ANT COMMUNICATION AND COGNITION

Zhanna Reznikova, Laboratory of Communiti Ethology, Institute of Systematic and Ecology of Animals, Novosibirsk

Cognition in an individual ant: is it possible? - yes, in those ants that have flexible and rational communication.

There are approximately 12,000 ant species on Earth.

For ants there are different possibilities to be smart, and among them:

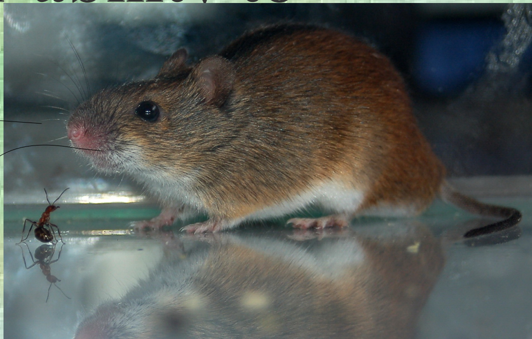
- **to react collectively, as a "super-organism";**
- **to learn and to do clever things individually;**
- **to obtain knowledge by means of "distributed social learning" (sensu: Reznikova&Panteleeva, 2008, Acta Ethologica) ;**
- **to become a member of an elite club of rare "cognitive specialists"**

-(1) to react collectively, as a "super-organism"

The "swarm intelligence" concept: patterns of interactions among individuals are governed by rules of self-organisation, and fairly simple units generate complicated behaviour by the group as a whole.

ants are not smart but ant colonies are

From A.Dornhaus (2008), PloS, as of from many examples. Worker allocation to tasks is unrelated to their ability to perform them.



Indeed, these species do not need flexible and rational communication!

-(2) to learn and to do clever things individually

Two examples:

Cataglyphis fortis. Photo by R. Wehner

(1)

MEMBERS OF SOLELY FORAGING SPECIES ARE MORE AGILE AND CLEVER THAN MEMBERS OF MASS RECRUITING SPECIES

Field experiments with Cataglyphis fortis. See: Cheng K., Narendra A. & Wehner R. 2006 (Behavioural Ecology); Sommer S., vonBeeren C. & Wehner R. 2007 (PNAS) .

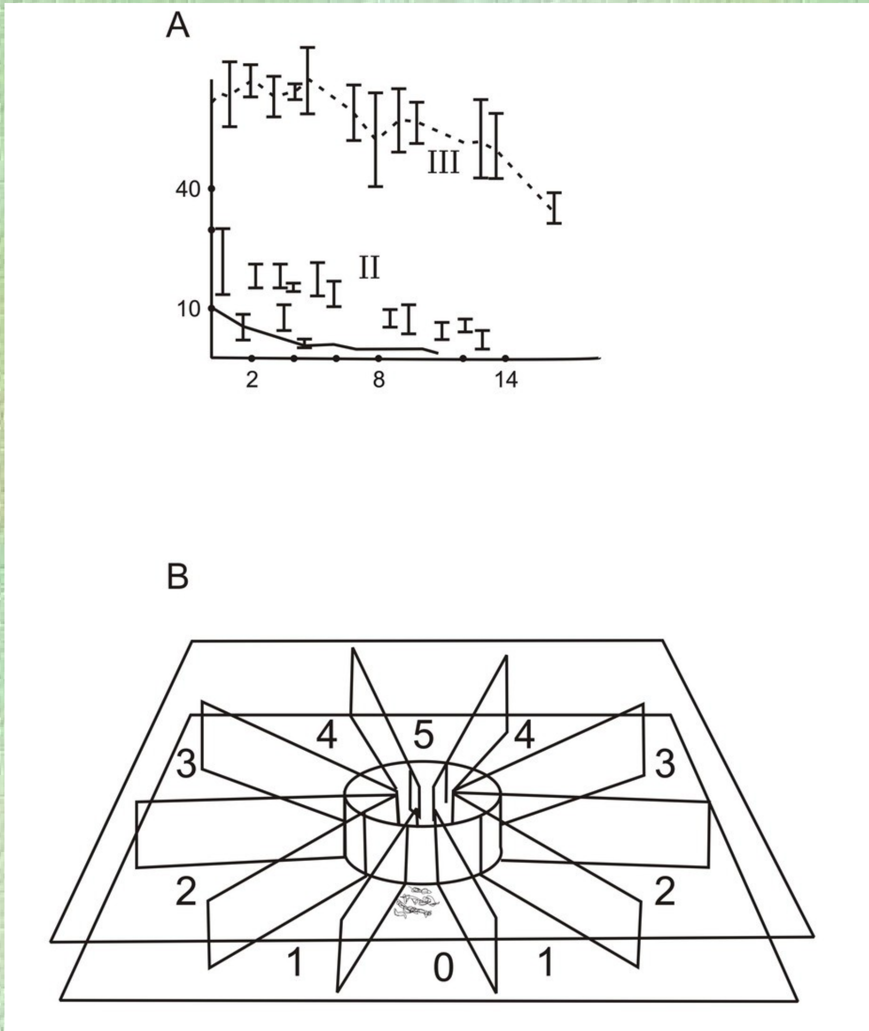
Individual ants learn and memorize many routes

(2): The solely foraging Formica cunicularia learn faster, and these ants serve as scouts for mass recruiting F. pratensis

Formica cunicularia:
Small colonies (several hundreds members), soil nests,
solely foraging

Formica pratensis: large colonies (tens of thousands members), ant-hills, group foraging

The solely foraging Formica cunicularia serve as scouts for mass recruiting F. pratensis



A – The change of the number of errors during the training:
I: F. cunicularia (scouting species);
II: F. pratensis (scroungers) in contact with F. cunicularia;
III: without contact.

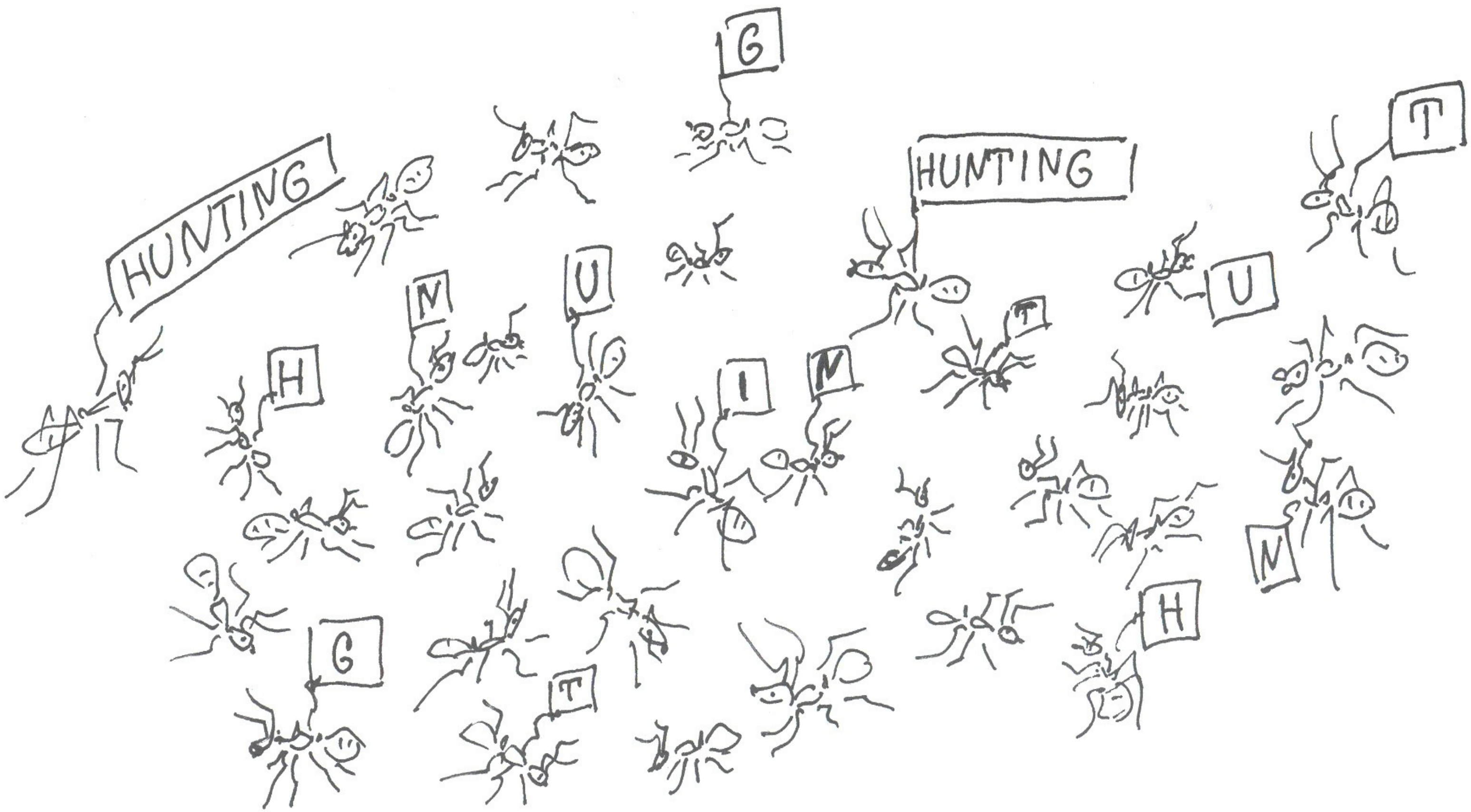
B – a circular maze with a bait in one of the sectors.
0-5 – numbers of the sectors.

Adapted from Reznikova, Behaviour, 1982; see also: Reznikova, 2007 “Animal Intelligence” (Cambridge Univ. Press)

(3) to obtain knowledge by means of "distributed social learning"

(Reznikova & Panteleeva, 2008, Acta Ethologica)

The presence of individuals equipped with an inherited complete stereotype is necessary for triggering and completing this stereotype (yet incomplete) in other members of the colony



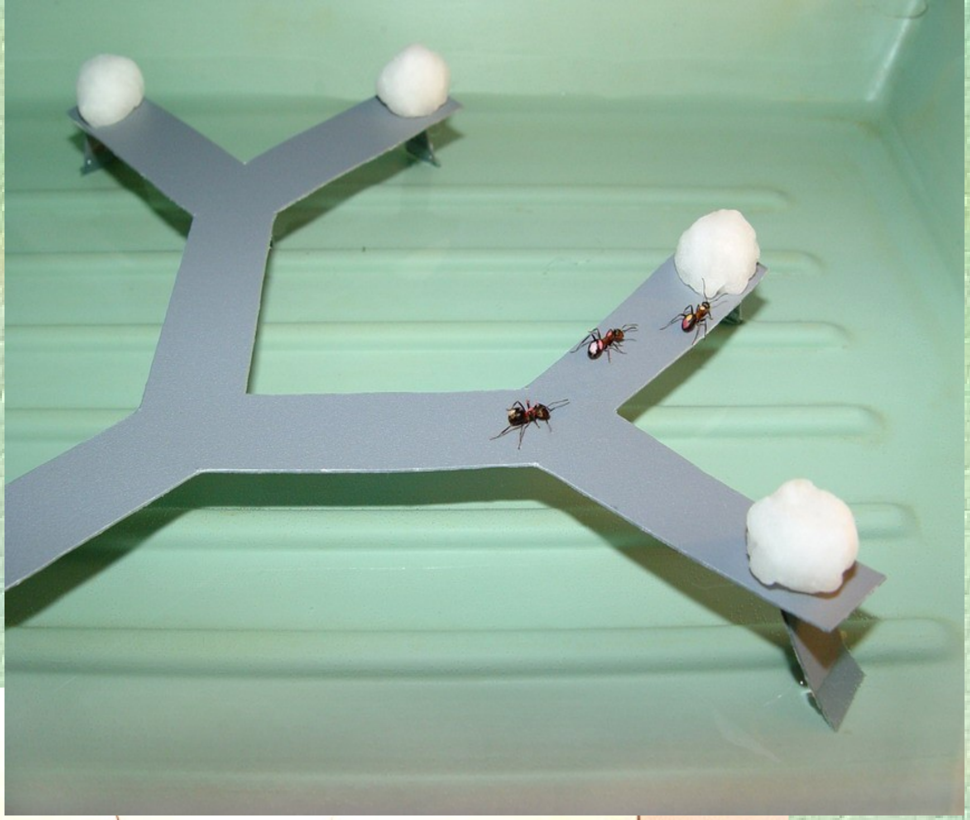
The scenario of hunting for active victims in Myrmica is based on "distributed social learning": initial performances by a few carriers of "at once and entirely" available pattern propagate it among specimens who have only dormant incomplete "sketches" of this pattern.

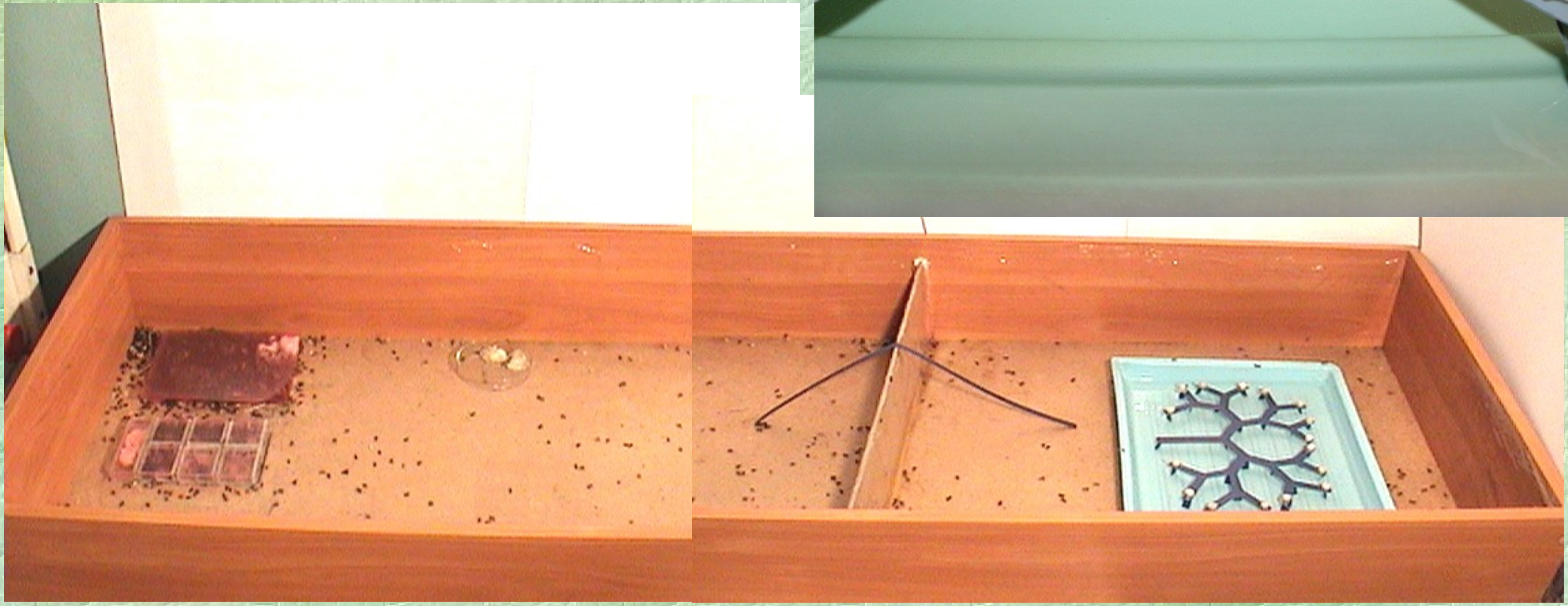
A "born hunter" catches a jumping springtail from the first encounter

This individual (of the same age) has to learn

- (4) to become a member of an elite club of rare "cognitive specialists”

“Binary tree” experimental paradigm





(Ryabko B. & Reznikova Zh.: Complexity, 1996; Entropy, 2009; Reznikova Zh.: Acta Ethologica, 2007; Myrmecological News, 11, 2008)

The «Binary tree» paradigm simulates a natural situation when the task requires distant homing: Messages about remote events come from scouting ants, without other cues such as scent trail or direct guiding.

In group retrieving red-wood ants small foraging groups search for a certain leaf with an aphid colony within a tree crown.

This tree is also binary!

Solving such problems is based on individual inter-relations within teams <u>which remain stable for some days and even weeks</u> (*this is not a nonsense!* Details in: Reznikova, 2008, Myrmecological News).

Red wood ants Formica polyctena, one of the most intelligent species on Earth

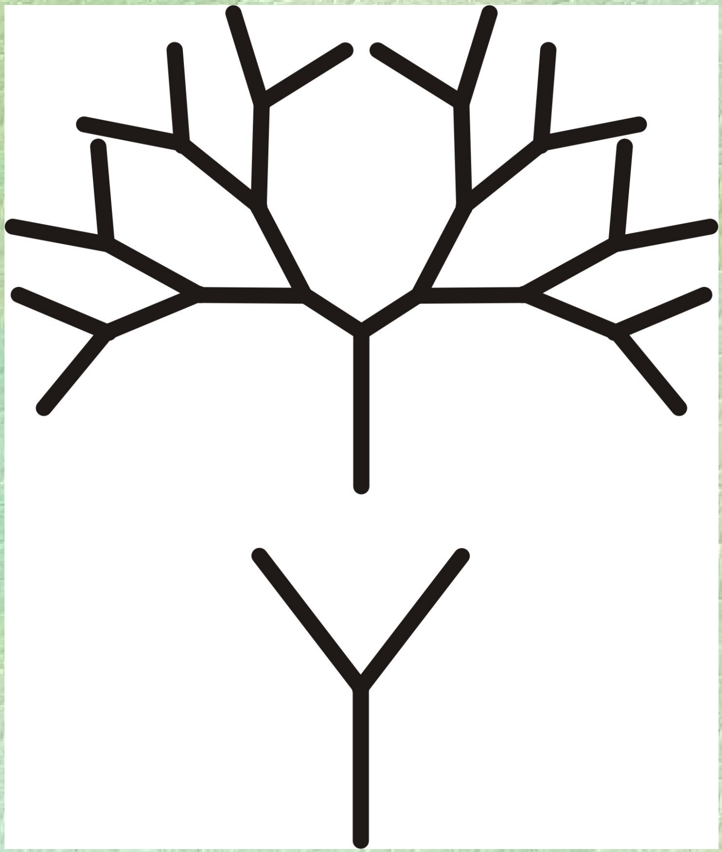
Distant homing in red wood ants is based on a scout-foragers recruitment system: ants work in stable teams for many days, and a scout shares the information about the discovered food only with members of its team. Special experiments revealed that foragers are not able to transmit information; this is a privilege of scouts.

The use of the "binary tree" experimental paradigm demonstrated that red wood ants are able to transfer information about sequences of turns on the way to a feeder that was situated on one of the leaves of the binary tree.

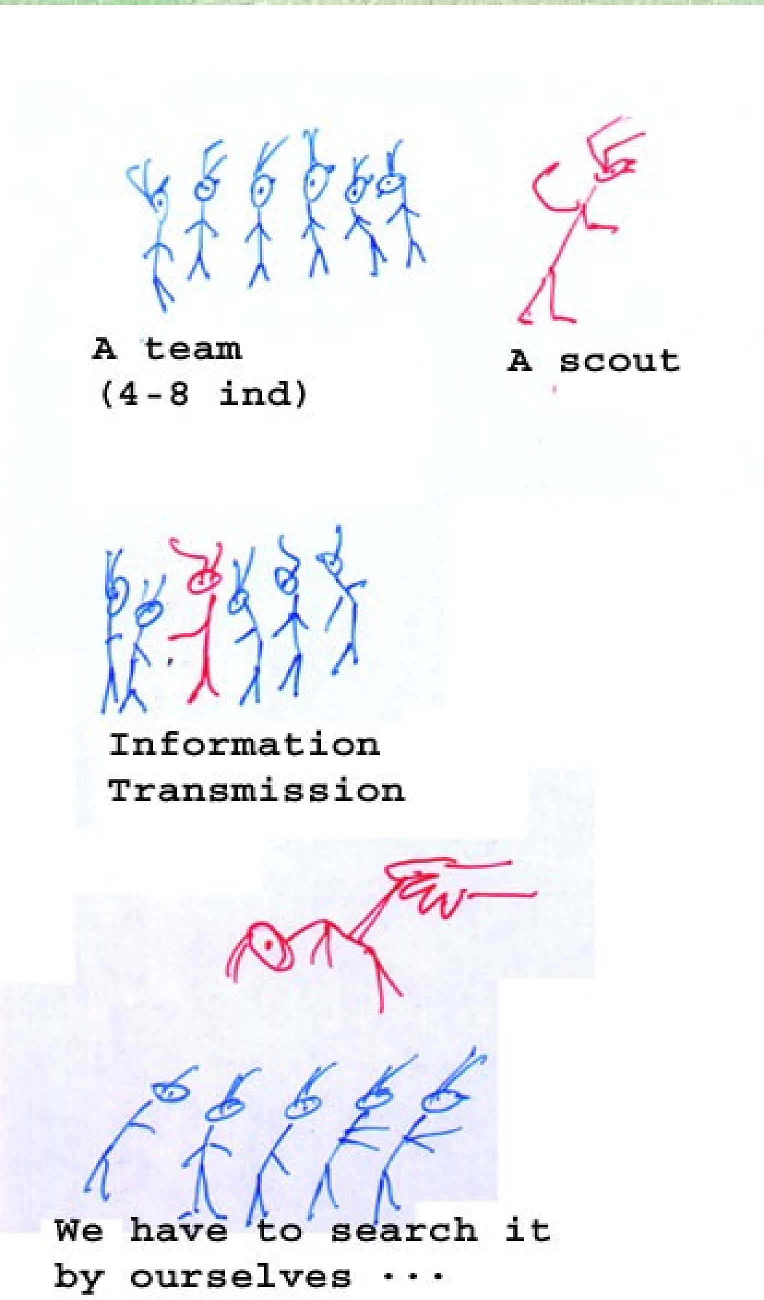
These experiments are based on ideas of information theory (see: Ryabko, Reznikova, Complexity, 1996; Entropy, 2009).

Experiments provide a situation in which ants have to transmit a precisely defined amount of information in order to obtain food.

Each leaf of the "tree" ends with an empty trough, except for one which is filled with syrup. In the simplest situation a scouting ant should transmit **one bit** of information to foragers:to go to the right (**R**) or to the left (**L**). In other experiments the number of bits necessary to choose the correct way is equal the number of forks (up to six). **So...scouts remember and transmit (to the members of their teams) up to 6 bits of information .**



HOW TEAMS WORK IN THE EXPERIMENTS



Teams include one scout and five to eight foragers.

The scout attracts only members of its team to the food; foragers are not able to pass information.

Experimental procedure

1. We placed a scout on the trough
2. The scout returned to the nest on its own
3. The scout contacted its team (the duration of the contact was measured)
4. The scout was isolated
5. The foragers searched for the food themselves; the video clips that demonstrate these stages are available at:

http://www.reznikova.net/infotransf.html

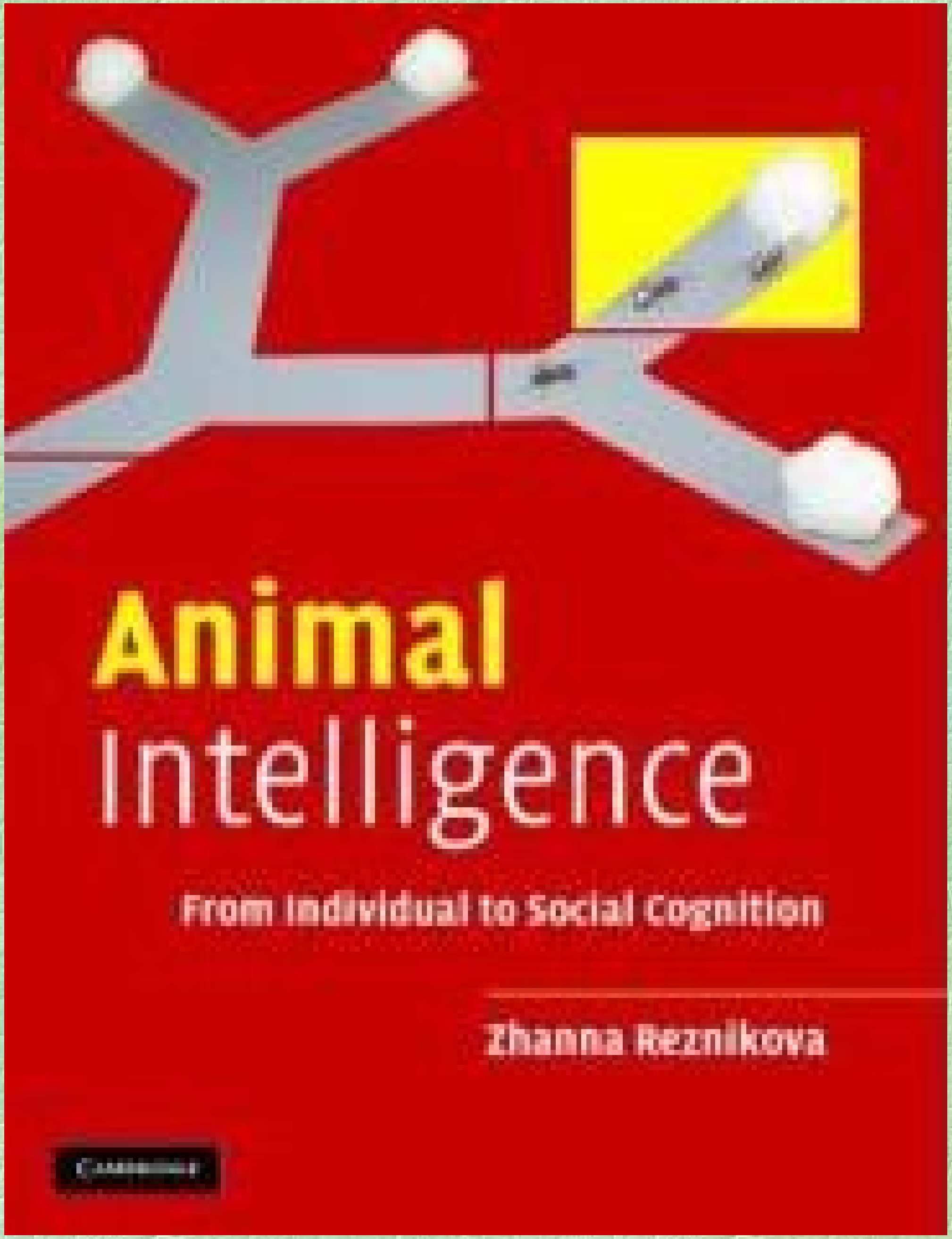
It is particularly important that scouts can not only transfer the exact information about a location, but they can also grasp regularities and use them to optimise and shorten their messages.

For example, they spent half the time for transferring the information about "regular" sequences of turns (such as "RRRRRR" or "RLRLRL", that is, "six times to the right", or "three times right-left"), as compared to shorter but "random" sequences, such as "RLLRL".

The complexity and flexibility of ants' communication is closely connected with their intelligence.

Duration of transmitting information on the way to the trough by F. sanguinea scouts to foragers (no.1-8 regular turn pattern; no. 9-15 random turn pattern)

No	Sequences	Mean Duration(sec.)	SD	Numbers of experiments
1	LL	72	8	18
1	RRR	75	5	15
2	LLLLL	84	6	9
3	RRRRR	78	8	10
4	LLLLLL	90	9	8
5	RRRRRR	88	9	5
6	LRLRLR	130	11	4
8	RLRLRL	135	9	8
9	LLR	69	4	12
10	LRLL	100	11	10
11	RLLR	120	9	6
12	RRLRL	150	16	8
13	RLRRRL	180	22	6
14	RRLRRR	220	15	7
15	LRLLRL	200	18	5



See details here

Study of ants numerical cognition using their own communicative means

Ants are able to pass information about a number of objects within thirty. They even can add and subtract small numbers.

Scouting ants had to transmit the information about the branch of a "counting maze" they had to go to in order to obtain syrup.

The analysis of time duration spent by scouts for the transmission of information to members of their teams allows us to suggest that the ants transmit information solely concerning the index number of the branch (see details in: Ryabko & Reznikova, 2009, Entropy).

Counting mazes: “horizontal trunk”, “vertical trunk” , and a grid-type maze.

fig. 1

fig. 2

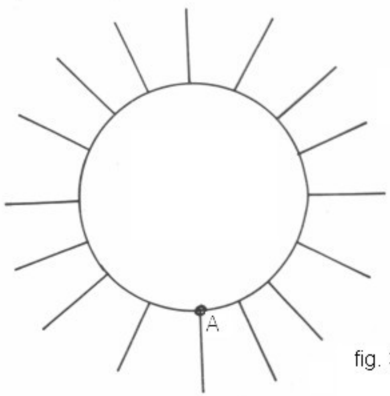


fig. 3

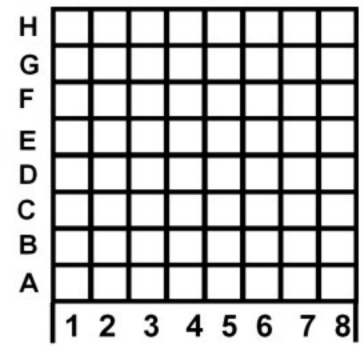


fig. 4

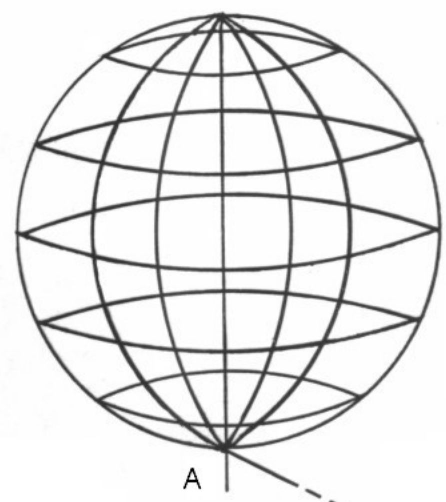
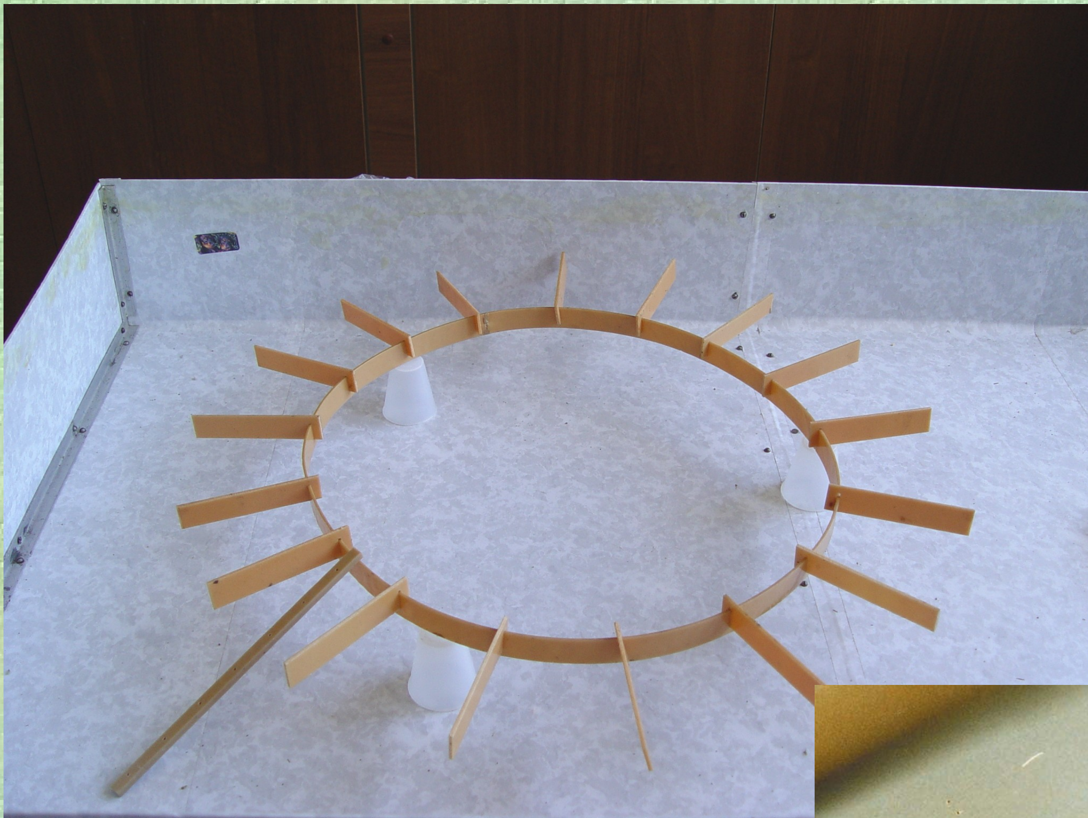


fig. 5



Counting maze:
Circle

Counting maze:
Horizontal Trunk
(experiments with Camponotus saxatilis: a team has just arrived to the empty brunch)

Ants' "arithmetic" skills

A fundamental idea of information theory: **The more frequently a message is used in a language, the shorter is the word or the phrase coding it.**

Ants were offered a horizontal trunk with 30 branches.

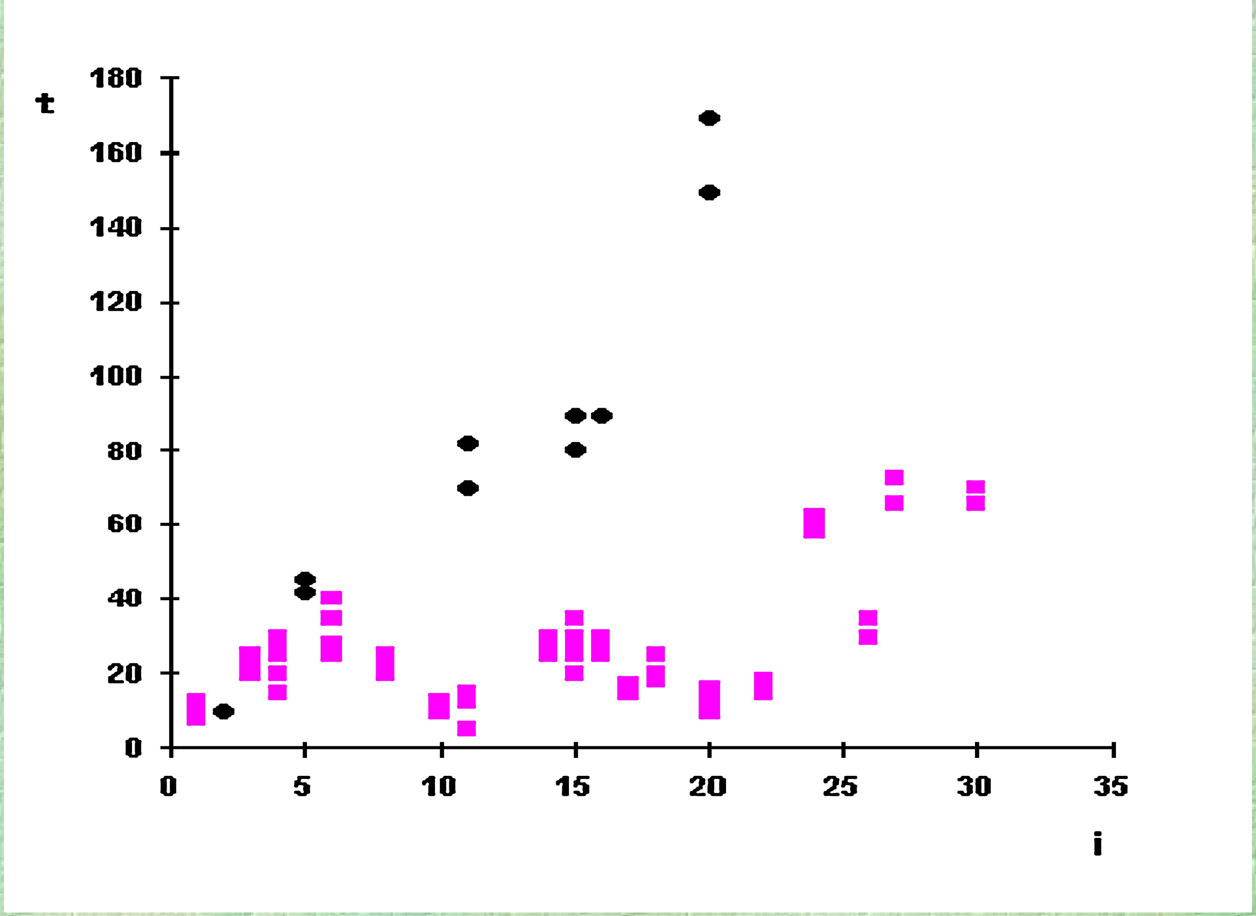
The experiments were divided into **three stages:**

I: the branch containing the trough with syrup was selected randomly, with equal probabilities for all branches. The probability of the trough with syrup being placed on a particular branch was 1/30.

II: two "special" branches A and B were chosen (N 7 and N 14; N 10 and N 20; and N 10 and N 19 in different years) on which the trough with syrup occurred much more frequently than on the rest: with the probability **1/3** for "A" and "B", and **1/84** for each of the other 28 branches. In this way, two "messages"-"the trough is on branch A" and "the trough is on branch B"- had a much higher probability than the remaining 28 messages.

III: the number of the branch with the trough was chosen at random again.

Dependence of the time (*t*) of transmission of information about the number of the branch having food on its ordinal number (*i*) in the first and the third series of experiments



Diamonds: the time taken for transmission of information at the first stage; Squares: the same at the third stage (adopted from: Ryabko, Reznikova, Entropy, 2009).

The patterns of the dependence between the time of information transmission and the index number of the food-containing branch at the first and third stages of experiments are considerably different.

At the first stage the dependence is close to linear.

At the third stage: (1) the information transmission time was very much reduced, (2) the dependence of the information transmission time on the branch number is obviously non-linear, with a depression in the vicinities of the “special” points (10 and 20).

These data enable us to suggest that the ants have changed the mode of presenting the data about the number of the branch containing food.

Our interpretation is that ants of highly social group-retrieving species are able to add and subtract small numbers.

This also indicates that these insects have a communication system with a great degree of flexibility. Until the frequencies with which the food was placed on different branches started exhibiting regularities, the ants were "encoding" each number i of a branch with a message of length proportional to i, which suggests unitary coding. Subsequent changes of the code in response to special regularities in the frequencies are in line with one of the basic information-theoretic principles that states that in an efficient communication system the frequency of use of a message and the length of the message are related.

Possibly these ants argue who of them is more clever

Highly social ant species possess rational and flexible communication, which is based on cognitive specialization, that is, the division of “brain-work” between scouts and foragers within stable teams.

So.... when you accidentally crush an ant, it may mean nothing for the interaction network of which it was part, but it is possible that you have deprived a community of a member of an elite club of rare "cognitive specialists".

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