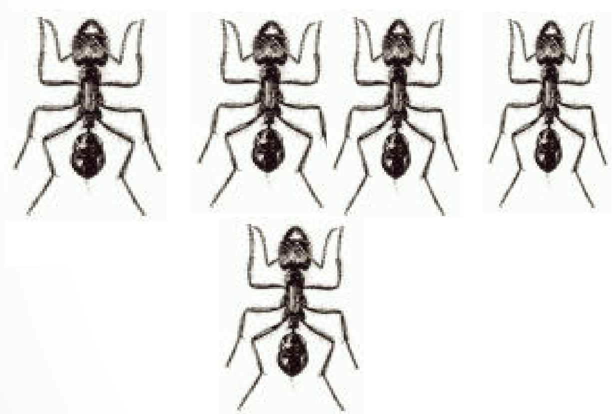


Time evolution of Pheromone field



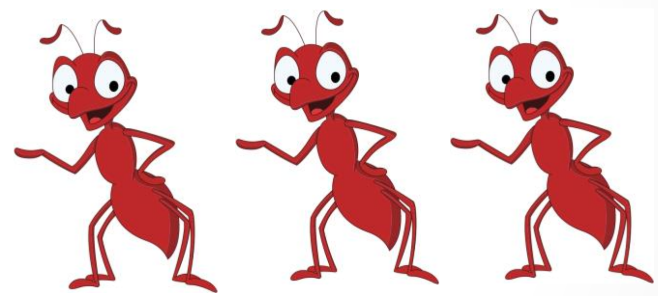
Parameters characterizing the error strategy of each colony:

{**Number of normal ants n (in totally 500ants)** & **Accuracy of dull ants α (< α_{normal}=50)** }



Normal Ants
($\alpha=\alpha_{normal}=50$)

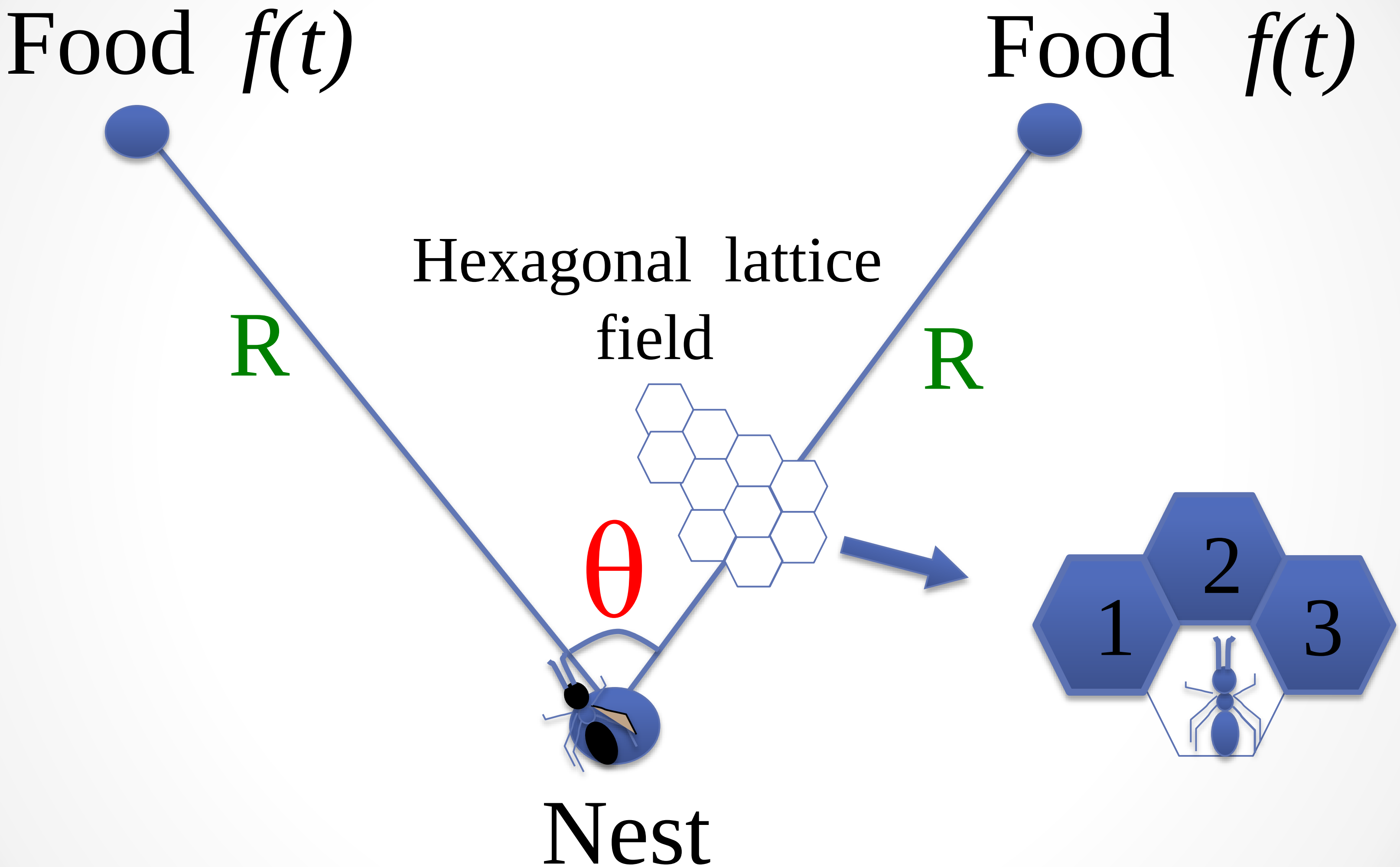
+



Dull Ants
($\alpha < \alpha_{normal} = 50\times10^{-1}, 50\times10^{-2}, 50\times10^{-3}, 50\times10^{-4}, \cdots, 50\times10^{-7}$)

number ratio n : 500－n

What we simulated



- θ, R ：Environmental Parameters

What we measure

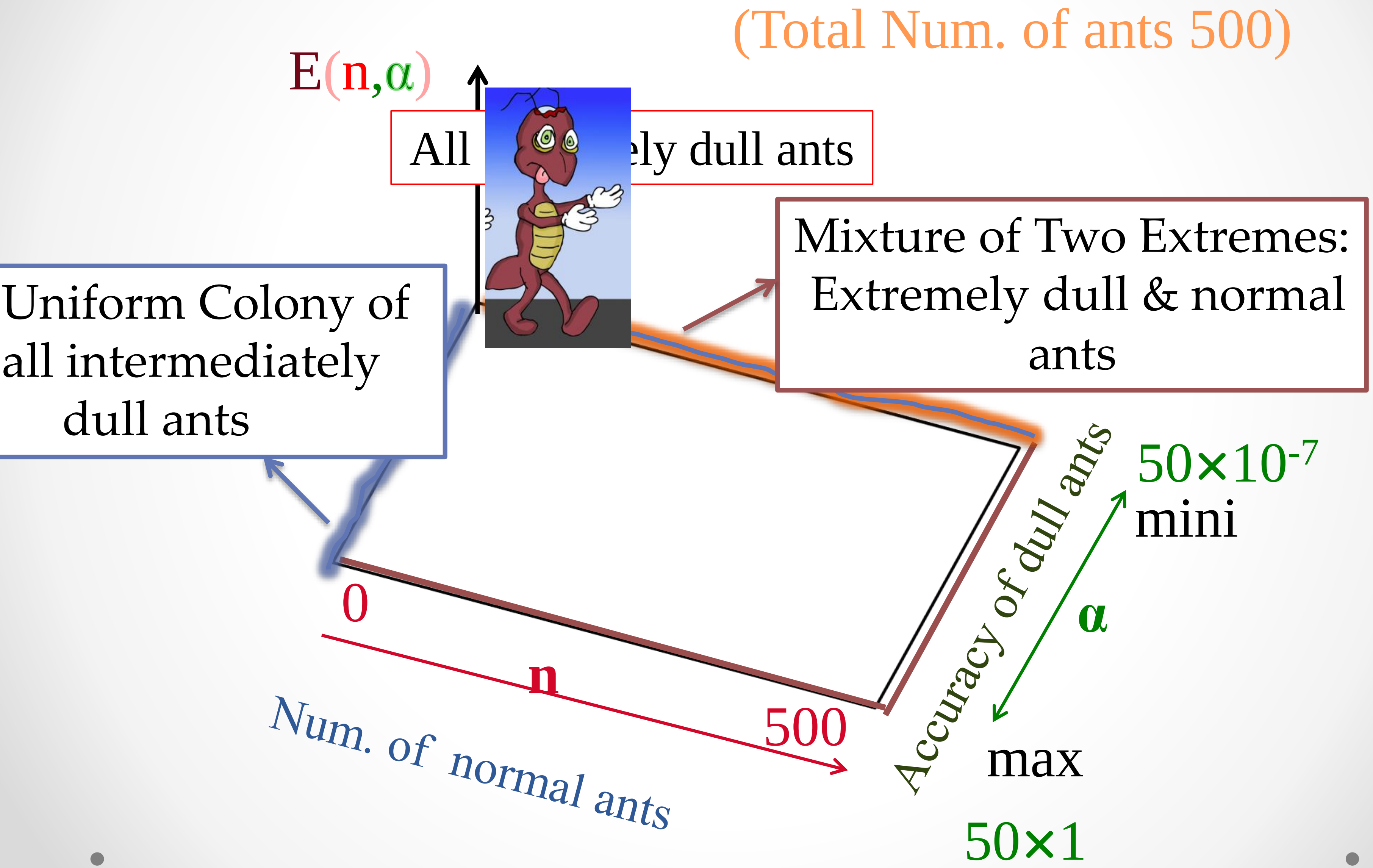
→Foraging Efficiency $E(n, \alpha)$

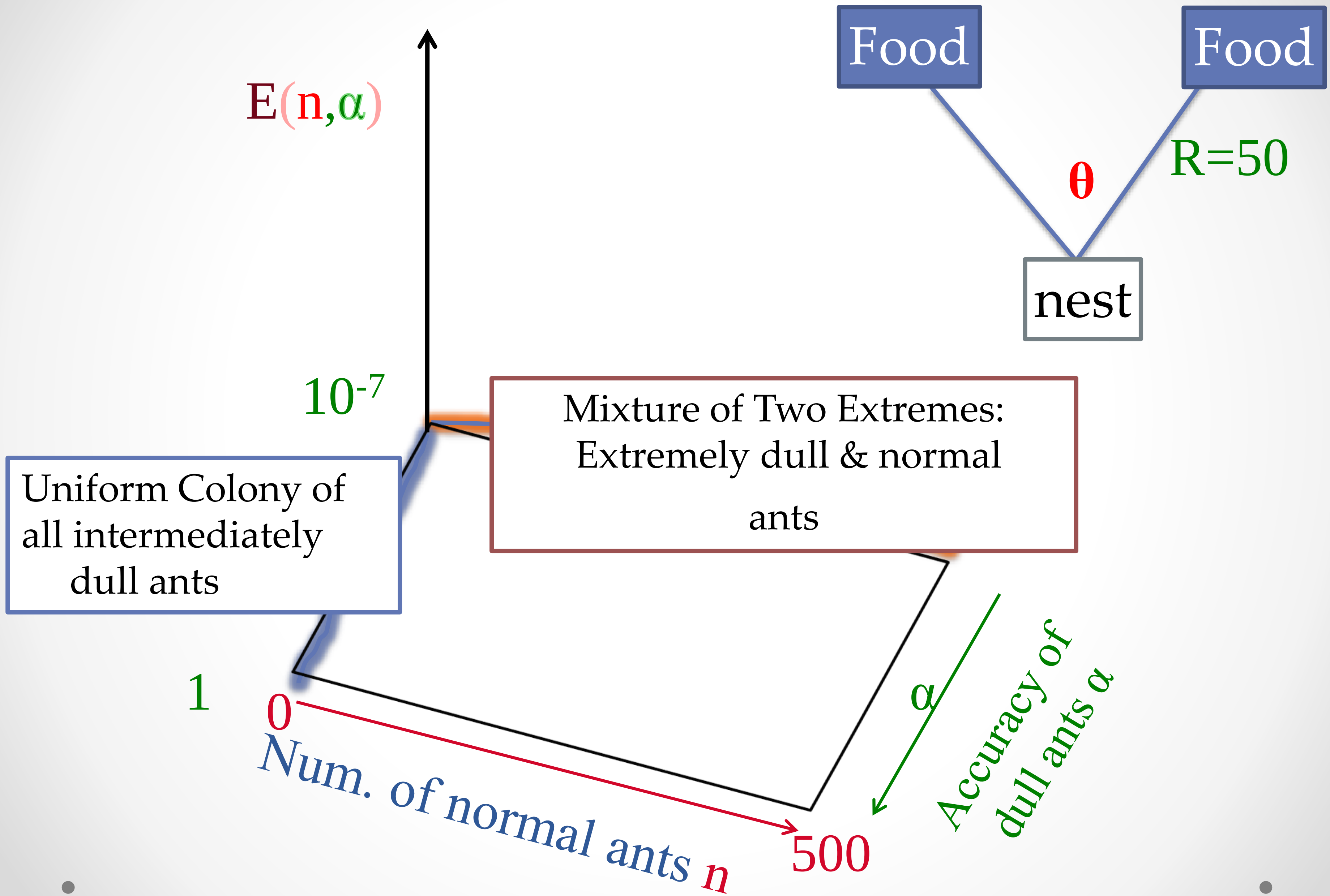
E: Total amount of food which a colony of 500 ants carry to the nest per unit time

$E(n, \alpha)$: Foraging Efficiency as the function of

Num. of normal ants & **Accuracy of dull ants**

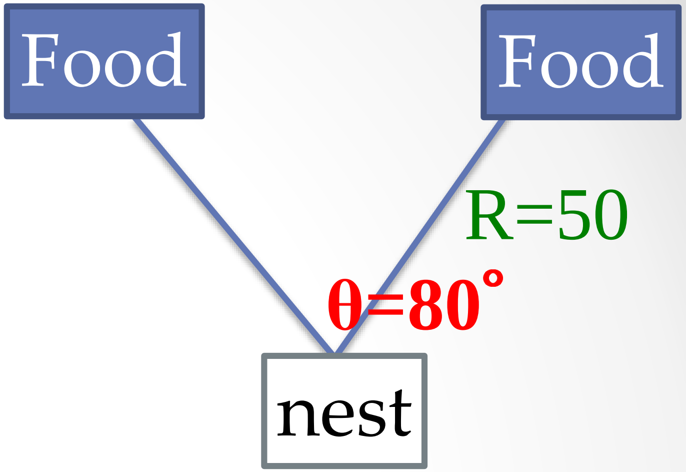
E: Foraging Efficiency in **n--α** space

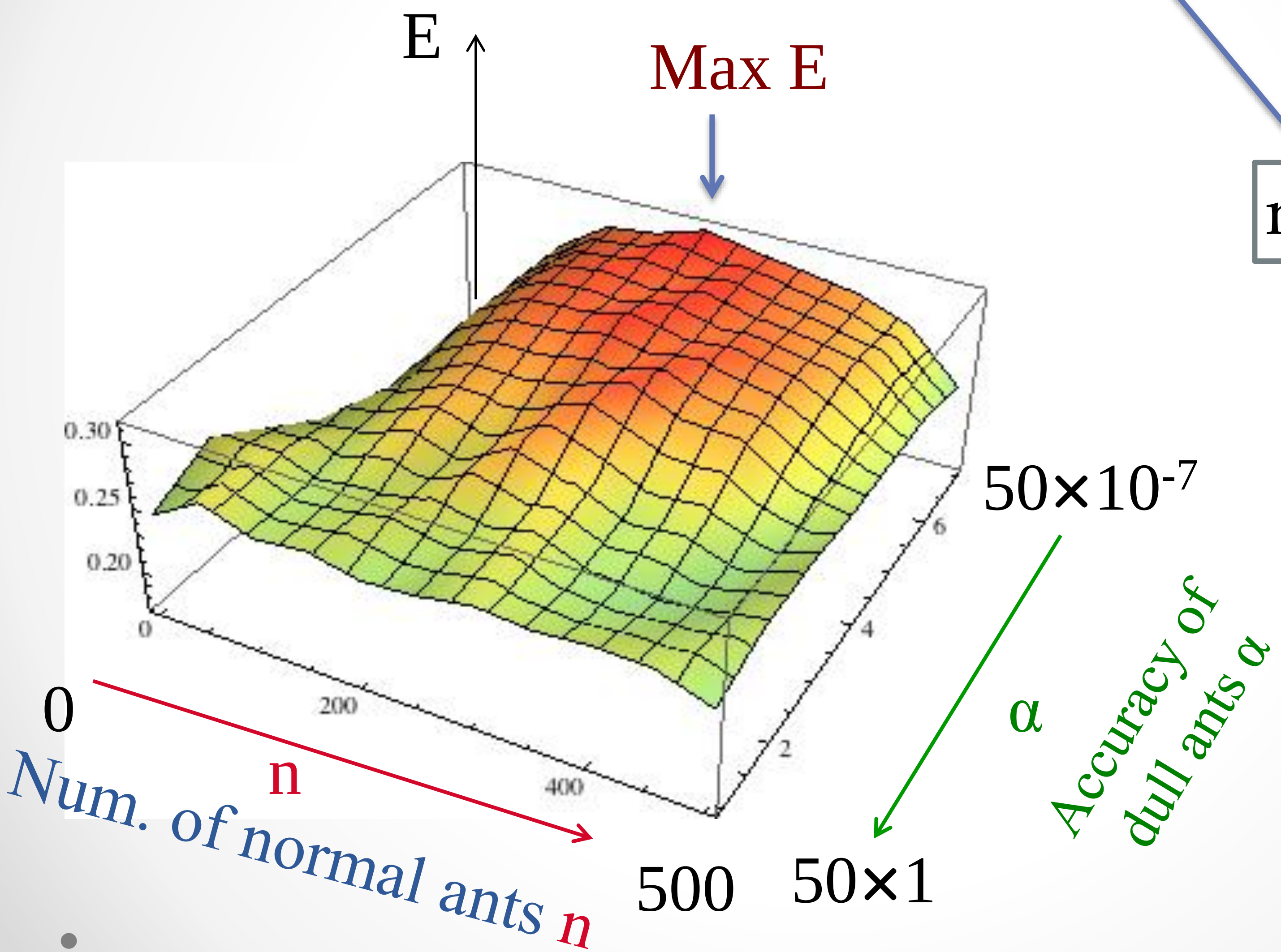



Food
Food
R=50
θ
nest
E(n,α)
10-7
Mixture of Two Extremes: Extremely dull & normal ants
Uniform Colony of all intermediately dull ants
1
0
500
α
Num. of normal ants n
Accuracy of dull ants α

Result 1 E(n,α):

(total number of ants 500)

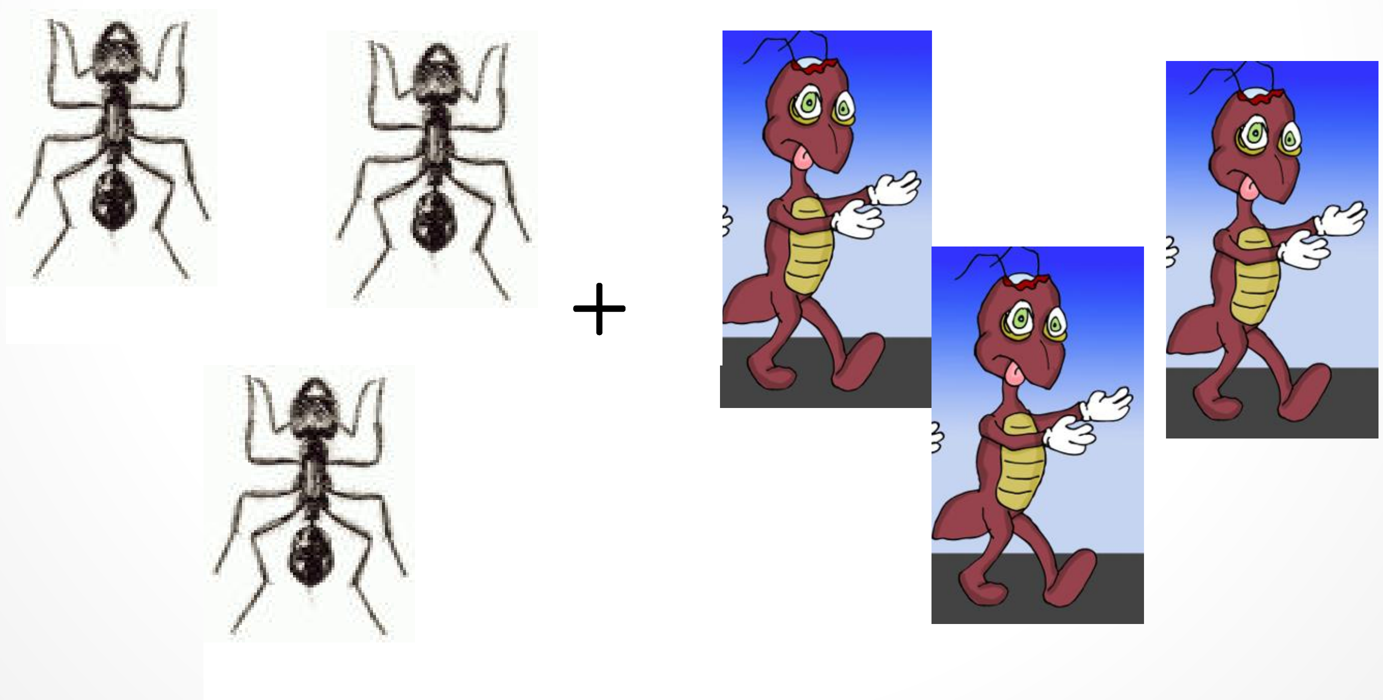




Optimal colony :

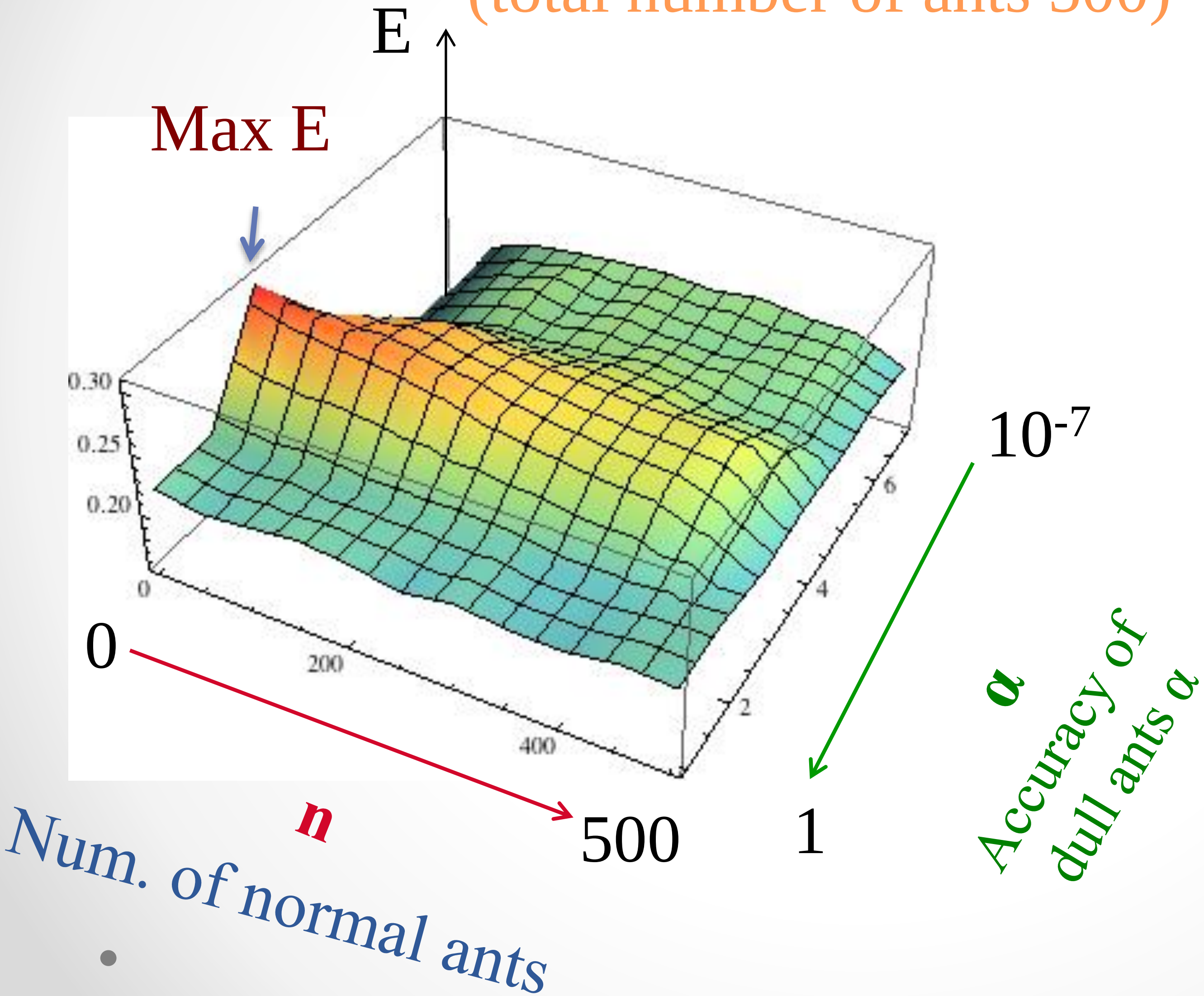
Binary-Mixture of two types of extreme ants

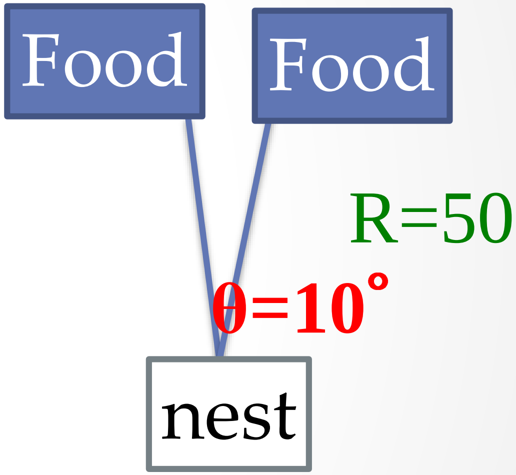
Normal ants & Extremely-dull ants



Result 2 $E(n,\alpha)$:

(total number of ants 500)

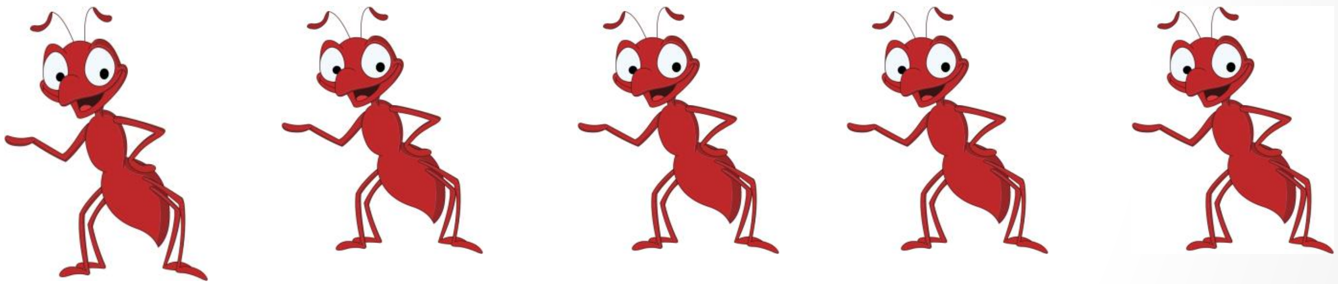




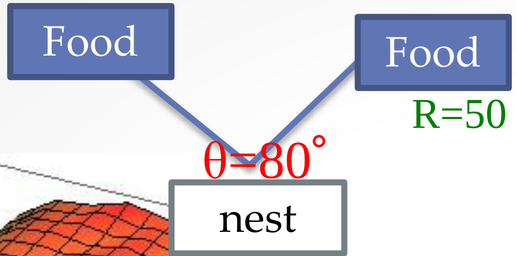
Optimal colony :

Uniform colony of

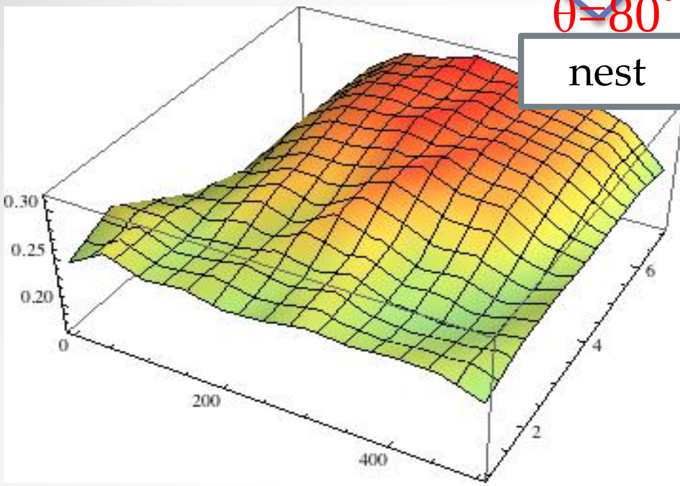
All Weakly(Intermediately) Dull Ants



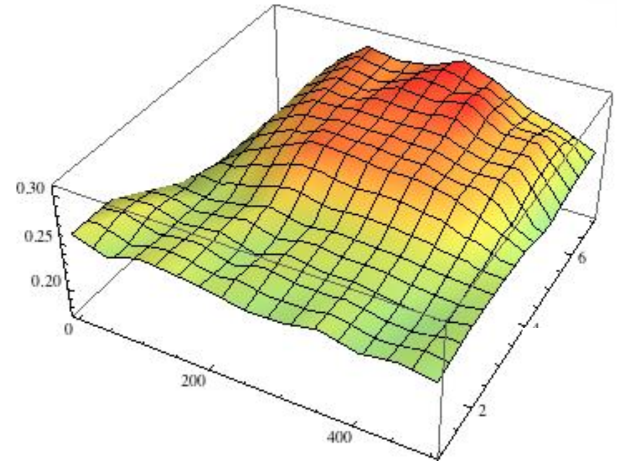
R=50 :fixed



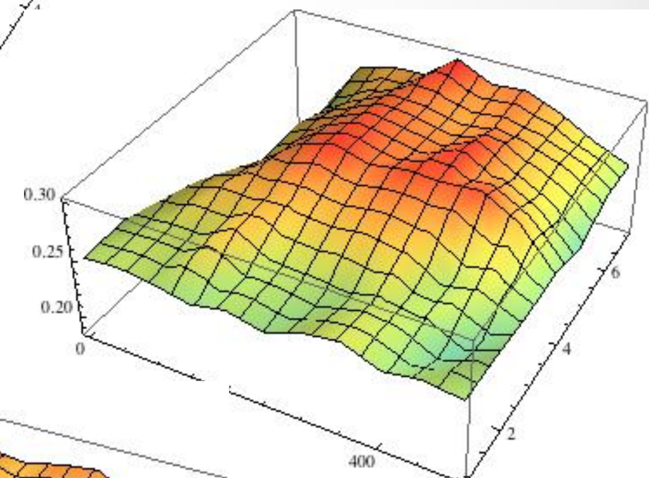
θ=80°

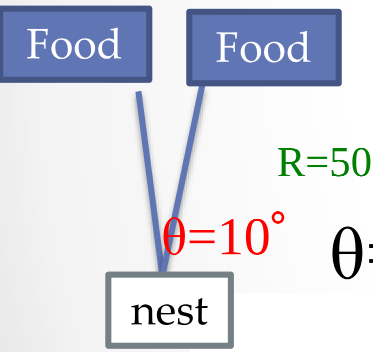


θ=50°

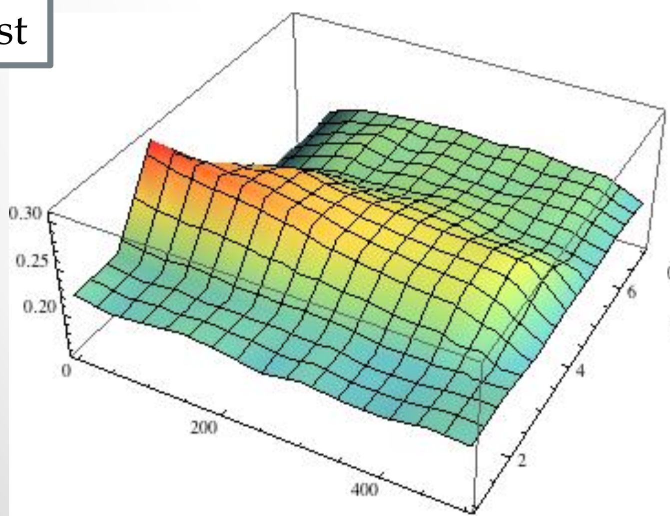


θ=30°

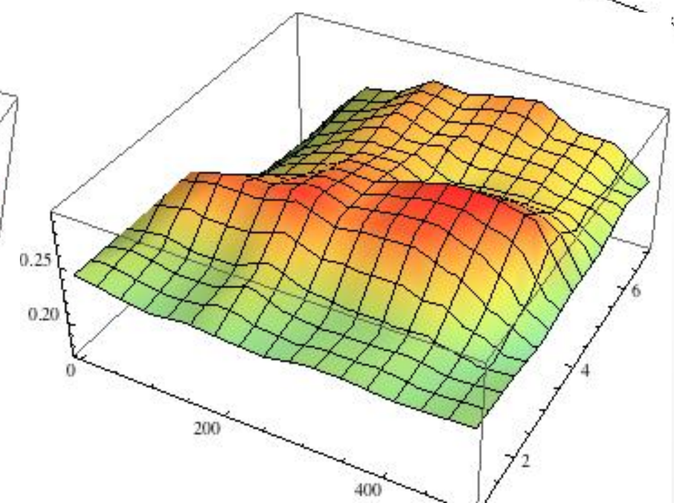




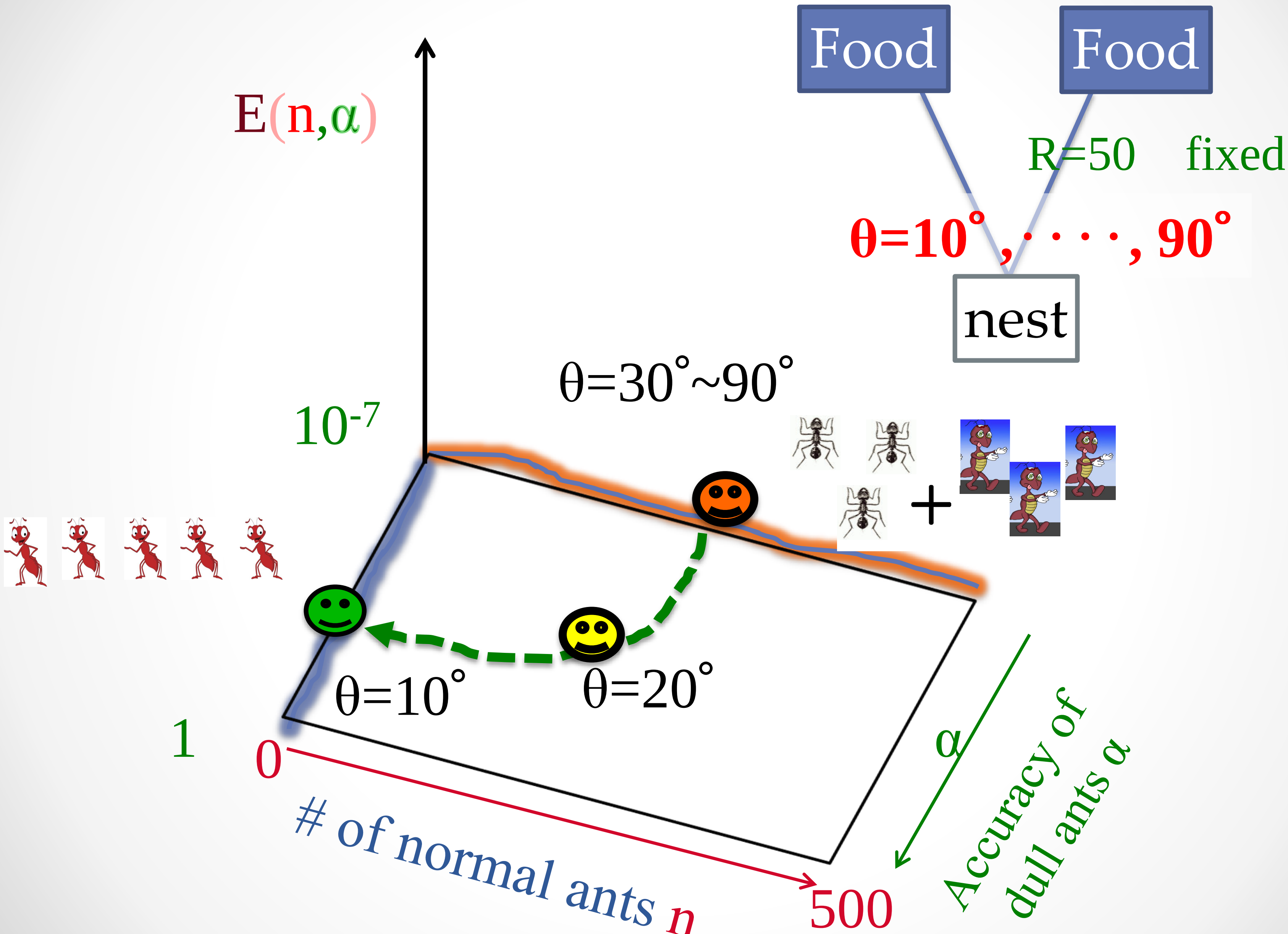
θ=10°



θ=20°



Shift of Optimal Colony According to the change of θ



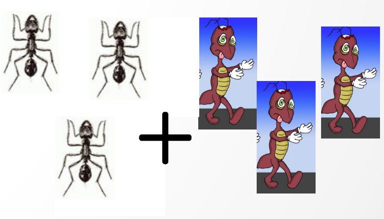
Summary of simulations

○Including inaccurate (=dull) ants within a colony
increase the foraging efficiency of colony

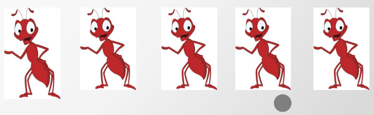
→***Strategy of Errors***

○According to the change of foraging environment
the optimal binary distribution of inaccurate ants
in a colony sharply change between:

i)a binary mixture of extremely-dull
and accurate ants



ii)the uniform colony of all-weakly dull ants



→***Variations of Strategy of Errors***

Remaining Problems

Only numerical results for the model:

○Need proof in the reality (in experiment /field)

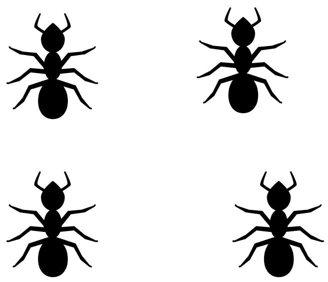
○Need some theoretical explanation for the results

Through an more abstract model

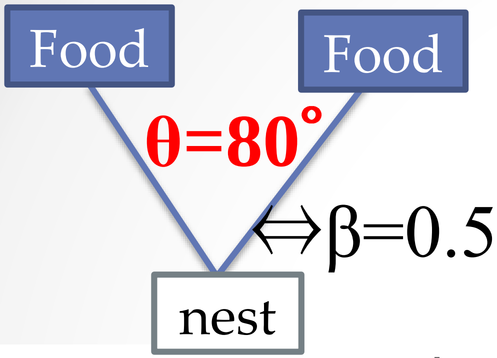
we extract the essential feature of the above results

=Emergence of the non-uniform of error strategy

§4.Conceptial model

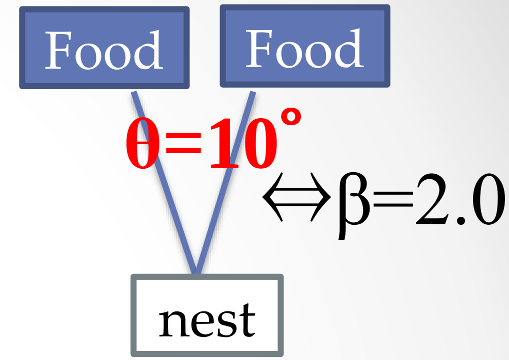


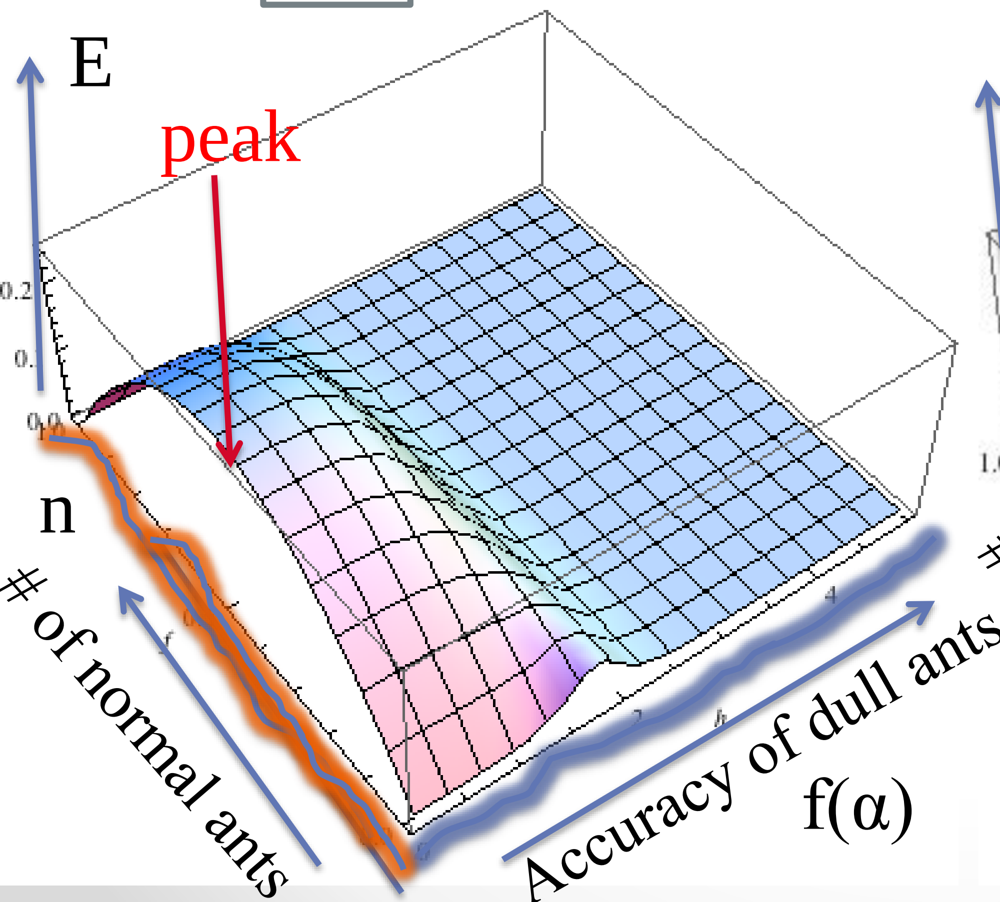
$$E == (500-n)\left(1-f(\alpha)^{\beta(\theta)}\right)^{1/\beta(\theta)} \cdot \left((500-n)f(\alpha)+n\right)$$

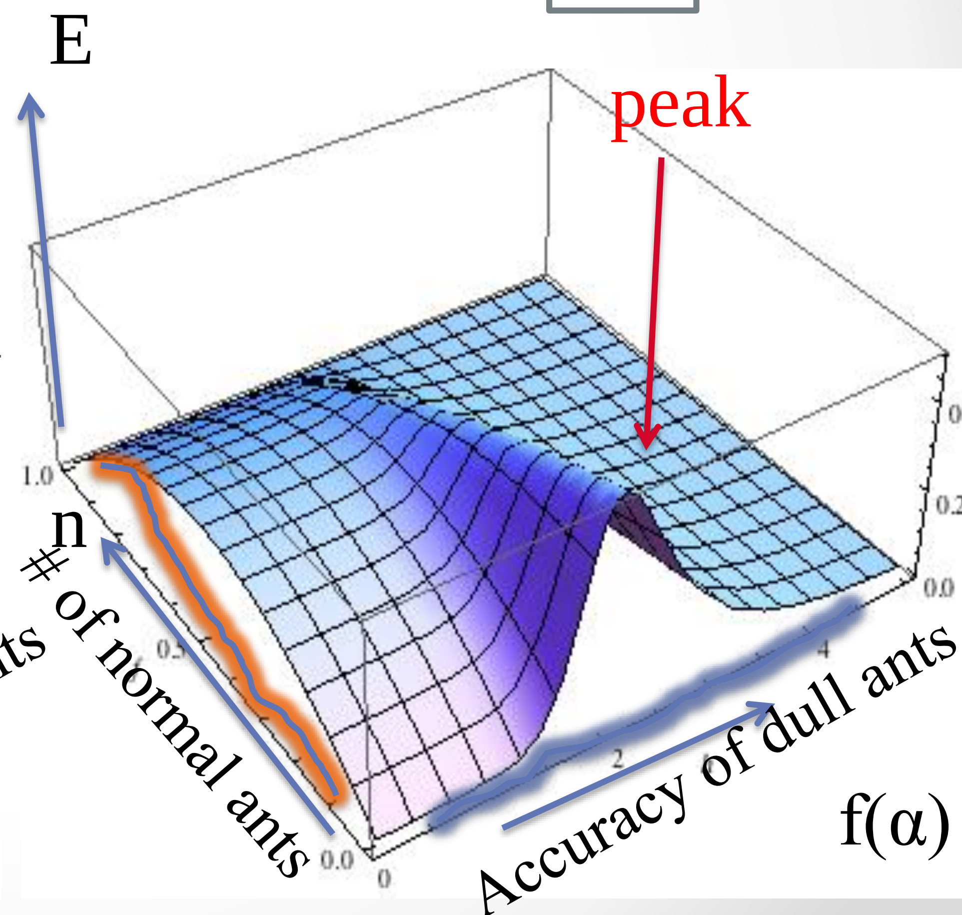


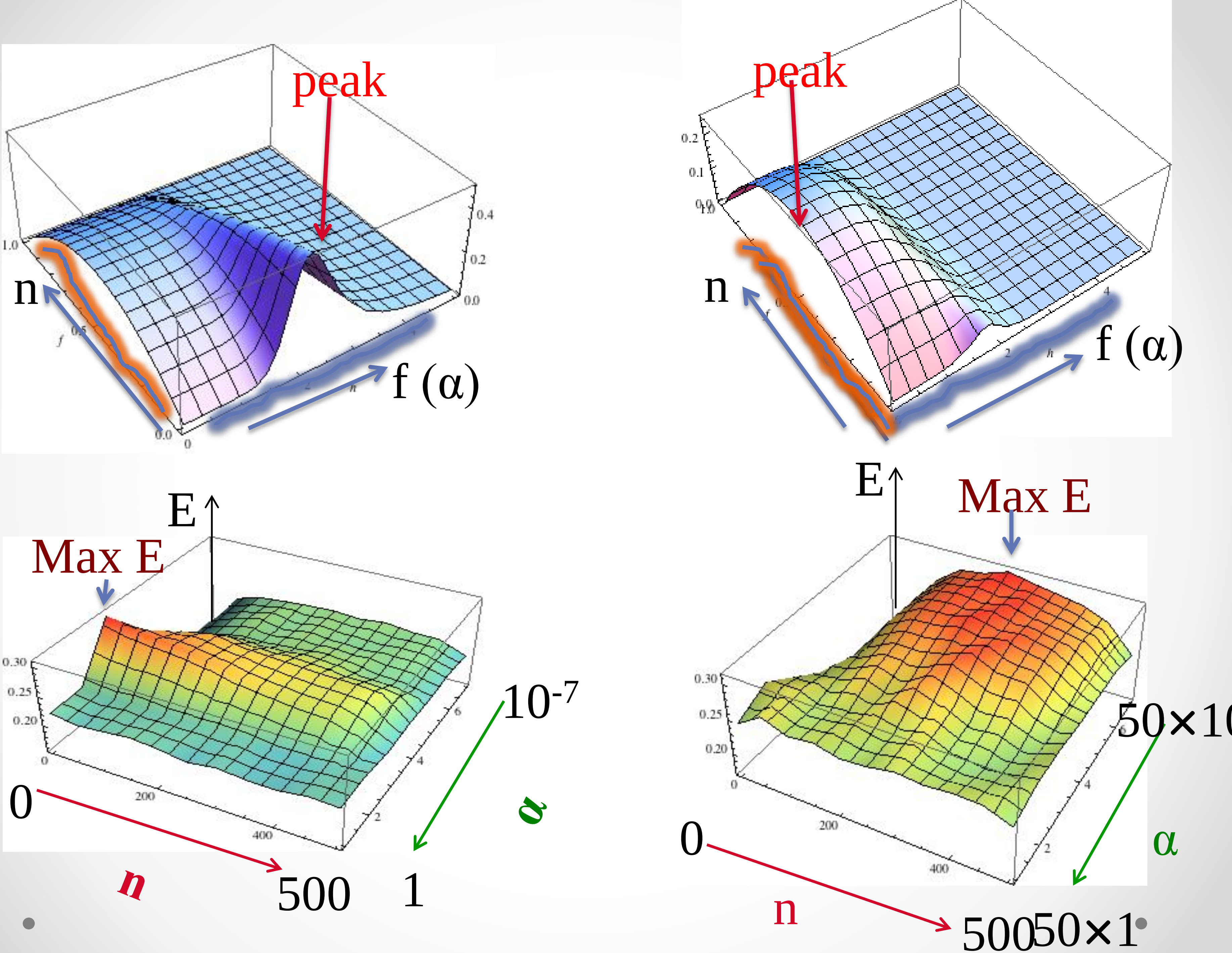
$$f(\alpha)=\alpha^b/(2^b+\alpha^b)$$

$(b=10)$









peak
n
f (α)
peak
n
f (α)
E
Max E
0
n
500
1
10-7
α
E
Max E
0
n
500
50×1
α

§5 Conclusion

〇Including inefficient (=dull) ants within a colony increase the foraging efficiency of colony

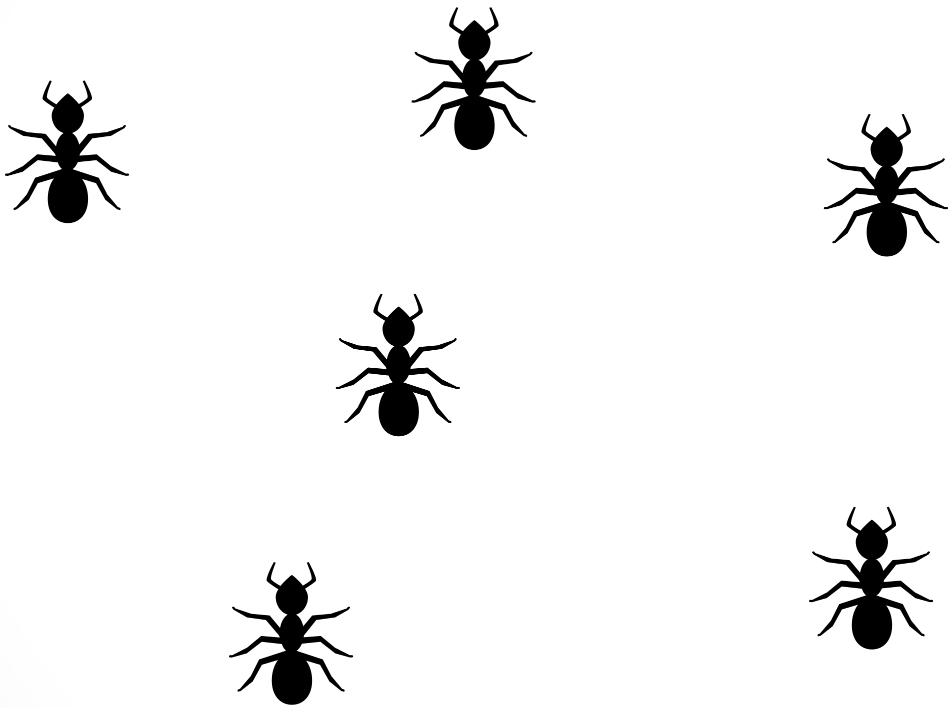
〇According to the change of foraging environment the optimal binary distribution of inaccurate ants in a colony sharply change between:

i)a binary mixture of extremely-dull and accurate ants

ii)the uniform colony of all-weakly dull ants

〇A simplified mathematical model indicates that the transition between different strategies of errors is reduced to the change of optimal division of role according to the feeding environment

§6.Perspectives



Remaining Problems

Only numerical results for the model:

- **Need proof in the reality** (in experiment /field)

Experimental study of group strategy of ants
(Collaboration with a making company of RFID chips)

RFID chip
Produced by
CO., LTD. (

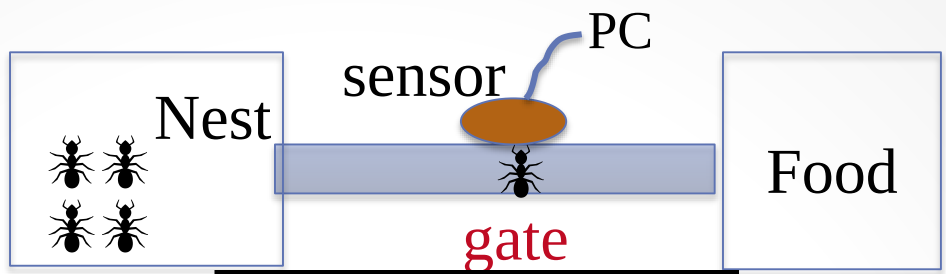
〇Size 0.4

〇on the RI

〇a reading
then we ca ing
through th

Camponotus japonicus

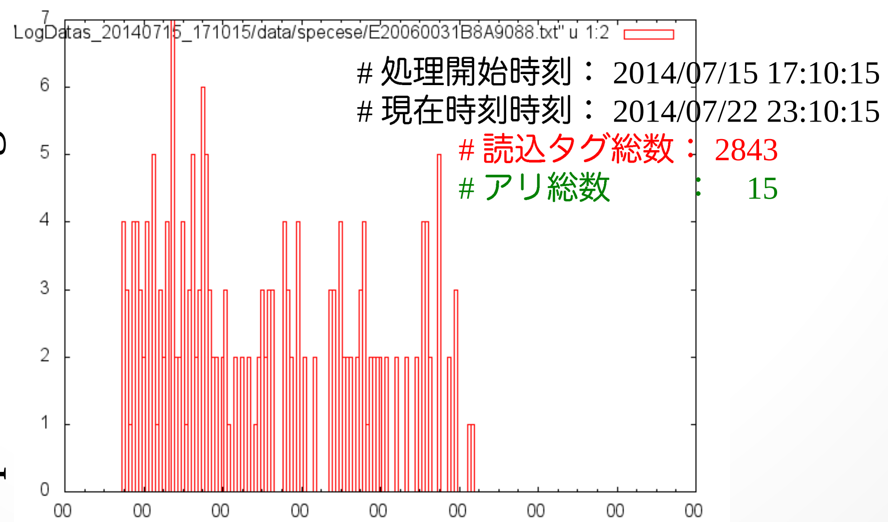
Setup



corridor
(transparent tube)

Example of obtained data 1

Activity=
Number of passages
per hour at the gate



Time(every one hour)

Data extraction and analysis using RFID tips is started very recently and still little data has been obtained

If you are interested in it,

Please come to Poster session
And visit poster P29

'Activity statistics of foraging ants'
Osamu Yamanaka, et al